

Masters Capstone Project

Connecting Math Talk Communities, Student Reasoning and Math Assessments

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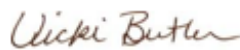


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Abstract

This action research project explores the possible connections between the development of a math talks community in a classroom and student performance on standards-based assessments. The project includes nine student volunteers in a fifth-grade classroom and utilizes their classroom participation, exit ticket scores, and assessment performance as data measures. The project was interrupted by a county-wide school closure due to the COVID-19 pandemic shortly after the intervention period began. Initial findings seemed to confirm earlier research around the connection between exit ticket scores and student test performance but no conclusions could be drawn regarding the connections between math talks and student performance.

Introduction

Mathematical reasoning is a cornerstone of student math ability; in fact, The Common Core Institute refers to a student's ability to express their reasoning as one of their eight core standards (Common Core Institute, 2015a). Battista (2018) defined three key structures that must exist to allow students to move through the process of synthesizing new information: ongoing professional development for instructors; clear definitions of expectations for students, created in a framework that recognizes possible teacher bias; and appropriate placement of students along academic tracks. All three structures lead to the creation of a space in which students gain the ability to explore mathematics in a teacher-supported framework. This dovetails with the concept of math talk communities. In these classroom communities, teachers transition students from the traditional classroom structure of teacher-led direct instruction to student-led discussion, commonly in a tiered approach (Chapin, O'Connor & Anderson, 2003; Hufferd-Ackles, Fuson & Sherin, 2004).

The classroom community is supported by the teacher first. This is done through consistent modeling (Chapin et al., 2003), the creation of supporting materials such as sentence strips (Rawding & Wills, 2012), and adjustments to teaching based on self-reflection (Bennett, 2010). Teachers should also take care to use age-appropriate language and accessible terms, especially in the presentation of new and challenging material (Pupura, Napoli, Day & Gold, 2016). To spur authentic conversations, teachers can shift their classroom environments to be more conducive to discussion, such as large circles of desks facing inward rather than rows (Hung, 2015). As not all of these strategies can – or perhaps, even should – be used simultaneously, the onus is on the teacher to select the strategy most appropriate for his or her classroom.

Dilemma

The problem was that students struggled to express and justify their reasoning on math assessments, even in the framework of Common Core standards. In a review of existing literature, the researcher found evidence that demonstrated that math talk communities led to qualitative increases on a teacher's self-assessed instructional abilities as well as student participation in the classroom. Assessments are integral to evaluating student understanding; research indicated that pairing the method of assessment to the reason for the assessment leads to accurate evaluations (Bennett, 2010).

Rationale

The mathematics standards of Common Core are grounded in eight core practices, one of which is the ability to “construct viable arguments and critique the reasoning of others” (Common Core Institute, 2015a, para. 4). This ability is intrinsically language-dependent and requires students to not only know the math fact that tells them ‘seven eights is seventy’ but why that is true. Students can arrive at this answer through multiple means such as: rote memorization of times tables; adding eight to itself seven times; or multiplying seven times ten then adding seven more would be three methods. Math talks recognizes the language of mathematics as a vital tool for students to utilize when problem solving, individually or in a group (Chapin, O’Connor & Anderson, 2003). This connects the base concepts behind math talk to the central tenets of Common Core and standards-based evaluations. In using this instructional method, one teacher felt that “students would learn from each other more efficient strategies” as she continued to implement the program in her room (Chapin, O’Connor & Anderson, 2003, p. 77). Another teacher saw math talks as a community process that lead students to “develop their own shared, accurate interpretation of the symbols they’ll use in future

computations” (Chapin et al., 2003, p. 101). The two views are compatible in implementation. As students create their own understandings, as the latter teacher argued, they may have new insights for their peers as they work in peer groups toward understanding, as the former teacher hopes.

The researcher found that students showing high levels of proficiency found it difficult to express why they were computing algorithms in a certain way or shifted to using new methods presented in the curriculum. Students who were not at grade-level struggled to explain where they found challenges in problems or participate in group discussions, impeding the ability of the researcher to provide support. The remaining students, representing most of the class, often skipped key steps in a problem but achieved the correct answer or were unable to use new vocabulary to explain their accurate methods. Math instruction for this grade at the school occurred in the latter half of the school day and students spend most of their day thinking about language and story before they switched to ‘math mode.’

The district in which this research takes place required that math assessments be formally scored in one of three standards-based categories in the first and second trimesters of the school year. ‘At Risk’ (AR) indicates that students are unlikely to reach proficiency in their grade level math standards by the end of the year. ‘Progressing Toward’ (PT) identifies those students who are currently behind expected grade level proficiency but are likely to close the gap before the end of the year with focused work. ‘On Target’ (OT) is the highest level and students in this category are on pace to reach grade-level proficiency in their year-end assessment. The rubrics used to evaluate student progress are based on the Common Core standards for the appropriate grade level and topics being assessed.

Literature Review

The concept of ‘math talks’ focuses on the creation of a math talk community within a classroom and the possible methods of implementation that lead to student success (Chapin, O’Connor, & Anderson, 2003; Hufferd-Ackles, Fuson & Sherin, 2004; Wagganer, 2015). While the existing literature clearly defined math talk, the strategies around its implementation, and possible methods of assessment, there is an opportunity to explore the connection between math talks and student performance on standards-based math assessments. The existing literature on creating a math talk community is robust with authors creating meaningful connections between their work and the existing discourse (Hancewicz, 2005; Hufferd-Ackles et al., 2004; Murata, 2017; Wagganer, 2015). The math talk community building strategies are meaningful and actionable and robust literature surrounds these strategies as well as methods of mathematics assessment (Bennett, 2010; Fowler, Windschitl, & Richards, 2019; Laud, 2011; Nasir, Hand & Taylor, 2008). Additional research around math anxiety is a supplemental tool to consider student confidence in math instruction and performance (Ashcraft, 2002; Hembree, 1990). Other math intervention strategies include using student self-assessments and integrating additional materials, though these do not always lend themselves to math talk communities.

Math Talks

Hufferd-Ackles, Fuson and Sherin (2004) defined math talks as “a classroom community in which the teacher and students use discourse to support the mathematical learning of all participants” (p. 82). Their inquiry into math talk learning communities occurred at a parochial school, where researchers focused on their work within a third-grade classroom, and became a defining piece of literature for this area of research. The classroom community that supports math talk is one in which students continually engage in “questioning,” which gives students a

sense of independence, room to explore mathematical ideas, and learn to take “responsibility for learning” (Hufferd-Ackles et al., 2004, p. 82). A successful math talks community is built through a tiered system in which the class moves through levels of engagement (Hufferd-Ackles et al., 2004; Wagganer, 2015).

The first level, Level 0, follows the guidelines of traditional instruction in which the teacher leads the class with little to no student input (Hufferd-Ackles, Fuson & Sherin, 2004). At Level 1, the teacher begins to elicit student response, but there is limited back-and-forth interaction and any student-to-student conversation is teacher-facilitated (Hufferd-Ackles, Fuson & Sherin, 2004). At Level 2, students begin to have more agency in the classroom as they not only respond to questions but engage in active listening as a learning community (Hufferd-Ackles, Fuson & Sherin, 2004). At Level 3, there is a shift to “teacher as co-teacher and co-learner” (Hufferd-Ackles, Fuson & Sherin, 2004, p. 90) with students working to understand each other’s responses through subject-focused conversation and shared work. This tiered approach has been modified and adapted by other authors, including Murata et al. (2017) in their work with lower elementary grades.

Math talk communities can be built in all grade levels. Multiple scholars connect math talk communities and building number sense when looking at elementary school applications. Murata, Siker, Kang, Baldinger, Kim, Scott, and Lanouette (2017) examined the use of math talks in a comparative analysis of two first-grade classrooms. By selecting two classrooms, the authors were able to do a deeper analysis that still allowed them to see breadth in practice (Murata et al., 2017). Murata et al. (2017) built on the work of Hufferd-Ackles et al. by using their tiered framework as an analytical base. Murata et al. (2017) found that a teacher’s understanding of their students’ skills and areas of growth are key to the successful

implementation of math talks. This understanding allowed the teachers to scale the class through math talk at an appropriate pace with appropriate language. The authors also recognized that student response will vary based on their experience and background: “diversity amongst student ideas should be expected, valued, and used to drive meaningful mathematical discussions” (Murata et al, 2017).

Waggener (2015) used an approach that mirrored the tiered structure of Hufferd-Ackles et al. (2004) while maintaining a focus on the teacher, which would later be utilized by Murata et al. (2017). Waggener built on this by centering the work around students’ ability to actively listen, making that skill integral to the classroom’s math talk community. Waggener (2015) explored math talks in a fourth-grade classroom and developed five key strategies to effective math talks. Like Hufferd-Ackles et al., Waggener focused on approaching math talks through tiers of discussion. While Hufferd-Ackles et al. (2004) began with Level 0 being teacher-led instruction, Waggener’s (2015) first intervention strategy was to ensure students are prepared to become active participants in teacher- and peer-led work. Waggener (2015) found that the core requirement of being an active listener became one of the main challenges in integrating math talks into her classroom and devoted additional instructional time to instructing her students in how to be active listeners (2015). Waggener (2015) employed modeling as a key component of her application, which was then echoed in the work of Murata et al. (2017) and their subsequent finding that student success must be teacher-supported and properly scaled.

Hancewicz (2005) described mathematics discourse as being a three-tiered structure, similar to the structure defined by Hufferd-Ackles et al (2004). In their work, Hancewicz defined discourse as “the genuine sharing of ideas among participants in a math lesson, including both talking and active listening” (2005, p. 72). The first tier is “traditional” discourse, similar to

what Hufferd-Ackles et al. defined as teacher-led instruction, in which a teacher poses problems to students with the expectation that students will respond with a “pre-planned answer” and the teacher will lead students to that answer should they be unable to generate it independently (Hancewicz 2005, p. 73). The second tier is “probing” where a teacher will open a line of questioning that is designed “to hear about a student’s thinking rather than from a need to move students along a pre-planned route” (Hancewicz 2005, p. 73); this is in line with Hufferd-Ackles’ Level 2. Finally, Hancewicz (2005) described the third tier as “discourse-rich” or an open dialogue between students and teacher in which students question each other and build on other students’ ideas and learning. A classroom example of this third tier is Student A presenting their work on the board and Student B following up with not only their idea of what to do but the phrase “I can prove it” and then themselves going up to the board to show their work (Hancewicz, 2005, p. 74). This can continue until all students have shared their method. If a student’s method is not accurate, it will be up to the other students to share and prove why this is the case.

Hancewicz (2005) stated that “If we believe that the goal is for students to build mathematical understanding as well as efficient procedures, a well-crafted lesson depends upon students effectively sharing their strategies and ideas” (p. 74). Therefore, a teacher who uses this tier model as their implementation strategy will need to allow students the space to try new strategies and methods as they move through the tiers. This is also a move away from a traditional model in which one problem has one method for solving that leads to one solution. Instead, Hancewicz argued, “when students solve problems by whatever method makes sense to them and share their work, many strategies can arise within the context of one problem” (2005,

p. 82). By creating space for students to learn through struggle and exploration, teachers design an implementation strategy that allows greater chance for success in their math talk community.

Implementation Strategies and Challenges

Waggoner (2015) defined five strategies to follow when implementing math strategies: discuss why math is important; teach students how to listen and respond; introduce sentence stems that students can build from; contrast the concepts of explanation versus justification; and give an example. Waggoner's work was an extension of the research conducted in two related studies. Chapin, O'Connor and Anderson (2003) focused on five strategies to implement math talks, and Rawding and Wills (2012) focused on the connection between math talks and classroom community.

Rawding and Wills (2012) addressed building a positive classroom community to support their math talk, especially their work on using and posting sentence stems to inspire student response. Chapin, O'Connor and Anderson found that modeling and prompting were key to math talks (2003) and Rawding and Wills' (2012) proposed use of sentence stems in these conversations is a natural progression of their work. Rawding and Wills (2012) presented this community building as an all-year endeavor and encouraged teachers to build in new strategies as layers. Rawding and Wills (2012) determined that repetition of a conversation strategy and teacher modeling are key to student engagement with the strategy. They did not define when teachers should begin to layer in the next strategy nor provide insight as to what to do as students 'forget' or cease to utilize earlier skills. This echoes the work of Chapin et al. (2003) and the emphasis that the teacher is the conduit for successful student conversations within a math talk community. Both researchers' conclusions allowed space for teachers to make instructional choices in the best interest of their population.

Bennett (2010) focused on how two new teachers created an effective math discourse in their classrooms. The two classrooms covered a range of mathematics topics in middle and high school, leaving an opportunity in existing research to delve into similar areas for elementary work, where the research tends to focus on student community versus teacher practice. Bennett (2010) examined how teachers helped develop student discourse by using evaluations of teachers' speech during 'traditional' instruction and math talks. Both teachers were found to speak more often and ask fewer open-ended questions than they reported in a pre-observation survey (Bennett, 2010). Bennett (2010) emphasized the importance in honest self-reflection and the value in gathering data around a specific teacher's implementation of a strategy to better their practice.

The implementation of math talks within a classroom community depends not only on the students' ability to engage as active participants in the math talks process, but their ability to express themselves appropriately. Purpura, Napoli, Wehrspann and Gold (2017) explored the ability of early intervention to increase the mathematics vocabulary comprehension of students. While their work in the same area focused primarily on pre-kindergarten to third grade students, their point that "children must have access to a variety of mathematical language terms in order to understand mathematical content" (Purpura et al., 2017, p. 130) must be taken into consideration when designing lessons. Purpura et al. (2017) provided the mathematical task of evaluating whether one number is 'greater than' or 'less than' another number as an example - students may not be confident with this language, but they will be more familiar with the idea of 'bigger than' and 'smaller than,' so teacher should be prepared to use both in the course of their lesson with an eventual transition into the higher vocabulary. Math talks provide teachers with

time and structure in which to have these necessary conversations utilizing both levels of discourse and increasing student familiarity with new math vocabulary (Pupura et al., 2017).

Implementation can occur not only in shifting the discourse within the classroom and across participants but the layout of the classroom itself. Hung (2015) sought to find a way to structured discourse that allows all students to have access to the conversation and found that shifting classroom layout was a key piece of his strategy. Hung's strategy was developed in line with his school administration's focus on using "a set of non-academic rituals that are practiced by all teachers," including a talking circle (2015, p.258). Hung had been reticent to regularly implement the talking circle in his math instruction as he felt the talking circle was more targeted to humanities based courses; as he began to notice that the same students continually participated, skewing his ability to evaluate full class understanding, he chose to begin hosting problem discussions within a talking circle format (2015).

In talking circles, the teacher and students go through two rounds of patterned discussions, or "share-outs" (Hung, 2015, p. 258). In the first round, the teacher provides a prompt, such as a math-based query or problem, and each student provides their response in order (Hung, 2015). In the second round, students share out their responses to what their peers said in the first round or introduce new ideas building upon what came out of the first round (Hung, 2015). Hung found that more students participated in discussion as a result of this new style of discourse but "the highly mediated structure [...] decreases the spontaneity – in some instances, it virtually eliminates it – and increases repetitiveness in share-outs" (Hung 2015, p. 260). For future implementations, Hung suggests utilizing a speaker tool that allows students to share freely in the first round if the discussion merits it or using some of the round strategies within a more traditional small group setting (2015).

Math Assessments

Chapin, O'Connor and Anderson (2003) stated that assessing math talks is not simply standards-based but a process that occurs through observation and self-reflection at daily and weekly intervals. The student-focused discussion of assessment is as a formative process in which math talk framework is used to explore student response (Chapin et al., 2003). A daily assessment task undertaken in many classrooms is the exit ticket, which are “short response tasks that teachers administer to students after an activity” to help teachers adjust their teaching as needed to support student growth in the topic area (Fowler, Windschiti, & Richards, 2019, p. 19). One interesting point from Fowler, Windschiti and Richards was that exit tickets required teachers to “frame the reasons” (2019, p. 26) behind the use of the exit ticket – this connects to the work of Wagganer (2015), in which teachers provided students with the ‘why’ behind the task to elicit student engagement and honest response.

The importance of student voice in assessment methods is key to Laud’s work and, while it can relate to an exit ticket, student self-reflection can be elicited through a variety of means at different times. Laud (2011) stated, “the preassessment is also for the students so that they can self-score it and get a realistic sense of what they do and don't know” (p. 26) cannot be undervalued, especially in the statement’s use of the phrase ‘realistic sense.’ This can be used in conjunction with Rawding and Wills’ (2012) stance that a positive and diverse classroom community is key to student success. An accurate self-reflection allows students to see not only where they are but where and how they want to grow in the subject area. Laud (2011) pointed out that students must “clearly understand the unit’s targets” (p. 35) to do this reflection properly, which is, in turn, predicated on the teacher’s ability to design lessons and units toward clear learning targets.

The math standards in Common Core were developed partially from the perspective that “students should understand and be able to do” (Common Core Institute, 2015b, para. 5) the tasks asked of them within the grade-level standards. However, the Common Core Institute specifically states that students will also need to “justify, in a way that is appropriate to the student’s mathematical maturity, why a particular mathematical statement is true or where a mathematical rule comes from” (Common Core Institute, 2015b, para. 5). The research around math talks is predicated on the same belief that to become mathematically proficient, students must understand the ‘why’ behind the answer. This is exemplified in the Common Core’s own introduction to the Grade 5 mathematics standards, which uses the word ‘understanding’ for each of the three main subject areas (Common Core Institute, 2015a). The mathematical practices that underscore the standards for all grade levels include “construct viable arguments and critique the reasoning of others,” which students can learn to do through modeling and practice instructional methods such as math talks (Common Core Institute, 2015a, para. 10).

While a summative assessment is usually the tool used to assign final grades and evaluate student proficiency, formative assessment provides insight into student progress between the more formal or traditional summative assessments. Bennett (2010) explored the concept of formative assessment, which found that formative assessment remains loosely defined. Bennett (2010) stated that when designing formative assessment, teachers must keep both the assessment’s format and implementation in mind as the two pieces are inextricably connected. Bennett (2011) also cautioned against using formative assessment as a method of assessing student learning - instead, he argued that formative assessments are best used as assessments to support instructional methodology shifts. One point of interest in Bennett (2010) was his stance

that formative assessments exist within the context of one's educational system, at micro-and macro view, and are therefore limited by the bounds and rules of that system.

While Bennett (2010) focused on the bounds of the classroom and school systems, students bring their home and social systems into the school system every day. Connecting to student background and interest can increase engagement, as found by Nasir, Hand and Taylor (2008) in their work. Nasir, Hand, and Taylor (2008) tasked basketball players in middle and high school with two worksheets related to the same math concepts, but one was written within the context of basketball. The students worked more conceptually with the basketball worksheet and stayed within the confines of the usual algorithms on the plain worksheet - though errors were made in computation on both worksheets (Nasir et al., 2008). These researchers believe that the different processes on each sheet “reflect differences in students’ sense of themselves and their abilities in these settings” (Nasir et al., 2008, p. 189). That is, students are willing to take more risks in the application of mathematical inquiry when working with problems that connect to a topic or activity with which the students already have a positive relationship. (Nasir et al., 2008).

Student Confidence

Whether students are willing to take risks in class connects to student confidence in their abilities. This could be their ability to do the math work, to express themselves properly, or to demonstrate concepts to their peers and instructor. To properly assess whether a math talks implementation could be successful requires, then, the evaluation of the students who will be using this method within the classroom. Ashcraft (2002) defined math anxiety as “a feeling of tension, apprehension or fear that interferes with math performance” (p. 181). Ashcraft (2002) stated that due to “avoidance tendency,” or the instinctual move away from anxiety-causing

tasks, causes “highly math-anxious individuals [to] end up with lower math competence and achievement” (p. 182). To assess the connection, Ashcraft (2002) used a test that was split into two pieces: basic computational and higher-level elementary problems. The results indicated that the math anxiety in his adult participants did not trigger for the former but was present in the latter. Therefore, Ashcraft (2002) stated that “investigations of higher-level arithmetic and math, though, do need to take the competence-anxiety relationship into account” (p. 182). Ashcraft’s work should be taken into consideration when implementing math talks as students at a higher tier of math talk may need more teacher support for higher-level – and, therefore, more anxiety-causing – work and discussion.

The concept of test anxiety should also be considered when evaluating student performance in the context of a research project or study. Behaviorists considered test anxiety as coming from a blend of two major sources: behavioral and cognitive (Hembree, 1990). Hembree (1990) investigated the connection between test anxiety as a general source of student anxiety and mathematics anxiety specifically; that is, if a student demonstrates anxiety during a mathematics assessment, is it the mathematics performance or the concept of taking the assessment itself that is the main source of concern for the student? Hembree (1990) concluded that students who engaged in activities meant to reduce anxiety, such as cognitive behavioral therapy, had an increased score on subsequent math assessments; demonstrating a connection between anxiety and performance as the decrease in the former led to an increase in the latter. This indicates that students who consistently have anxiety around math and who are not engaged in activities inside or outside of school to reduce stress and anxiety will not see such shifts in their academic progress. However, activities that boost student morale may in turn lead to growth in performance.

Other Strategies for Math Improvement

The challenging issue of how to improve student math performance has led to a variety of intervention strategies, some of which are not in the scope of math talk or related interventions. Grouws and Cebulla (2000) partnered with the International Academy of Education to make several key recommendations for use across educational systems. One key component of their strategies is the creation of opportunities for learning: expanding class time devoted to math to more than thirty minutes per day; balancing lessons to include time to review old material, access new material, and practice through solving rather than rote repetition; and addressing equity issues in the classroom and school communities that create barriers between certain groups of students and math (Grouws & Cebulla, 2000). Grouws and Cebulla also point to the integration of calculator use as a mathematical skill can improve student performance through the student's interaction with the possibilities presented by the calculator, rather than asking students to ignore the rather ubiquitous presence of calculating instruments in modern life (2000). This use is based on the ability of the student to correctly assess how to integrate the calculator into their mathematical reasoning process. The calculator exists, then, as an additional tool for students to use in their reasoning and explanations rather than a mini-computer doing the work for the students.

Morin, Watson, Hester and Raver (2017) also saw the need to integrate tools and systems as reasoning methodologies for students. Since students do not have inherent reasoning skills for all systems of mathematics, it is integral to student development that methods of reasoning be regularly integrated and introduced in curriculum (Morin et al, 2017). Morin, et al. (2017), explore “the intervention of bar model drawing on student performance” (p. 91) with a focus on students who have demonstrated a math difficulty beyond diagnosed disabilities or other possible

factors, such as English as a Learned Language. Morin, et al., concluded that the integration of modeling caused a positive influence on student performance in fifteen word problems used for the final assessment (2017). Two key counter-points to this improvement were defined in the conclusion. First, despite learning the same strategies, students still showed a variety of strategies on their responses. Second, the writing load placed on the students by the word problems highlighted gaps in student literacy, such as a sixth-grade student reading at a first-grade level, which could not be eliminated as a co-morbid factor in the student's low performance (Morin et al., 2017). These concerns should be kept in mind when integrating modeling into instruction of any kind, including math talk communities' focus on developing student-led modeling and discussion between peers.

In contrast to development of tools that can be used in a community integration, such as modeling for a group, self-regulated learning focuses on students' ability to progress toward their own self-defined goals. Self-regulated learning (SRL) consists of three phrases: defining individual goals; tracking performance toward that goals; and regular self-reflection on the progress and goal (Callan & Cleary, 2018). Callan and Cleary used self-reports from students and student behavior assessments from teachers to create a profile of each student's SRL. By comparing these results to student work, including a regular assessment and a standardized tests, Callan and Cleary found that while there seem to be correlations between higher levels of self-regulation and better test performance, the correlation was not strong enough to definitively state that SRL is a key contributor to student performance. Instead, the study suggested that by examining student SRL, teachers and other education professionals can have a better sense of intrinsic motivations in their students and zero in on areas where students are identifying issues in their own work independently. This tailored approach to instruction requires the students to

be considered a teammate in their own education, but still sees the educational environment as grounded in teacher-led instruction.

Conclusion

The existing literature showed that there is a disconnect in the research of each piece that deserves to be more deeply explored. The nature of student conversation may be best evaluated through formative assessment due to the subjective and ever-shifting nature of participation (Chapin, O'Connor & Anderson, 2003); student confidence and progress can be evaluated through traditional grading of written work (Nasir, Hand & Taylor, 2008). While a range of other teaching and intervention strategies exist within the field of mathematics, the variety present within this range prohibits the integration of all styles within a single intervention. With the move into standards-based assessment following Common Core implementation, it is appropriate to explore how an objective measure will allow one to better understand how or if students are being supported by the implementation of a math talk learning community.

Question

In what way does the integration of math talks into daily instruction impact student scores on standards-based assessments?

Purpose

. The purpose of this study was to explore if the implementation of a math talks community using these types of instructional strategies lead to an increased ability of students to explain their reasoning in mathematics. The ability to do so was evaluated using student scores on math assessments and a review of anecdotal evidence from classroom discussions. Following daily integration of math talks into classroom routine in conjunction with the pre-determined math curriculum, students were evaluated to see if they demonstrated increased proficiency in

the standards addressed by the curriculum through (1) their written responses on weekly exit tickets; (2) their verbal responses during instruction; and (3) their written answers to the curriculum's end-of-module assessment as compared to either the previous unit's end-of-module or the current unit's mid-module assessment.

Methodology

Design

The action research began with a comprehensive review of the existing literature around math talks and standards-based assessments. The participant group were given the opportunity to opt-in to the research study and approval forms submitted to students and guardians. Student scores on previous math assessments were reviewed, with a breakdown of which standards were or were not met. The researcher integrated math talks into daily instruction at the start of a module, with each day's math talks focusing on the standard(s) addressed in that day's lesson. Throughout the module, the researcher recorded observational notes on the math talks and utilized exit tickets as a method of formative assessment. After the end-of-module assessment, the researcher intended to score the assessments using the same rubric as the pre-study assessment and compare scores in each standard.

Context

This action research study was conducted in a fifth-grade classroom at a suburban elementary school in Washington. The school has 514 students in Kindergarten through Grade 5 (Office of the Superintendent of Public Instruction, 2019a). The school is socio-economically diverse and serves students from high- and low-income neighborhoods of a small suburb. 19.3% of students are categorized as low-income (Office of the Superintendent of Public Instruction, 2019a). The majority of students are White or Hispanic and male students are a slight majority

to female students (Office of the Superintendent of Public Instruction, 2019a). These school population statistics are in line with the district as a whole. At the elementary school, 7.1% of students are engaged in ELL services (Office of the Superintendent of Public Instruction, 2019a). In contrast, only 3.2% of the students in the district qualify for ELL services (Office of the Superintendent of Public Instruction, 2019b).

Participants

The participants were selected based on the author's student teaching placement. The twenty-nine students are all fifth-grade students in an enclosed classroom. The class had fifteen male and fourteen female students. Two students had Individualized Education Plans (IEPs) for math and are pulled out for support in the resource room during a half hour of the math instructional period. These students participated in the core lesson and go to the resource room during continued instruction after recess. During the same half hour period, students who had been identified as needing additional support but did not have IEPs receive push-in support from a specialist twice a week. Three students qualified for English as a Learned Language (ELL) services.

The participants had the opportunity to choose whether or not to participate in the action research study. Guardians were contacted if the student chooses to participate for final approval. If a student or their guardian elected for the student to not participate in the action research study, there was no impact on their grade and they had the same level of instruction as the participating students. The researcher observed all students for progress toward grade-level proficiency. Student identity was not disclosed in the action research study and all related data will be kept confidential and secure. Physical papers, such as exit tickets and assessments, were and will be

kept in a locked cabinet. The researcher's electronic journal was password-protected and saved directly to the device.

Intervention

The researcher's action project intervention was based on the daily integration of short math talks lasting less than five minutes at the start of each day's math lesson. Over the course of the intervention, the teacher scaffolded the students into deeper engagement and higher leadership in the math talks. Daily journaling and regular formative assessments served as critical tools as the final summative assessment did not allow time for the teacher to adjust her intervention to meet student needs. Existing research suggested that math talks, or the creation of a classroom community that engages in meaningful, student-led mathematics discussion, leads to student agency and stronger number-sense skills (Hufferd-Ackles, Fuson & Sherin, 2004; Murata et al., 2017; Wagganer, 2015). The teacher existed as a facilitator of discourse rather than a lecturer and the teacher must engage in meaningful self-reflection to successfully fill this role (Bennett, 2010). Bennett's (2010) work was partially based on the findings of Chapin, O'Connor and Anderson (2003) that any assessment of math talks must include observational elements for the assessment to have validity. The formative assessment allowed the conversations to be shifted to meet student learning needs and interests. Nasir, Hand and Taylor's (2008) research found that math work that used student interests as a base for problems had higher scores than standard worksheets and this intervention will allow the math talks to occasionally turn toward the interests of the students involved in the project. Existing research did not address the connection between these conversations and standards-based assessments, which will be the summative tool used for the unit in which the intervention occurs.

Prior to implementing the intervention, the researcher recorded journal notes for two weeks that include: the lesson target, observations of student participation, classroom environment, and discussion styles used during math instruction (Appendix A). These topics were drawn from Chapin et al.'s (2003) suggested self-reflection topics with the addition of the daily learning target. The researcher also collected exit tickets for at least fifty percent of the math lessons taught during this period. These pieces of information, as well as the pre-test, were used as baseline data for the research project. This research needed to be timed to occur for an entire module or, for longer modules, during one half of the module to properly align with assessments.

On the first day of implementation, the researcher defined expectations and used whole group discussion to create classroom norms for math discussions (Appendix B). Chapin et al. (2003) stated that the integration of students into this norm-setting increases their engagement with math talks as a community. These norms were recorded and posted at the front of the room for the class to reference during future discussions. The teacher referred to this 'chart' during math talks to encourage the community to stay within the guidelines or revisit the norms should practice show a gap in the original list.

Waggener (2015) posited that during math talks, a classroom community moves through four levels of discussion, transitioning from teacher-led to student-generated discussion. The researcher integrated this level progression into the sequence of implementation, increasing student responsibility in the daily math talks during each week of the action research project. Chapin et al.'s (2003) first step in implementation, in which the teacher focused not on wholesale change in the classroom environment but instead utilized re-voicing and adjustments in wait

times for student response, was a natural partner to Wagganer's (2015) Level 0, in which the teacher leads and models the majority of discussion.

During the weeks of research, the researcher used the daily journaling to appropriately transition students from teacher-led to shared to student-led discussion during the math talks period (Chapin et al., 2003). Each day's math talks occurred at the start of the lesson and served as an opportunity to review the work of the prior lesson, reinforce concepts, or preview that day's learning target. The exit tickets from the prior day's lesson served as a key resource as the student responses will indicate which of these three options will most benefit students as they move through the module. The discussion strategies that underpin math talks continued to be used throughout the math lesson itself, with a focus on re-voicing, collaborative discussion, and engagement through multiple discussion styles. Chapin et al. (2003) suggested utilizing partner work and small-group work to assess student proficiency with math talk norms and expectations; the researcher should begin to integrate these discussion styles in Week 2 onward as students become increasingly familiar with the process. The timing of these shifts was to be informed by student progress within math talks and the length of the module. A shorter module may not allow time to reach the highest level of student-led math talks but efforts should be made to progress through Wagganer's levels.

Math instruction occurred daily. A one-hour block was dedicated to that day's lesson. Four days a week, after the subsequent break for recess, students had another half-hour of math instruction that included time to work in small groups and complete the daily problem set. Twice a week, the small group time included a breakout session for six students to work with the school's math interventionist. These six students could change each session and were chosen based on recent performances on written work, responses during class discussion, and any

absences that interrupted regular learning. The other small groups were changed regularly to balance student abilities across groups. Due to early dismissal on Fridays, there was no small group work on Fridays, though time was reserved to ensure exit tickets could still be completed.

During whole group discussion, all students had a whiteboard and marker on which to record responses to questions. The classroom expectation was that all students would use these to record their responses for teacher review. Depending on the question type, students may be asked to volunteer their answer or the teacher may select students at random using popsicle sticks to share their work. The whiteboards allowed the teacher to easily perform formative assessments despite the large class size.

The researcher explained to students that these are skills that they are already using sometimes in math, but that the goal is to think about using the sentence stems to share their thoughts during math class in whole group and small group discussion. Since the anchor chart had five major areas, the first focus was “Explain.” The researcher used sentence strips to display the three main sentence stems for this concept above the Smartboard used during math instruction; this ensured students had easy access to the stems throughout instruction. During Lesson 14, the teacher rephrased student responses to include the sentence stems. For example, Student 7 provided the answer directly without explanation. The researcher rephrased as “I think the answer is” and asked the student to provide the “because” that would follow. Student 2 already used phrasing similar to “I used the strategy...” and their answers were prompted to be rephrased to use that wording specifically, which they successfully did independently in the next day’s discussion.

At the end of the module, the researcher was to assign the end-of-module assessment to each student. If a student is absent, that student would have been given the assessment during

their next day at school. Students would have had one lesson to complete the assessment, which will be graded using the district-created rubrics. The two rubrics – one each for the pre- and post-test – are included as Appendices D and E, respectively. The rubric addressed each standard addressed within the assessment and the standard-specific and overall scores were to be compared to the pre-module assessment for the quantitative data collection for this research project. The teacher observations were used as a qualitative source of data in the final review.

The intervention was projected to occur over a seven-week period. Each week was planned in such a way to include at least one lesson segment or unit within the larger module with the expectation of each day of instruction covering at least one lesson. The school is set in mountain foothills and snow delays or cancellations were likely to occur during this time period. As a result, there was an anticipation that dates may shift during implementation. However, due to shifts in the curriculum plan for the year, instruction in this module did not begin until after winter weather passed for the year.

The intervention period for this action research project covered Module 4 of the Eureka Math program (Great Minds, 2015). To thoroughly assess the possible effects of math talks on student performance, the first half of the module was to be instructed normally. Following the mid-module assessment, the researcher planned to introduce math talks immediately and then focus on key skills needed in each week of subsequent instruction, following the tiered models implemented by multiple prior researchers. The original planned timeline follows:

Week 1: Regular instructional methods used to instruct Lessons 1 through 5

Week 2: Instruction of Lessons 6 through 10

Week 3: Instruction of Lessons 11 and 12; mid-module assessment

Week 4: Review assessment results with class; implement intervention; instruct Lessons 13 through 16

Week 5: Lessons 17 – 21

Week 6: Lessons 22 – 27

Week 7: Lessons 28 – 33; end-of-module assessment.

During Week 4 of implementation, the state governor instructed districts in three counties, including the county containing this school, to close to “minimize COVID-19 exposure in Washington counties hit hardest by the virus” (Inslee, 2020a). In following weeks, this closure was extended to cover the entirety of the remaining school year (Inslee, 2020b). As a result, the researcher was unable to complete the full implementation of the action research project. The results discussion that follows includes the results of the mid-module assessment, initial observations and exit ticket scores from Weeks 1 through 4, and reflections and hypothesis of what may have occurred should the research have been able to continue through the remaining weeks of planned intervention.

Data Gathering Instruments

Multiple data sources were utilized in the process of this action research project to ensure project credibility. First, observations of student participation in math talks were noted in a daily journal (Appendix A). Due to the large class size, when a majority of students chose to participate, students from multiple tiers of current proficiency were selected for observation to create an appropriate sample group. Next, students completed exit tickets throughout the module as method of formative assessment and integration of student voice. Finally, students took a module assessment, which was be scored using the district-designed standards-based rubric. This gave insight into student proficiency in each assessed standard as well as overall progress. The pre-study assessment was scored using the same rubric, allowing validity in comparison.

An electronic journal (Appendix A) was kept for the duration of the action research project. The journal's data was stored directly onto the computer and the file and device will both be password-protected. The journal included: how many students were present for math that day; the minutes devoted to math talks; the subject of the lesson; observations of student participation in math talks; observations of student participation across the school day; and data from that lesson's exit tickets. The outline for the daily entry can be found in Appendix A.

Assessment #1: Pre- and post-test data. The pre- and post-test data assess student performance in several key Common Core math standards for this grade level. These students are all working out of the Eureka Math Grade 5 curriculum (Great Minds, 2015), which is broken into modules centered around specific standards. This action research will cover one module of the curriculum as dictated by the timing of the IRB and participant enrollment sections of the action research project. The math program is built around Common Core Standards with each assessment measuring student proficiency in multiple Grade 5 standards. The assessments are graded using the rubrics from the curriculum and the district; these rubrics are on a 1 – 4 scale for each question presented on the assessment. The rubrics clearly define the standards addressed within each question to allow appropriately direct comparisons.

Assessment #2: Exit tickets. The Eureka Math program (Great Minds, 2015) includes exit tickets for each lesson. By ensuring the exit tickets are completed regularly, there will be daily insight into student progression toward proficiency and adjust instruction as needed. The exit tickets are solely based around student ability to work within that day's lesson and additional exit or entrance tickets may be designed to include a student reflection on their own progress.

Baseline data will be an integral component of completing a rigorous and objective action research project. The baseline data used will be student scores on previous math assessments

and an anecdotal review of participation rates and style in a period prior to the implementation of math talks. The prior assessments will show the current progress of each student toward grade-level proficiency and provide a point of reference for post-test data. The anecdotal review and notes will allow me to have a running record of student participation and whether the conversations and participation rates recorded during math talks are or are not in line with overall participation trends in the classroom.

As a qualitative study, Hendricks (2013) suggested that the validity of this project can be defined in three ways:

Validity can refer to the degree to which results are true for the participants (internal validity), the degree to which the results can be generalized beyond the participants in the study (external validity), or the degree to which a test or assessment measures what it is supposed to measure (test validity) (p. 124).

The components of this action research project engage each of three types of validity. The students are active participants in their work throughout the process, both the math talks and their regular mathematics curriculum, which lends the project internal validity (Hendricks, 2013). As this occurs in a large class of a diverse cross-section of learners, the results can be extended to a larger population, lending external validity (Hendricks, 2013). Test validity comes from the measurement of student performance using the scores from assessments at the start and close of the study (Hendricks, 2013).

Results

All 29 students in the researcher's student teaching placement were offered the opportunity to volunteer to participate in this action research study. Twenty-two of the 29 students volunteered to be included in this project. Of those students, nine were selected for

inclusion based on their academic background and aptitude. None of the students in this class who qualify for IEP and/or ELL support volunteered and, as a result, these populations are not included in this report. The nine students all have varying assessed grade level equivalencies on their STAR testing, historical participation in class discussion in whole and small group settings, and scores on assessed math work. The nine students represent students who show grade level aptitude from 3.6 to >8 on their testing, as seen in Table 1.

Table 1: Student Grade Level Equivalent

Student	Grade Level Equivalent
Student 1	5.7
Student 2	8
Student 3	3.6
Student 4	7.7
Student 5	5.8
Student 6	5.8
Student 7	4.8
Student 8	3.6
Student 9	5.8

Table 1 shows that two students, Student 2 and 4, are testing high above grade level on this test. Students 3 and 8 are below by more than one grade level. The remaining students are within the grade-level band range. This range allows the researcher to take student proficiency entering the year into account when evaluating student performance.

Classroom Discussions

The research results for classroom discussion are the researcher's daily reflections on the quality of work demonstrated on the whiteboards, student participation during whiteboard and verbal response opportunities, student choices to volunteer responses, and level of understanding demonstrated by students during discussion. The nine student volunteers who participated in the research study represent an array of student participation rates. Of the nine students, eight

regularly wrote responses on their whiteboard, though two of those eight would often need to be prompted to provide the full response or were slow to begin work. Student 8 often chose to use the whiteboard for unrelated purposes, such as drawing or writing, and had to be redirected frequently. For verbal participation, Students 1, 2, 4 and 6 regularly contributed to discussion. Student 9, would participate only in small groups, indicating that they were not comfortable sharing in larger groups. Student 3 would participate only if they knew or were told that their whiteboard answer was correct first. The confidence boost of this would push them into participating.

Student 7 participated in small group but tended to be distracted in the whole group environment, leading to a decreased participation rate. This was true with multiple seating configurations. The remaining two students, Students 5 and 8, were reluctant to participate; even when randomly selected, they would see if a peer could speak instead or provide a brief response. The math interventionist indicated that these behaviors held even when these two students were placed in the small group. These proportions are in line with the observed participation of the larger class of students, indicating they can be used as a metric for this study.

The researcher collected journal notes for each lesson instructed. Lesson 1, for which exit tickets were not completed, focused on 5.MD.2 and challenged most students. 5.MD.2 is a measurement and data standard that state students can “make a line plot to display a data set of measurements in fractions of a unit” and “use operations on fraction for this grade to solve information presented in line plots” (Common Core Institute, 2015c). The lesson introduction student asked students to define the type of graph before them as a line plot and no students were able to define this correctly. To help build understanding and connect to their knowledge, the class collaboratively created line plots that showed how many students were born in each

calendar month and how many siblings each student had. Student 2, who is a high-achiever in mathematics, consistently participated but struggled to define the reasons for using a line plot and took several attempts to correctly read the finished line plots. Students 1 and 4 demonstrated understanding of the purpose and reading of the line plots and were instrumental in continuing the limited student discussions that were able to occur. However, during the instruction of this standard, the majority students volunteered questions rather than answers and most answers were through popsicle stick responses or teacher-led instruction.

Question 5 on the mid-module assessment addressed line plots and asked students to extend their knowledge beyond what was included in the original lesson by integrating skills used in subsequent lessons of the module. In this question, students had to interpret the line plot, which was included in the line plot lesson, but they had to write an expression to solve for the total volume reflected on the line plot, which connects to two additional common core standards, 5.NF.4a and 5.NF.6. Based on the assessment rubric, if a student could not write a multiplication expression or find the total volume, they received a score of one. If they could only do one of the two, they received a two. If they could both but made a calculation error, they received a three. If they did both correctly with no errors, they received a four.

This was the only test question in which no students received a four. Only Student 3, the most vocal student in discussion, and Student 6 scored a three. One student, Student 3, did not attempt the question and received a zero as a result. She did not participate in the discussions of this standard other than to contribute her information to the actual plotting. One surprising result was that Student 1, who did speak and show understanding, scored a one. Based on the student's other low score on Question 6, which addressed the same concepts of writing expressions based on information, it appeared that their low scores are based on the ability to write expressions

rather than their ability to perform arithmetic. The average score on this question was a 1.56 out of four, which tied with Question 6 for the lowest scoring question on the assessment. The next lowest was a 2.22 out of four, a gap of 0.67 points.

Exit Ticket and Assessment Scores

The mid-module assessment covered seven standards and the lessons in this section of the module addressed each standard at least once. The exit tickets selected for inclusion in these results include six of the seven standards. Students did not complete an exit ticket for 5.MD.2, which focuses on creating and interpreting line plots, due to time constraints on the day of instruction. However, there are journal notes available for this lesson that will be discussed. As discussed in the timeline, the results include only the work through the mid-module assessment due to the closure of the district during the COVID-19 pandemic. As a result, a discussion of anticipated results will be based on the data collected prior to the closure.

Exit tickets were graded on a scale of 0 to 4, with 0 indicating a student handed in work that had no accurate answers or work toward an answer. A blank entry indicates that the student was absent that day and did not have an opportunity to complete that exit tickets. Exit tickets were not made up when the student returned to class as the exit ticket process is based on the student being present for the lesson. Each question on the mid-module assessment was graded on a 0 to 4 rubric, with a 0 only used to indicate cases where the student chose not to answer the question. On both the exit ticket and mid-module assessment, a final grade was calculated but the score was reported not as a letter grade or percentage but as At Risk (AR), Progressing Toward (PT) or On Track (OT) based on district scoring guidelines.

Figure 1: Comparison of Student Grades on Exit Tickets to Mid-Module Assessment

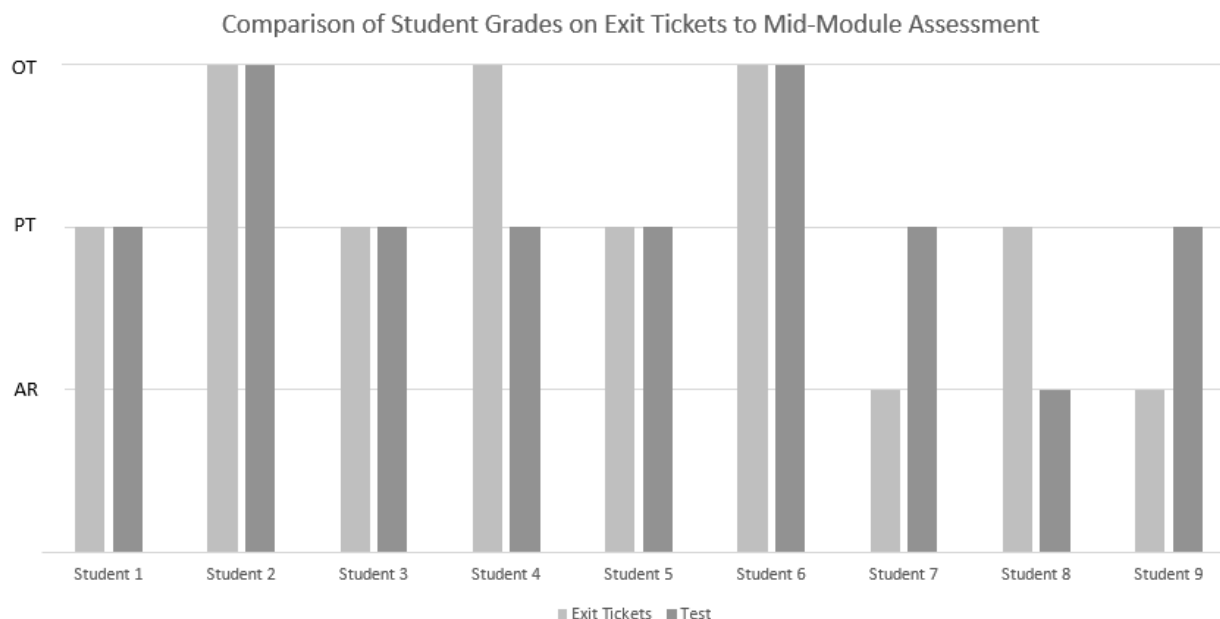


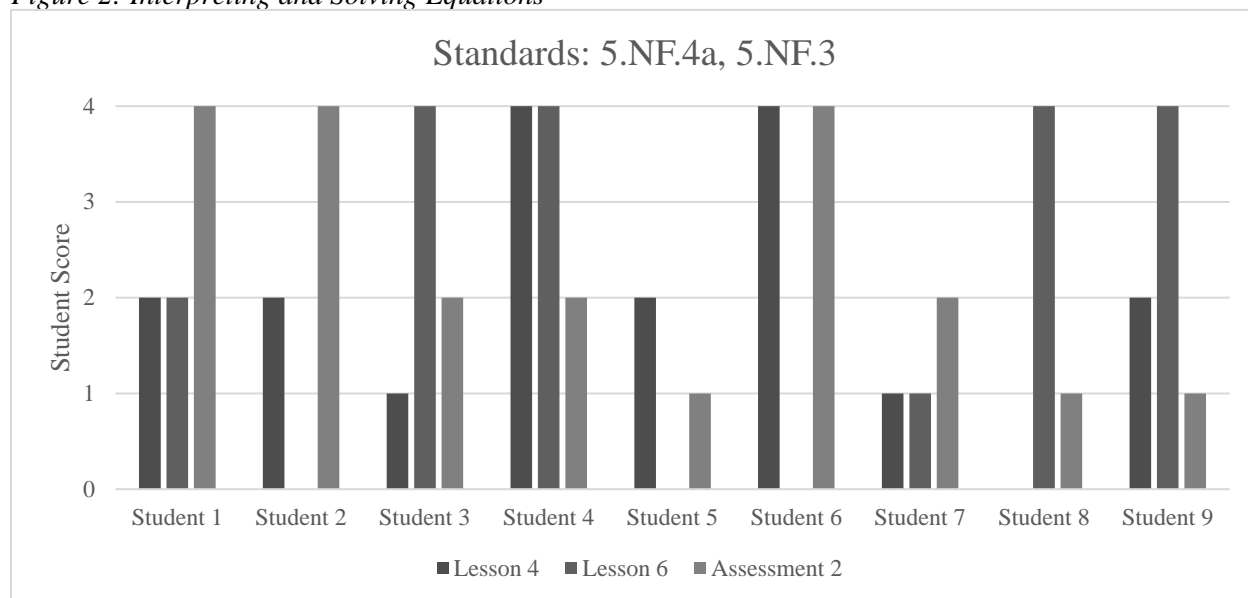
Figure 1 shows the students' overall scores on the exit tickets and the mid-module assessments. The students' cumulative work on exit tickets was reviewed to assign their grade. Based on the exit tickets, three students were OT, four students were PT, and two were AR. On the mid-module assessment, one of the OT students dropped to a PT, one PT student dropped to an AR, and two AR students rose to a PT. The other five students assessed at the same level on both their exit ticket review and mid-module assessments.

Figure 1 captures only overall student scores. As discussed, the exit tickets are for each lesson, which will focus on only one or two standards each. In contrast, the mid-module assessment included seven standards. To review true student progress, the assessment was broken into each standard or standards addressed and aligned with the exit ticket(s) that covered the same standard(s). Some problems did address multiple standards, but these tended to come in the same groupings in the exit tickets as well.

An early section of lessons focused on interpreting and solving equations and word problems with an emphasis on seeing fractions as division statements, connected to Standards

5.NF.4a and 5.NF.3, both of which are in the numbers and fractions domain. Figure 2 shows student progress between the exit tickets and assessment question centered on these skills.

Figure 2: *Interpreting and Solving Equations*



Four students showed clear growth in this standard from the two exit tickets to the assessment question. Students 1 and 2 demonstrated the most growth, from a consistent 2 on the exit tickets to a full score of 4 on the assessment. Student 7 scored a 2 on the assessment question but grew one point from their previous exit tickets. Student 6 maintained their full score across the exit ticket they completed for Lesson 4 and the assessment question. Students 3 and 9 had inconsistent scores on their exit tickets, with Student 9's work on the assessment showing a significant drop from previous scores. The inconsistency in Student 3's scores will continue through the other questions as well and points to the student's continuing struggle with math concepts.

Two questions on the mid-module asked students to interpret and solve problems with fractions and unit conversions, covering Common Core Standards 5.NF.4a, and 5.MD.1. Lessons 7 and 8 covered 5.NF.4a and Lesson 9 addressed 5.MD.1. Students had worked with unit conversions in previous modules and were familiar with the concept of unit conversions;

Lesson 9 taught how to combine that knowledge with their use of fractions. Figure 3 shows student performance on the exit tickets and on the assessment questions related to these standards.

Figure 3: Interpreting and Solving Problems with Unit Conversion (5.NF.4a & 5.MD.1)

Student	Lesson 7	Lesson 8	Lesson 9	Assessment 1	Assessment 6
Student 1	2	3	3	3	0
Student 2	4	4	4	4	4
Student 3	3	4	3	3	1
Student 4	4	4	4	3	3
Student 5	3	Absent	3	3	0
Student 6	Absent	4	4	3	4
Student 7	1	4	2	3	0
Student 8	2	Absent	Absent	1	2
Student 9	1	Absent	0	2	0

Two assessment questions, 1 and 6, connected to these skills. Students 1, 5, 7 and 9 did not receive any points for Question 6. The rubric for Question 6 required that students provide correct responses for at least two of the five components within the question to receive a one. Students who (a) did not answer any components, (b) worked on the question but could provide no correct components, or (c) only provided one correct response were all assigned a 0 on this question based on that rubric requirement. In the case of the students included in this study, all four zeroes came as a result of not being able to obtain more than 1 correct component in their response. All four students did attempt the problem, which reflects in their other work. For example, Student 5 received threes on the two exit tickets she was present for and assessment question 1. The final question required Student 5 to write a duplication expression and the student wrote in the margin next to this question “I dont [sic] get how to solve by multiplying.” This student’s other method showed understanding of fractional division but did not lead to the correct answer. The final piece allowed the student to use this method to solve for one of the six pieces, which is the one component the student correctly solved.

The final set of standards evaluated focused on how to write and interpret numerical expressions, referencing standards 5.OA.1 and 5.OA.2, both of which are in the Operations and Algebraic Thinking domain, specifically the skill of writing and interpreting expressions. Only one lesson focused specifically on the ability to translate words into numerical expressions, though the concept of this translation was discussed in other lessons tangentially. While not explicitly defined in the curriculum, multiple lessons included teacher-led discussion of the order of operations principles, which connect to this domain and are necessary to correctly write expressions. Figure 4 shows the student scores on the exit ticket for the related lesson, Lesson 10, as well as scores on to the two assessment questions in this domain, Assessment 3 and 4.

Figure 4: Writing and Interpreting Numerical Expressions

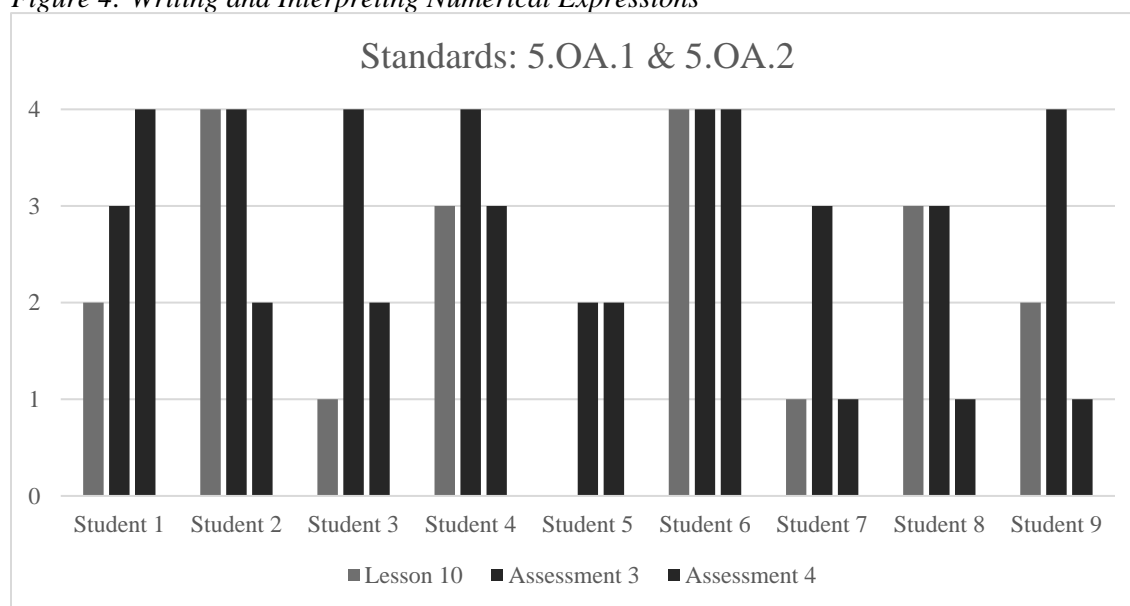


Figure 4 shows the variability in student scores in this area. Student 5 was absent on the instructional day related to these but scored a 2 on both questions, which may indicate the efficacy of the related discussions that occurred during other lessons. While the two standards are used in Assessment 3 and 4, the two questions address them differently, and this difference may be the cause of the gaps in scores between the two questions for most of the students. Assessment 3 asked students to evaluate five expressions and indicate which were equal and

explain why the rest were not equal with words, pictures or numbers. Assessment 4 provided the students a written expression with vocabulary words instead of arithmetic symbols and asked the students to rewrite them as numerical expressions using only symbols and numbers. The burden of extension is solely in Assessment 4 and broke from the pattern of solving used in the assessment up to that point, which may be why Students 2, 3, 4, 7, 8 and 9 all experienced a decrease in their scores – some of which were significant, such as Student 9 going from a 4 on Assessment 3 to a 1 on Assessment 4. Student 6's strength in vocabulary, demonstrated in their speaking abilities and aptitude for Language Arts, may have supported this student in avoiding a drop and maintaining a 4 on both questions.

Math Talks in the Classroom

The concept of math talks was introduced to students following an in-class review of the mid-module assessment. During this review, only two of the nine students involved in the study participated in discussions of correct answers and the mathematical reasoning behind each answer. These were also the only two students to receive a grade of OT, indicating that the confidence from a high score and that their work was therefore accurate were the leading factors in their choice to participate. Due to the range of scores, students were selected to speak based on volunteered hands only; no random selection of responses occurred.

Lesson 13 did not introduce any new standards to the student and built on understanding from the first half of the module, which centered around 5.NF.4a. This standard was reviewed multiple times on the mid-module assessment and students showed most success when asked to do the arithmetic without the context of a story problem; Lesson 13 centered around the same basic arithmetic problems but integrated story problems, allowing student to build the skills that showed opportunities for growth. Lesson 13 utilized fractional models familiar to students from

a previous module. The availability of the visual model as an option increased the participation of Students 8 and 9, who tend to be stronger with the use of visual models than arithmetic methods. To continue this participation, the researcher exemplified the visual model as an option to demonstrate reasoning in a math talks process.

The math talks process was introduced to students between Lesson 13 and 14. Since the mid-module assessment challenged most students, the researcher chose to take Lesson 13 as an opportunity to build confidence without integrating the new conversational concept at the same time. Anchor charts were created to guide students through the introduction of the concepts behind math talks and the sentence strips posted at the front of the room for students to reference (Appendix B).

Lesson 15 was the final lesson instructed prior to the school closure. Multiple students were absent for this lesson due to parent concerns regarding health and wellness. During this lesson, students had time in their small groups, and the researcher focused on using the sentence stems with the small group specifically. This allowed the researcher to hear the use of the stems from more students as Students 7 and 8 participated in this small group setting and did not volunteer in the whole group for this or the previous lesson. Students 7 and 8 preferred to use the shortest stem, “I think,” but did verbally participate using this starter instead of waiting to be selected to share or leaving their answers as solely written responses.

Discussion

Conclusions

The data collected during the pre-intervention period and the observations at the start of the intervention period indicate a possible connection between student vocal participation and written work on exit tickets and resulting scores in the same standards. It is not possible to

firmly state whether this connection is supported as the intervention period was not completed due to school closures implemented to slow the spread of COVID-19 amongst the population. However, student behavior records from the researcher's journaling does show that student focus and effort during class has a direct correlation to performance on the daily exit tickets. In addition, the researcher found that students who continued to participate and bring in ideas from other lessons to each day's discussion showed sustained performance or growth in performance within the standards addressed.

Figure 1, which compared student grades on exit tickets to the mid-module assessment, demonstrated a connection between the two pieces of data and validated that the exit tickets are an effective tool for evaluating student progress toward goals. Students 4 and 8 were the only students who did not show growth or maintenance of their exit ticket grade history on the mid-module assessment. Student 4 dropped from an OT to a PT, but their actual graded score on the test was 71%, a passing score indicating that they did comprehend the majority of the concepts. In contrast, Student 8 dropped to an AR score, putting them at risk of not achieving grade level expectations by the end of the year. Student 8 did not consistently complete work or participate in class. Following the mid-module assessment, Student 8 began to ask questions in the safety of a small group and began to accept teacher support during regular check-in's during whole-group instruction. Student 8's shift indicates that continued instruction and implementation of conversational strategies to support this growth in verbal response may support them to grow back to a PT grade by the end of the module. Student 8 is a prime example of Ashcraft's theory that more challenging math triggers higher levels of anxiety (2002); their only score of 3 or higher on the assessment was on the question that allowed them to focus on the facts of arithmetic and did not require the combination of multiple skills.

While it would be imprudent to draw conclusions from a study that was not completed, the results gathered in the initial phase leading through the pre-test do show a connection between the level of understanding on the exit tickets addressing a standard and performance on assessment questions addressing the same standards. As a result, one may be able to do continued work to confirm this possible connection and ensure that any other performance reviews in a similar project ensure standards-based ties between pieces of data for analysis. One challenge encountered by this researcher was the blend of multiple standards into assessment questions versus the single standard focus of each lesson in this curriculum. In these cases, the lessons that represented the standard(s) of each assessment question were grouped together. This researcher believes that the strength of the conclusion is based on that pairing strategy.

Implications

Based on researcher observations and the literature review, it appears that the implementation of a math talks community within this classroom would have led to increased student proficiency in the addressed standards. There are several indicators of this within the data and the observations of student participation during the limited period of intervention. Laud (2011) stated that the exit ticket is not only a method for teachers to gauge student progress, but a tool in which students perform a daily self-reflection on their own progress. The connections in scoring discussed previously support Laud's argument and underscore the importance of this daily work. This connects as well with Bennett's (2010) statement that exit tickets as formative assessment are useful but only in the school environment as students who did not attend school on a given day were not given this opportunity for self-reflection and the exit tickets are not utilized for any larger purpose.

Due to the closure, this group did not progress past Level 1 in Hufferd-Ackles et al's (2004) structure of math talk. In fact, the students' general hesitation to speak indicates the need for teachers to guide students to each new tier, which correlates with the existing research in this area (Hufferd-Ackles et al., 2004; Wagganer, 2015). This is not to say that students are not capable of making this shifts independently, just that support is needed as they transition to new styles of classroom interaction and discussion. Hancewicz (2005) suggested that students need to have an element of struggle to achieve higher levels of understanding, but this struggle caused the students in this group to hesitate to a point that impeded discussions, so perhaps grade level or age should be taken into account when exposing students to this challenge. Creating a positive support structure to increase student engagement is key to the work of Rawding and Willis (2012) and the researcher noticed in daily journaling that there was a connection between positive student attitudes and willingness to speak and work.

Limitations

COVID-19's sudden spread and the resulting school closure posed the greatest limiting factor to this action research project. Due to the closing of schools and the shift to remote learning that did not include direct instruction of new material during the intervention period, the research project had to end prematurely, just a few days into the intervention period. The conclusions and implications drawn above have been considered in the context of this limiting factor.

Had the researcher been able to complete the project, there would remain the limiting factor of population representation in the volunteer sample used. Since no IEP or ELL students volunteered to participate in this study, no conclusions can be drawn about the impact of math talks or math talk communities on these populations. Additionally, approximately half of the

student volunteers are the students who regularly volunteer information in class while only one of the quietest students volunteered to join, skewing the data toward students who may already be inclined through personality or socialization to volunteer for class activities.

Recommendations

If this study were to be replicated without interruptions or re-created in another environment, one recommendation would be to implement the project in a more diverse classroom or school community. In this instance, diversity referred not only to the racial, ethnic, gender, and socio-economic composition of the school, but the diversity represented in terms of ELL and IEP enrollment and representation in classrooms. This would allow the study results to have higher validity for a larger population moving forward and increase the possibility that similar interventions would or would not be successful for multiple student populations, depending on the results of the study. There are also opportunities to better address the role that student anxiety plays in mathematics class, such as evaluating students attitudes around math using the structures employed by Ashcroft (2002) or by engaging in anxiety reduction techniques to boost academic performance (Hembree, 199) to see if the anxiety is a limiting factor to the ability of students to participate in math work and math talks at their highest possible level.

The timing of the study in the school year is another opportunity to make changes in future implementation. This project began more than halfway through the school year; any positive impacts noted for integration into the classroom moving forward would have limited time to improve student performance. If the math talks integration could be timed to be introduced at the halfway mark of the school year, such as at the semester change or midway through the second trimester, there would be more opportunities for an effective outcome. The tiered models of previous researchers – the models on which the implementation of this study

were based – are long-term implementations and the length must be taken into consideration when planning the intervention.

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Appendix A

Daily Journal Outline

Observation Journal

Date:

Learning Target:

Classroom Environment:

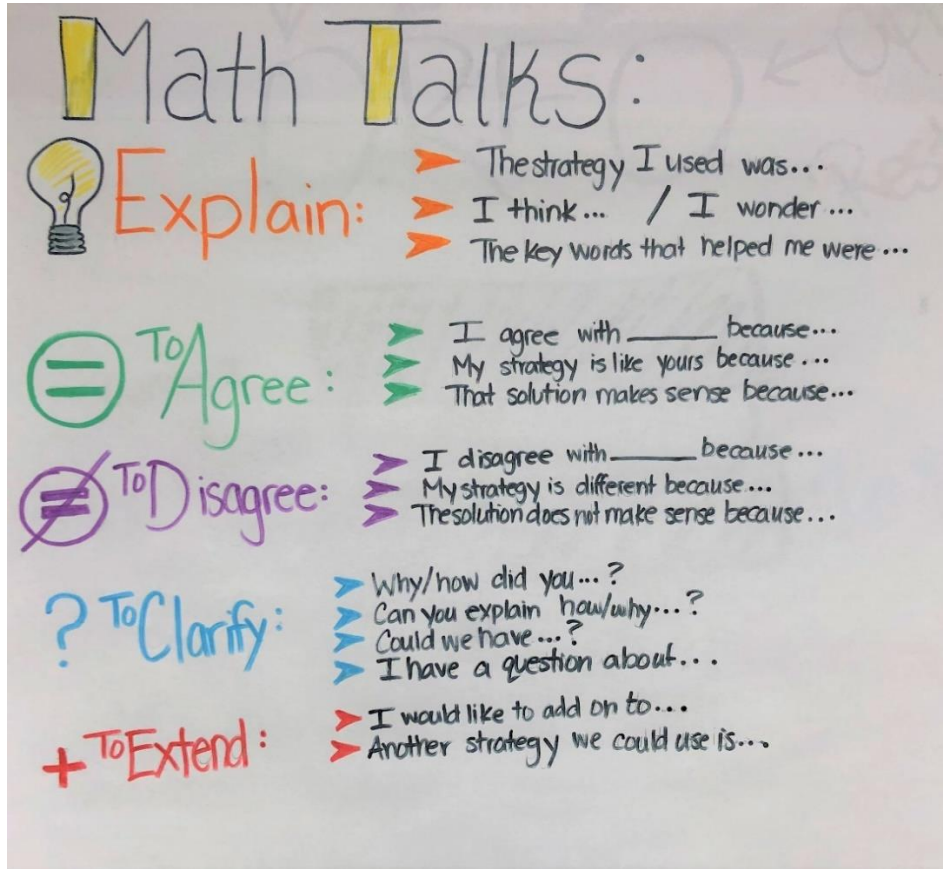
Level of Discussion:

Observations of Student Participation:

Appendix B

Anchor Charts

Math Talks Anchor Chart



Sentence Stems (Posted at Front of Classroom)

