

Going from “I can” to “I can and here’s how!”: Writing about math in a 3rd and 4th grade mathematics classroom

Emily Garner and Jennifer Duncan

New Albany Plain Local School District and Hilliard City School District

Keywords

Mathematics, comprehension, written communication, verbal communication, journals, reasoning,

Abstract

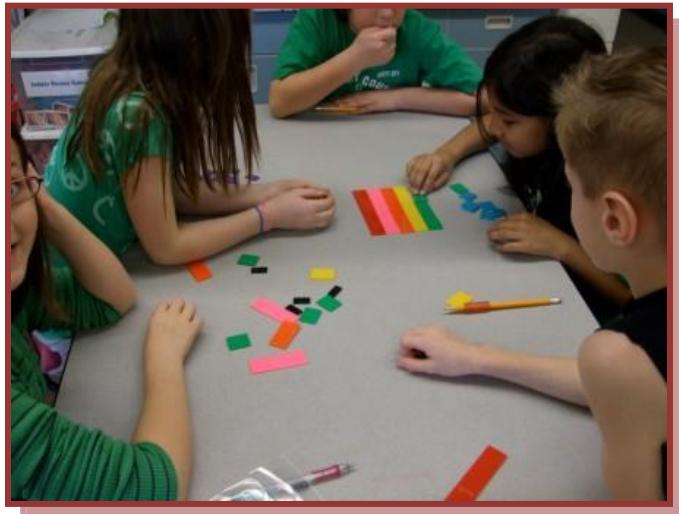
We are teachers in two different elementary grades, in two different districts. After many discussions we discovered that both of us had experienced the same results with students’ math performance when it came to their ability to extend their thinking, both verbally and in written form. We felt passionately that we wanted our students to succeed in math, not only in our classes, but for the future. We noticed that even when our students were successful with an overall math concept, when they were asked to express "how" they arrived at an answer, many times faces and papers were left blank. Our mission was to change that by helping students learn "how" to express their thinking and to make this a habitual part of their life-long mathematical learning. Over the five month study, we used strategies that we felt would best meet the needs of our students. We found that when focused, intense instruction was given to our students, they not only met our expectations, but exceeded them as well.

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Statement of Significance

When asking our students how they solved a math problem, an answer we heard most often was, “I don’t know.” Through many discussions, we realized that we were both struggling with a common theme in our 3rd and 4th grade classrooms, despite the fact that we teach in different grades and in separate districts. We noticed that even if a student was able to solve a math problem correctly, too often that same student could not clearly articulate what steps they had taken and why. This led us to identify a more specific challenge: our students’ difficulty communicating mathematical thinking in writing, and a corresponding low level of confidence in solving math problems. Our goal in this action research project was to find a way of changing our students’ answers from “I can” to “I can and here’s how!”



We began this project with a strong belief in the promise of focused writing assignments to improve our students’ ability and confidence in math. The process of learning math concepts seems to require students to go through a variety of stages of understanding, and a higher level of understanding involves being able to explain how one solved it verbally and in writing, using words and pictures. So, a primary reason for us seeking to develop our students’ ability to communicate mathematical ideas is our sense that requiring this of our students would force them to think more deeply about the mathematical concepts, with a resulting improvement in understanding.

In addition to our experience-driven beliefs that students would benefit from writing about their mathematical processes, we also learned that research suggests that students who journal about their mathematics learning can benefit emotionally from the experience. According to Wayward (1991), venting learning frustrations and reflecting on feelings appears to have a therapeutic effect on students’ affect and attitudes toward learning math. Therefore, reducing our students’ anxiety and increasing their confidence as mathematics learners was a second goal of our teaching intervention.

Our experiences and our evolving understandings of research on communication in math drove the purpose of our study:

To examine the extent to which explicit instruction and practice in writing in mathematics would increase our students’ understandings of mathematical processes as measured on the Ohio Achievement Assessment.

While we hoped to see the immediate benefits of writing about math on a regular basis in our classrooms, we also hoped that, ultimately, our students would be able to successfully answer extended response questions on the state-mandated Ohio Achievement Assessment. Students in both of our classes have struggled with this component of the Ohio Achievement Assessment, which underscored for us the added importance of teaching our students how to communicate about math. By utilizing a variety of methods to teach students how to explain their thinking about math, we hypothesized that they would better understand mathematical concepts, improve their test scores, increase their confidence, and relieve their anxieties as a result.

Literature Review

Using language to communicate about math has many benefits within the classroom. Several authors note the importance of providing students the opportunity to think about their reasoning, to clarify, make sense of math, and share their ideas with others (Burns, 2004; McIntosh, 1997; National Council of Teachers of Mathematics, 2006; Pugalee, 2001).

Why are students expected to explain their thinking in writing?

According to the National Council of Teachers of Math (NCTM), it is no longer believed that teaching mathematical concepts and skills is all that is necessary to successfully learn math. The NCTM's communication standard highlights the importance of young children communicating their mathematical thinking coherently to peers and teachers (Cooke & Buchholz, 2005). With the focus of much classroom instruction turning to state mandated testing, it is relevant that students are able to extend their responses using not only figures and numbers, but words as well. "Writing in mathematics provides students an opportunity to develop their thinking as well as their use of language in mathematics. It is widely accepted that writing is part of the process of constructing meaning" (McCarthy, 2000, p 46).

Provide students the opportunity to think about their reasoning, to clarify, make sense of math, and share their ideas with others.

Why is writing used to explain mathematical thinking?

The process of written communication develops students' math vocabulary, builds understanding of mathematical relationships, and helps students to reason mathematically (Kenney, 2000). Written communication is driven by the understanding of concepts learned in a format that allows for expression. Students need to be proficient in writing to successfully communicate their thinking.

The reciprocal nature of communication opens a dialogue between teacher and student which helps the teacher to have a better understanding of student knowledge , thus enabling the teacher to better plan instruction.

It is important to understand that the term “communicating about math” does not refer to written communication alone. Verbal communication can provide many of the same benefits as written communication. Verbal communication allows for informal conversations where the teacher models mathematical thinking, reviews previously learned concepts, and invites student participation (Cooke & Buchholz, 2005; Jensen, 2000). Reflecting on her study of students’ communication as they engage in math processes Perry learned the importance of talking with them about the mathematics and about themselves as “learners, thinkers, doers, and people” (2001, p. 79). Through the use of one-on-one conferences, Jensen, Whitehouse, and Coulehan (2000) found that they could support students in connecting new knowledge to prior knowledge and make connections to mathematical terminology and symbolic notation. Verbal communication allowed the students to access a language that is learned through conversation with a more knowledgeable person.

How do written responses allow for more effective formative assessment?

In addition to providing students opportunities to use language to learn mathematical processes, the reciprocal nature of communication opens a dialogue between teacher and student which helps the teacher to have a better understanding of student knowledge, thus enabling the teacher to better plan instruction (Countryman, 1993; Perry, 2001). Perry found that students often feel comfortable writing to share their thinking, explain their answer, or to solve the problem. She states that it is also important give them multiple opportunities to write about mathematics to justify their thinking, reflect upon what they have learned, or test a new idea. Countryman (1993) states in her research on using math journals in the mathematics classroom that reading students’ math journals told her more about what students grasped and did *not* understand, liked and disliked, and cared about and rejected as they studied mathematics, than she ever learned from formal or traditional math assignments.

What are the concerns?

Krajicek (2001) notes that practicing teachers may have concerns about focusing on writing in math class. These concerns include the amount of time it takes to add writing into math, not feeling qualified to teach across subjects, and being unsure of how to implement writing assignments (Krajicek, 2001). Yet the documented benefits to writing in math are numerous and have encouraged us to explore its use with our third and fourth grade students. We were interested in finding out the extent to which explicitly teaching our students to verbalize their mathematical processes (orally and in writing) would increase their mathematical understandings and impact their performance on the Ohio Achievement Assessment (OAA).

Methodology

Participants

This action research study took place within two separate classrooms. Students in Emily's 3rd grade class in New Albany Plain Local School District participated as well as Jennifer's 4th grade students in the Hilliard School District.

Emily's School

New Albany Plain Local School District (NAPLS) is a suburban school district located just outside of Columbus, Ohio. The Ohio Department of Education has awarded New Albany 2-5 Elementary School with an "Excellent" rating, beginning in 2006. Within the 3rd grade classroom being referred to in this study, there are 12 boys and 12 girls. Eight of the 24 students are Asian, 2 students are African American, and 14 students are White. Ten students in the classroom have been identified as gifted in mathematics and receive services from the Gifted Specialist employed within the district.

Jennifer's School

Hilliard City School District is a suburban school district located in northwest Franklin County, providing education for over 15,500 students for grades K-12. Norwich Elementary School, one of 14 elementary schools, was opened in 1993 as the district's first and only multiage alternative school. "Multiage means placing together students of different ages in the same classroom so their learning can be enriched and accelerated" (District Website).

Within Jennifer's fourth grade classroom, there are a combination of 13 girls and 12 boys from both Jennifer's homeroom and the classroom of fourth graders next door to her classroom. This is the only time of the day that students are clustered together per traditional grade level. Amongst those students there are 3 students that are Asian American and 4 students that have Individualized Educational Plans. Three students are identified as gifted in mathematics and receive services from the Gifted Specialist in the district.

Pretest and Posttest

In November, at the beginning of the data collection period, the students in both classes were given extended response questions selected from the Ohio Achievement Assessments (OAA) from previous years. Third graders were given five questions and fourth graders were given seven questions. The responses were scored using a four point rubric based on the OAA rubric (see Figure 1). The students were given the same questions at the end of the data collection period, the following February.

Points	Student Response
4	The response provides a correct solution and adequate support to show and explain the concept while using mathematical vocabulary.
3	The response may contain a slight error in one of the following areas: solution, support, or use of mathematical vocabulary.
2	The response is incomplete and/or contains minor errors.
1	The response does not show understanding due to errors in reasoning and solution.
0	Student did not attempt problem.

Figure 1 Extended Response Rubric

Instructional Procedures

We each used a similar approach to teaching our students how to communicate about math in both written and verbal form. In Jennifer's class, the focus was more vocabulary driven because the content in 4th grade is deeper and the vocabulary is richer. While vocabulary instruction was important in Emily's classroom as well, the approach was more subtle and the focus stayed more on the process of explaining mathematical thinking. We each took our students' developmental stages into account when planning our instruction. It made more sense to us to go deeper into the vocabulary with the older students.

Emily's Story

In my 3rd grade classroom, I noticed that my students were being asked not only for their answers but to explain their thinking about math on formative, summative, and state-mandated tests through the year. After grading another set of math tests in which the students did not do as well on the extended response questions as I would have hoped, I reflected on what had been done to prepare the students for this type of mathematical thinking and

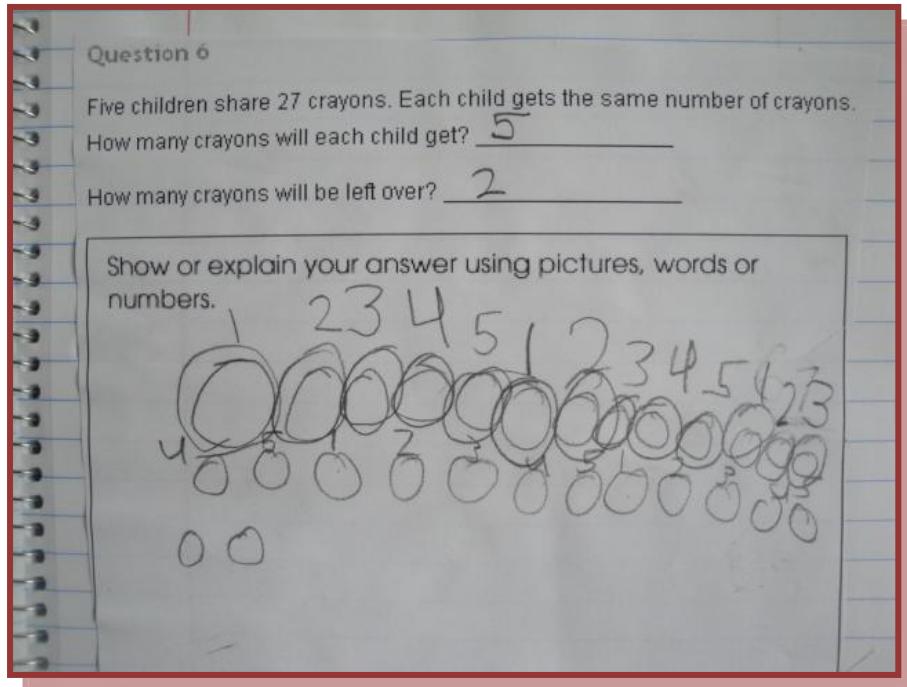


Figure 2 Example of Student Journal at beginning of data collection

writing. I noted that while the students learned mathematical concepts and skills, little or no time was spent on explicitly explaining or practicing how to think critically about math and put that thinking into words. I decided to give my students the opportunity to practice answering extended response math questions on a weekly basis. I gave each student a math journal where each week's extended response question was answered (see figure 2).

When the students began using the math journals I told them that this would be a place to keep the extended response math questions that we would be answering on a weekly basis throughout the school year. A math journal routine developed. The students first tried to answer the day's math problem independently. After the students attempted to respond to the prompt on their own, the question was reviewed together as a class. A Smartboard was used to review the math question. The question was displayed and answered using this interactive media tool. The Smartboard allowed the students to be able to view the question and answers as a whole class. The students used the Smartboard tools, such as highlighters and colored pens, to bring focus to certain parts of their answers. The students would then share their thought process about the particular question in a think aloud. The student initiated think alouds were used as an opportunity to explicitly talk about the strategies being utilized by the students. Vocabulary and specific math strategies were emphasized to make it easier for all students to explain their

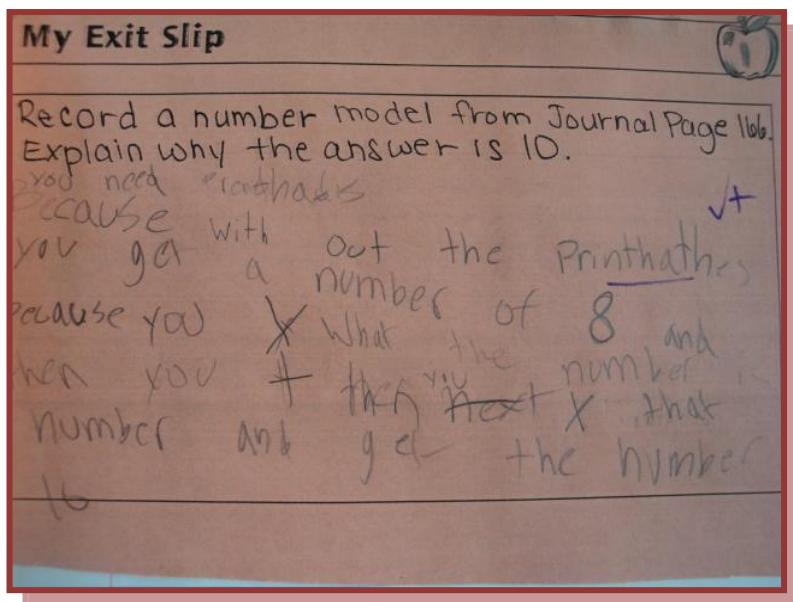


Figure 3 Student journal focused on vocabulary

thinking in writing. After the question had been answered through the class discussion, a group extended response answer was written through shared writing on the Smartboard. The students used the Smartboard to highlight any specific math vocabulary used in the answer (see figure 3). The students used additional time to edit their original answer in their math journals.

Jennifer's Story

In my 4th grade classroom, the main focus for the instructional practice was to connect content specific vocabulary to successfully answer extended response questions on the Ohio Achievement Assessment. As students begin to mature with their mathematical thinking, I noticed that my students were lacking the proper vocabulary usage in order to correctly answer

pertinent questions. A key quote from NCTM is as follows: "Through communication, ideas become objects of reflection, refinement, discussion and amendment" (p. 60). So I gave students a folder (math journal) with sample extended response questions, based on the Ohio grade 4 state standards that correlate with the Ohio Achievement Assessment. Within this folder I also included notebook paper for notes and thought processing and content specific vocabulary that would be covered over the course of the study. The first step in the instructional practice was to highlight vocabulary with which the students were familiar. After the initial highlighting, students continued to highlight new words as they were learned. They were to write a definition next to the word, along with the date we discovered the meaning to illustrate time lapse and recall of information. Along with the written definition, students were encouraged to illustrate their thinking using a labeled diagram, chart

or table, if possible, as an example of how it is used in mathematical reasoning. Randomly, the students were asked to verbally explain what the word meant during the class discussions. At various times within the instructional procedures, I would put a chart up in the front of the class with a question that they needed to respond to on post it notes (see figure 4). The students were to highlight important vocabulary on their responses and verbally explain how many points they believed the question was worth so that they knew how many parts they needed to answer. Students began to lengthen their written expressions, as this became a habit in the classroom.

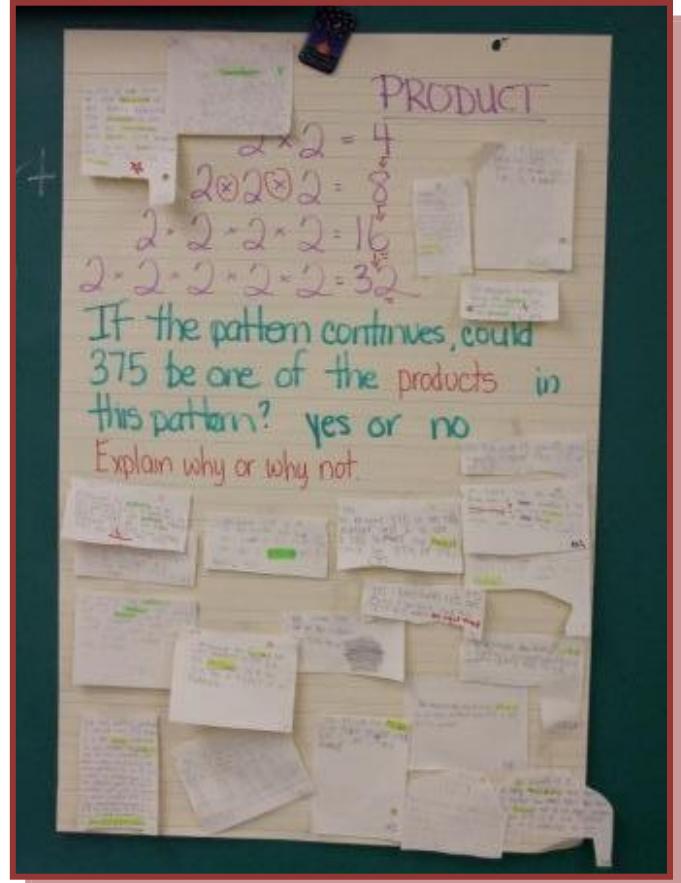
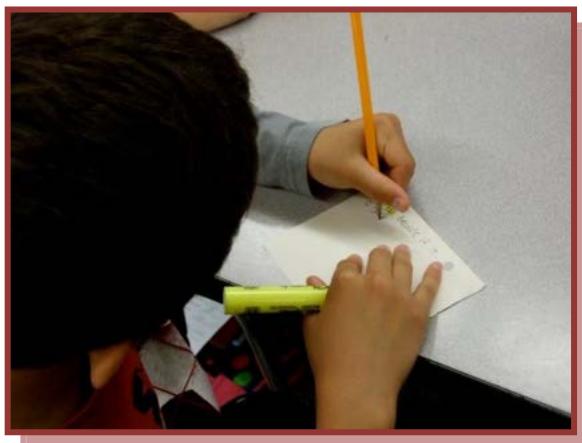


Figure 4 Class Chart



The second step was to familiarize the students with the format and construction of extended response questions. After reviewing and dissecting what to include in order to earn the full four points on the evaluation rubric, the students attempted to answer one question a session. As a group, we would analyze and share examples of what would receive four points, three points, two points and one point so that students could visualize and conceptualize what they needed to construct to receive full credit. To connect the vocabulary, the students would

highlight the vocabulary that was used in the question and what mathematical vocabulary they used in their reasoning. Then, after the highlighting process, the students would turn back to the vocabulary to attach meaning and the example from class to reinforce understanding, along with concrete examples. Students were encouraged to edit their answers based on the discussion, but with a different color to show how over time their answers changed independently.

Findings

The results of the study were determined by analyzing the pre and post rubric scores and student journals.

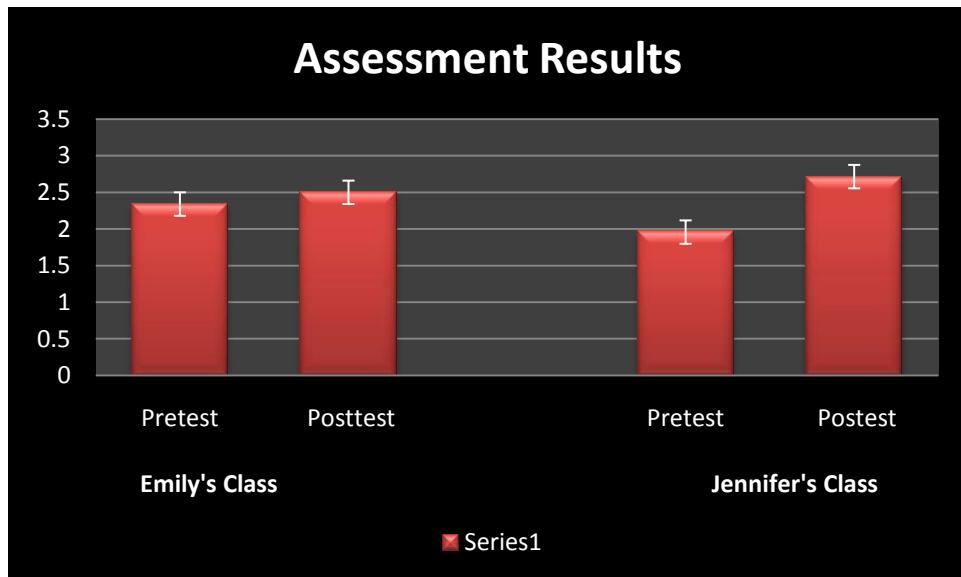


Figure 5 Comparisons of Pretest and Posttest Means

Was there a difference in pre and post instruction scores on the extended response questions?

Emily's Findings

I conducted a paired *t*-test to determine if the difference between the pre and post test scores were significant (see figure 5). In my class the mean was 2.34 (out of 4) on the pretest and 2.5 on the post test. This did not show a significant difference. Based on test scores alone, the results in my 3rd grade classroom did not show the amount of growth that I had anticipated. Yet, while the scores alone did not uncover significant changes, my field notes throughout the process reflected growth among the students.

I wondered whether the test scores were true indicators of the growth among my students. I feel that the students may not have taken the test seriously as it was done just after spring break amidst many other OAA test prep activities. Also, the students completed most of the math journal responses in a highly scaffolded and guided format. They were given a lot of processing time and were able to verbally think through their ideas before writing. Yet, the post test asked them to answer the questions completely independently and without the verbal preparation. While independent success is the ultimate goal, my class may not have been ready for this independence by the end of the data collection period. If repeating this intervention, I would try to relinquish control more gradually throughout the year to ensure independent success. I also noticed towards the end of the data collection period that students were providing longer and more detailed answers when discussing the math problems orally in class. Students were also better able to use specific math vocabulary aloud in a discussion.

Jennifer's Findings

My class mean was 1.96 on the pretest and 2.71 on the post test. This did show a significant difference and I believe that the main reason for that was repetition of vocabulary and how to apply it into written work. In my classroom, students often were given some type of manipulative to assist with visual understanding. I noticed on some of the student responses that the students would draw some of the manipulatives that were used in class. Another component that seemed to help their verbal reasoning was the fact that students worked in pairs or small groups, and they were to verbally express their thinking together, alleviating some possible anxiety. In addition, students would then connect to written understanding by taking what they verbally said and transferring it into written expression.

When looking at the results, I wondered why my 4th graders' test results showed a significant increase and Emily's 3rd graders' did not. One possibility is that the 4th graders began with a higher cognitive ability as well as having a more advanced vocabulary and better writing skills. This may have allowed them to be more successful in a short period of time. The 4th graders also began with lower pretest scores which allowed them to show more growth.

"We knew that by taking the rubber band around 4 pegs across the base and 3 pegs up for width that the area would be 12 since we are finding the inside, just like we see on the rectangle"
 (students working on formula for area)



Were there significant differences in pre and post test scores on specific questions?

Emily's Findings

I did find that one question from the pre and post test showed significant improvement (see figure 6). In this particular problem the students were required to add several different amounts together to find the answer. This particular item may have resulted in more improvement because of the concept itself as well as the related vocabulary. The students spent a great amount of time throughout the school year practicing addition and concepts using money. It was something with which they were comfortable.

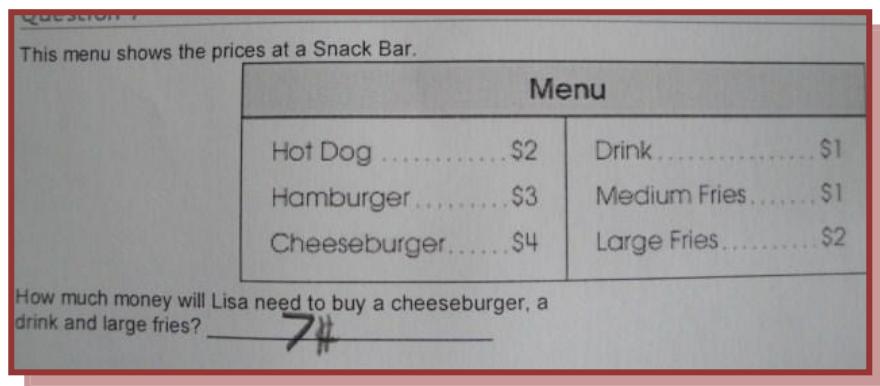


Figure 6 Posttest Question

Did specific students improve significantly?

Emily's Findings

In my class, three students showed significant improvement from the pre to the post test (see figure 7). The three students represent a range of math ability, but share similar reading levels. It may be that their improvement represents a growth in reading and writing ability and not just improved math ability.

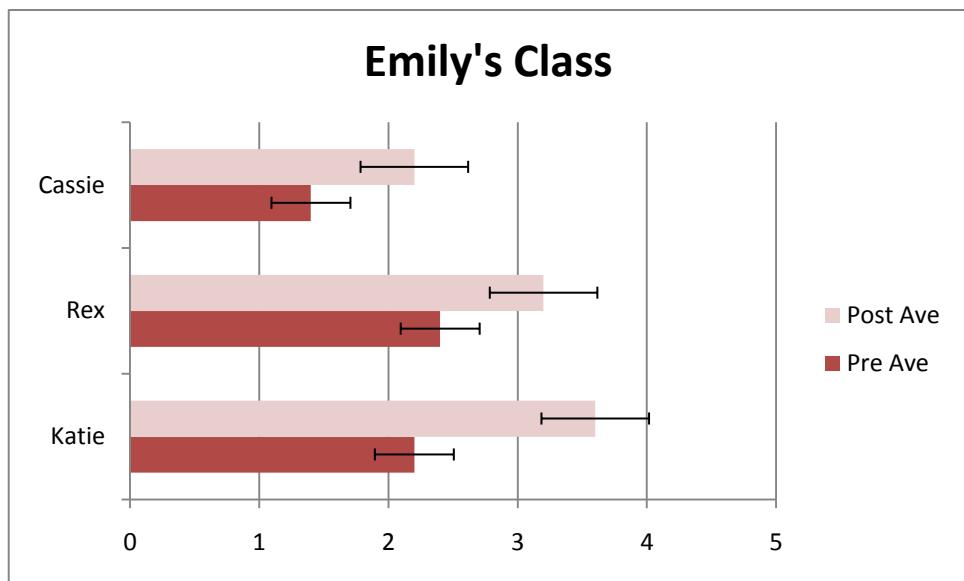


Figure 7 Students Making Significant Gains from Emily's Class

Jennifer's Findings

In my classroom, the *t*-test showed significant growth for 5 students (see figure 8). When I analyzed why this may have occurred, I noticed that these particular questions focused on concepts where all the information was given and the students were very familiar with the

vocabulary due to habitual practice. Some of these students also received much more intense guided reading during the language arts block, which helped with understanding how to read critically. In addition to reading strategies, these students also engaged in individual student-teacher conferences in which the students shared that they enjoyed math and that math was becoming easier for them. I observed students taking more risks verbally, and the interactions within the small group setting improved, which led me to believe that their confidence was increasing. Additionally, the fact that these students were in class on a regular basis helped to ensure the understanding of important math vocabulary.

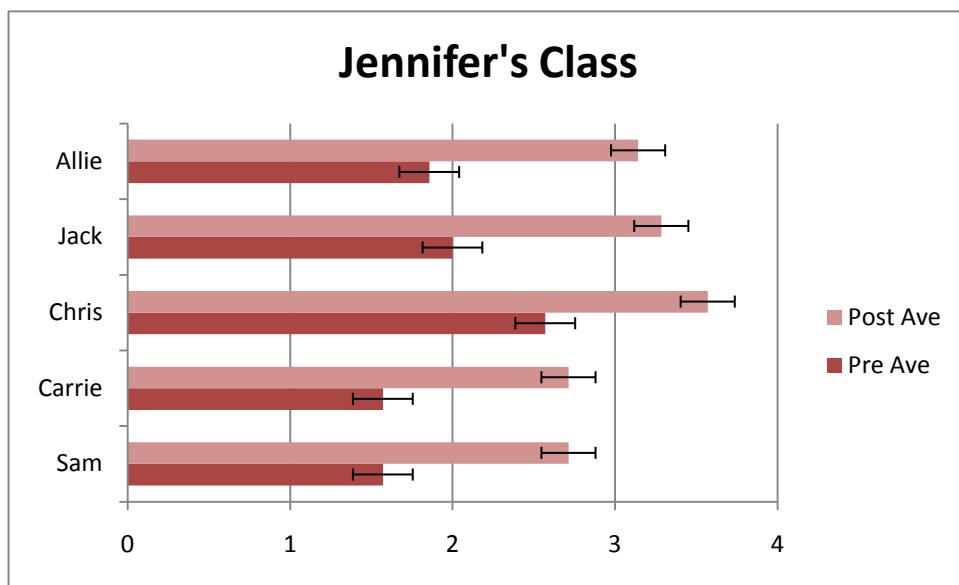


Figure 8 Students Making Significant Gains from Jennifer's Class

Student journals

When looking at the students' daily work journals, additional information is evident. A few students stood out due to an increase or decrease in score. In Emily's class, Alice's average decreased from a mean score of 3.2 on the pretest to a mean score of 2.8 on the posttest. When looking at Alice's math journal, her responses ranged from 2 point responses to 4 point responses with longer, more detailed responses occurring as the time progressed. This was interesting because while her test score decreased, her student work showed improvement. Alice's math survey showed a student who feels that math is very important although sometimes boring. One possible reason for this decrease may be because the math concepts became more challenging making it more challenging for her to explain her answers. I also noted an interesting finding in Carson who showed a decrease in score from a mean score of 3.2 on the pretest to a mean score of 2.2 on the posttest. However, Carson's math journal showed inconsistent results with many answers receiving 1-2 points. During one journal writing period, I overheard Carson saying,

"This is hard for me to think of what to write. I don't like doing it." The journal writing routine gave me more information about each student than just the test alone.

In Jennifer's fourth grade classroom, there appeared to be parallel links between students' interest and success on the response questions. For the two students that decreased in test scores, according to their interest surveys, both answered that "math was boring" and "it was just a little bit true" that they liked to come up with new ways of solving math problems". For the two students that remained the same, they both "like learning math" but one felt "math was boring" and the other said "math was not important throughout life". For the five students that improved, four said that it was very true that they "liked learning math" while two said it was very true that "learning new things in math is fun for me". From this, I concluded that when there is interest, student scores increase.

Implications

We found through review of the current literature regarding mathematical communication that student understanding of math extends and deepens when they are challenged to explain their thinking (Burns, 2004). The data collected within the two classrooms in this study provide further evidence that incorporating writing into mathematics can enhance student performance. We found that gaining students' interest was imperative to motivating them into taking the time to find new ways of finding answers and explaining their thinking. By making math journals a part of the daily classroom routine the students are able to practice writing about math regularly and routinely which helps them to gain experience with writing about math. While it can be challenging to find time in the busy school day for math journals, the predictability of the routine is crucial. In future years, we will ensure that the math journal routine is established at the beginning of the school year and is built into our schedule the same way we do with the rest of the curriculum. The use of charts and the smartboard were an important part of the process because it allowed the students to see what was expected of them and to collaboratively learn from their peers. In upcoming years, we will make an effort to begin more math periods with this type of writing to give the students as much exposure to math communication as possible. We also learned that each student's writing ability is an important factor to consider. If a student is a reluctant or struggling writer it can greatly impact the student's math journaling success. One strategy that may help these students is the use of highlighters to keep the focus on the math vocabulary. The students can participate in shared writing and math experiences with the teacher or a peer and then highlight the content-specific vocabulary.

Limitations

While current literature suggests that writing and communicating about mathematical thinking should improve and benefit students' overall math skill, this was not shown by all students within the data sets. Due to timing of the pretest and posttest, we wondered about the validity of the pretest and posttest scores. The posttest was given towards the end of the school year. Some

scores seemed inconsistent with what was observed in the student journals and through observations in the classroom. It is possible that some of the students were not taking the assignment as seriously in the spring as they had earlier in the year, which resulted in a decrease in the test score. Variables that affect a student's success when taking a state mandated test can be one of many.

Additionally, some of the students in the fourth grade classroom struggle in reading comprehension. Towards the end of the year, tutoring hours become more limited, students can begin to shut down and focus is decreased. Teachers attempting this study should be wary of the timing of the tests as well as the attitudes of the children, while taking into account the reading comprehension of the students.

The focus is not only the test; the focus is the child, the strategies, and the habits to form life-long math learners. With extensive practice, organization, and time to reflect, students can have success with math writing, but the teacher must provide many opportunities for this to occur.

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