Could You Put That in Writing? : A Study of How Students Express Their Understanding of Mathematic Concepts on Paper

By

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B.A. (California State University, Sacramento) 2006

THESIS

Submitted in partial satisfaction of the requirement for the degree of

MASTER OF ARTS

in

Education

in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA

DAVIS

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Abstract

Name: Roland C. Aichele
Title: Could You Put That in Writing? A Study of How Students Express Their Understanding of Mathematic Concepts on Paper

Research Question:
What happens to students' conceptual understanding and ability to communicate about mathematics when I incorporate writing and a strategy for promoting academic vocabulary into *every* math lesson?

Research Activities:
This research explored how using direct language instruction and activities, practicing writing about mathematics, and teacher modeling affected students' mathematical understanding, communication, and usage of academic language when focusing on one content area (division). Context: The study took place in a self-contained, third grade classroom at an urban public elementary school. Over half of the class consisted of English Language Learners which included such primary languages as Spanish, Russian, and Hmong. The research topic emerged when it became evident that students were experiencing more difficulty with written mathematics tests than with multiple-choice assessments. Methods and Data: The intervention lasted a period of two months, with a two-week winter break in the middle. Instructional approaches included direct academic language instruction and writing about the mathematical concepts learned. The student writing took place at the conclusion of each lesson within the adopted curriculum, followed by class discussion and teacher modeling of how to write about mathematics. Student writing at the beginning and end of the intervention were compared to determine the effect of the intervention in students' mathematical writing. The writing was analyzed using a researcher-generated rubric to determine growth in three areas: understanding, communication, and academic language. Student performance on a multiple choice content test was used to determine if

writing about division contributed to student learning. Results: Results indicated a dramatic increase of academic language usage in writing, indicating that the breakdown between written and multiple choice test scores may have been language-based and not a lack of understanding. Students also showed an improvement on the multiple choice content test. Conclusions: Writing about mathematics proved to be a powerful tool to support student learning, provided on-going assessment for the teacher, and increased student usage of academic language when writing about mathematics.

Grade Level: 3rd Grade

Data Collection Methods: Writing Samples, Writing Assessment

Curriculum Areas: Math, Writing in the content areas

Instructional Approaches: Writing-Expository

Table of Contents

Have you ever been unable to explain exactly what you are thinking? Or experienced writer's block when trying to write a paper? I have. I have noticed that my students struggle with this as well. This is especially true when it comes to mathematics. As a whole, they demonstrate computational skills and knowledge when it comes to various concepts, yet struggle with writing about the same concepts. A closer look at the math curriculum and district expectations reveals little emphasis placed on practicing writing about math. This is a study that observes the impact of practicing writing about math to foster growth in conceptual understanding, academic language, and overall communicative abilities in regards to mathematics.

Context

My Classroom

An observer looking in through my window would see a full classroom of twenty, 3rd graders. Most of them, with the exception of those who do not follow dress code, are in uniform, which consists of a white shirt and navy blue pants. As is standard with kids of this age, some of the white shirts are dirty, tattered, and well used, while others are fresh out-of-the-dryer-clean. The same is true for the rest of their hygienic appearance. About half of the students are well groomed with their hair brushed and styled, while there are a group of students who have a "don't you dare come near me with a bar of soap" look on their faces. They are generally a happy bunch with contagious smiles on their faces. Girls outnumber the boys 12 to 8.

My classroom has high ceilings and a wall of windows that provides plenty of natural light. There are two long white boards that almost meet at a corner opposite the wall of windows. The students are arranged in two rows in what I call a double rainbow formation with ten students in front and the other ten students behind them, which creates a focal point at the corner where the white boards come together. In the middle of the double rainbow is a walkway that divides the students into groups of five. My classroom has a tree theme, so the four groups are named after trees found in California: Laurel, Oak, Pine, and Cypress. Above one of the white boards is a mini forest of giant California Redwoods that I made out of construction paper. Behind the students there is a class library, a science center, a sink, and my teacher's desk. Between my desk and the students is a kidney table that is used for small group or one-on-one instruction. The tall ceilings have provided for lots of wall space, which is mostly taken up by bulletin boards filled with student work.

My classroom is, without a doubt, ethnically diverse. There are 10 Hispanic children, making it the largest ethnic group in the room. Next are White students, who compose 5 students all together. The next largest group is African Americans with 3 students. The last 2 students are of Asian descent. Figure 1 illustrates the ethnic make-up of my class.

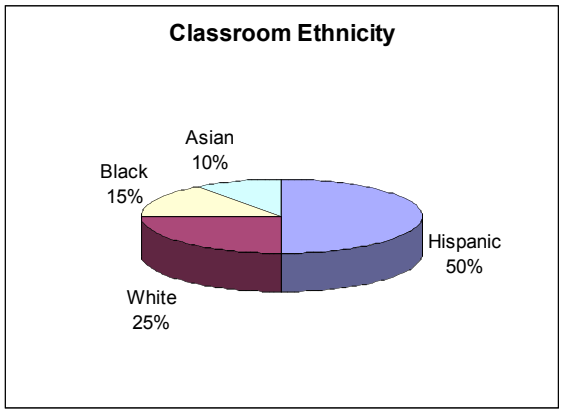

Figure 1: Classroom Ethnicity

Language Backgrounds

While there are only 4 ethnicities, there are five different primary languages that exist in the classroom. Half of the students speak English as their primary language, totaling 10 students. The next most represented language is Spanish, which 6 students have as their primary language. There are 2 primary Hmong speakers while Russian and Ukrainian each have 1 student, who spoke these languages before English. Figure 2 shows the different primary languages that are present in the class.

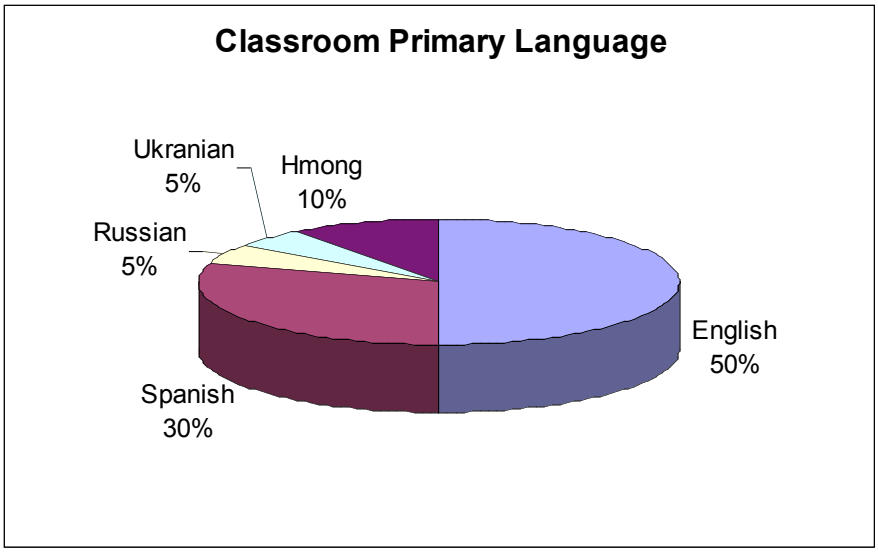

Figure 2: Classroom Primary Language

As it turns out, my students are largely considered "basic" as far as standardized achievement scores. The tables below show how my students scored on the STAR test at the end of second grade. It is important to note that they only contain data for 16 of my 20 students.

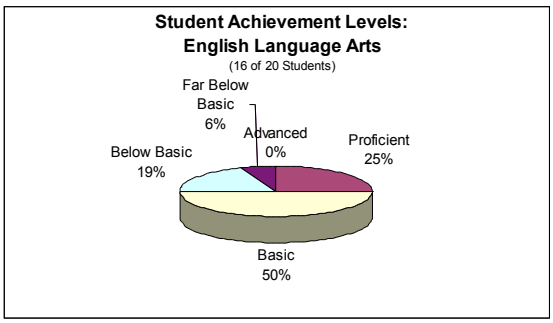

Figure 3: Achievement (ELA)

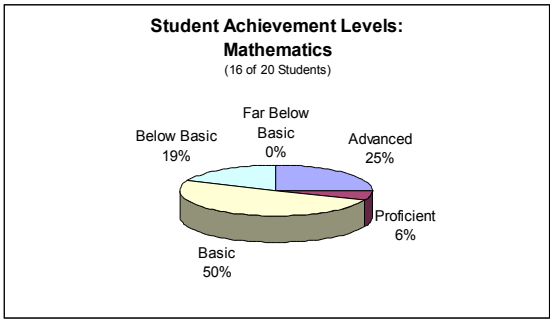

Figure 4: Achievement (Math)

This data states that 75% of my students scored basic or above in English language arts and 81% of the students scored the same in mathematics. According to this information, math is the stronger subject. This comes as no surprise to me as I have observed that the students eagerly anticipate math instructional time every day. If there is one challenge I have noticed amongst the students that the data does not and could not show, it is reading and following written instructions. This could prove to be problematic seeing how third grade is a time when more independent test taking becomes important.

The District

It is important to mention the district since the school's instructional culture is highly regulated from a district level. All schools in the district, with the exception of the year-round school, are on an identical pacing guide for all subject areas. The adopted curriculum for English Language Arts is Open Court Reading. Without question, this is the most important, strictly paced, and monitored curriculum in the school. In fact, it is highly recommended that science and social studies instruction is interwoven with the Open Court curriculum as opposed to getting its own instructional time. The science curriculum is actually a small packet that shows which Open Court lessons could also take care of state science standards if strategically taught. Mathematics is taught through the Houghton

Mifflin curriculum. Finally, Scott Foresman is the adopted social studies curriculum. It consists of 8 units which have two lessons per unit. That makes for a total of 16 lessons. There is no art or music instruction or enrichment at the school.

The majority of the daily schedule is dictated by the district with a small amount of leeway and creativity here and there. Our school is a Reading First school, which means that the entire morning up until lunch is dedicated to uninterrupted reading and writing instruction. After lunch is math instruction. The emphasis on mathematics is not as great, receiving much less instructional time than language arts. Also, the district math pacing guide is not as regimented, providing me with some freedoms. For example, I am given flex days, extra days beyond the needed days to teach a chapter before having to turn in student assessment scores, and my calendar is not mapped out by the day. In other words, I know exactly what I will be doing for reading instruction on any day between now and the end of the school year, but not so much for math. However, the components of a math lesson are supposed to be taught in a specific way and in a specific order. If a representative of the district arrived to observe a math lesson, they would expect to see certain elements, routines, and procedures practiced in the classroom. I deviate slightly from the recommended structure by adding a calendar segment in which we spend the first five minutes looking at patterns, tallying, using fractions to count the school days, tracking the daily weather with a graph, and creating equations from the information on the graph using either pictures, symbols, or words. Math instruction usually wraps up either just prior to or right after the afternoon recess. The last 30 to 35 minutes of the day is currently spent on social studies or science instruction

My School[1]

The history of my school is not a positive one. For the last three years, test scores have consecutively dropped, placing the school into its third year of program improvement. However, its future is looking much brighter. Last year a new principal was hired with the task of turning things around. After a rigorous year of new policy and many changes, the school saw its first increase in scores. In fact, the scores were enough to freeze the school in year two of program improvement. If test scores continue to rise this year, the school will be out of program improvement all together. It should prove an interesting task since there are over ten new teachers who have been hired to the staff due to teachers retiring, moving to other schools to protest the changes being made, and grant money found by the principal to hire new teachers and reduce class sizes in the intermediate grades.

API History

My school has a turbulent history with API scores. One year they improve, and the next year they dramatically drop. Some of the contributors to the fluctuation are due to a high transient student population (on the whole, the school experiences approximately a 45% rate of turnovers throughout the year), not to mention on-going staff tensions that have made the school legendary throughout the district. Consequently, the gains have not been enough to keep the school out of program improvement. The line graph below shows the API history of my school.

[1] All names and places are pseudonyms

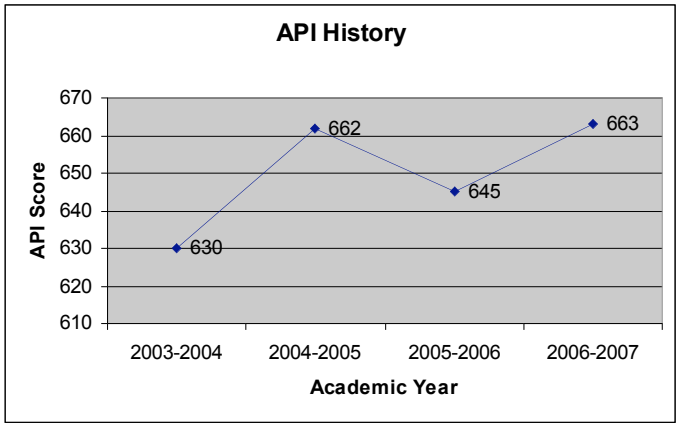

Figure 5: API History

Luckily, last year's jump in scores was enough to prevent the school from entering year three of program improvement (PI). Currently, the school is frozen in year two of PI. If test scores rise in a similar fashion this year, the school will be lifted from its PI status. This has proven to be uplifting and motivating news for the entire staff.

AYP History

In general, AYP seems to be a tough goal to achieve. There are 23 different categories or subsets of students. If only one subset fails to reach its individualized goal, the entire school fails its AYP for the year. Last year, along with a great leap in API scores, the school met the goal of each AYP subset. The Hispanic and English Learner subsets were the greatest improvements, jumping 73 and 51 points respectively. This is amazing news since these were two of the three subsets that had caused the school to fail its AYP the year before. Many of the teachers, including the principal, believe the rise in scores to be directly correlated to the "push in" philosophy they adopted with resource and low students, in which aids assist students in the classroom instead of taking them out and providing instruction elsewhere in an isolated setting.

Student Language Backgrounds

There are 9 different languages reported as students' primary languages. In order from most represented to least, the languages are: English (56%), Spanish (26%), Hmong (8%), Loa and Russian (2% each), and Rumanian, Ukrainian, Portuguese, and Hindi (1% each). Figure 6 illustrates the different primary languages spoken at my school.

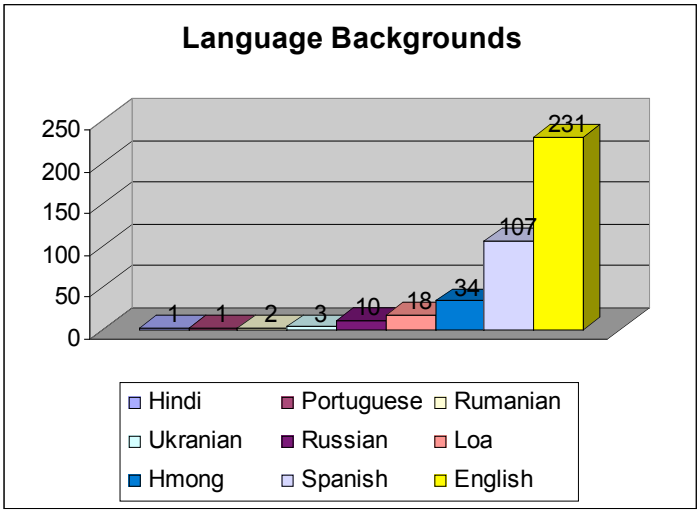

Figure 6: School Language Backgrounds

Student Ethnic Background

The nine different languages present at my school are lumped into seven different ethnicities. They are (in descending order) Hispanic, African American, White, Asian, American Indian, Filipino, and Pacific Islander. Figure 7 shows the ethnic distribution of my school.

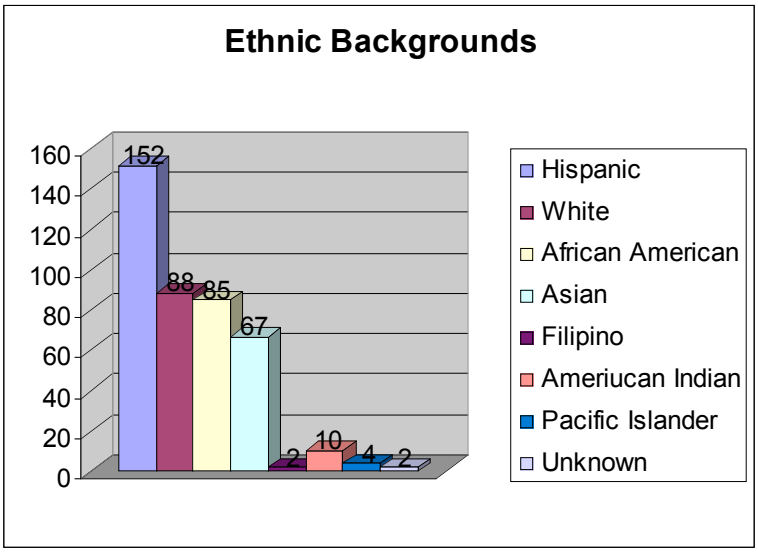

Figure 7: Ethnic Backgrounds

What I find interesting is that Hispanics dominate the population, yet there are twice the amounts of students who speak English as their primary language than students who primarily speak Spanish.

Purpose & Rationale

My interest in pursuing writing in mathematics was sparked by a major discrepancy I noticed between two sets of test scores from my students. The students take two different types of math assessments in order to demonstrate understanding of the concepts being taught. The first is a twenty question, multiple-choice test that is provided by the district. All twenty questions are weighted the same. The other is called a reasoning test. The reasoning test is one open-ended test that the students must answer using words, numbers, and pictures. The test is scored by using a district-generated rubric. The rubric gives a total of nine possible scores ranging from zero to one hundred percent. The main criteria for scoring well hinges on whether the students answered the question correctly with their words,

used pictures and numbers to justify and double check their responses, and whether academic language was used correctly. Both a multiple-choice exam and a reasoning test are administered at the conclusion of each chapter or concept. Below are examples from each type of test that were given to students at the conclusion of our first chapter, which focused on place value.

The reasoning test question was:

- If a five-digit number has no hundreds, is there a digit in the hundreds place? Explain your thinking in sentences and a place value chart.

Some questions that appeared on the multiple choice exam were:

Mark the standard form for each number.

- 900,000 + 50,000 + 200 + 70 + 5

A. 275,954 B. 572,459 C. 945,257 D. 954,275

- Five hundred sixty-three thousand, three hundred four

A. 563,304 B. 403,365 C. 304,563 D. 563 thousand, 300 four

The following graphs represent the whole class scores from the assessments that covered the concepts taught throughout the chapter on place value of numbers up to 10,000. Figure 8 shows the class scores of the multiple-choice exam and figure 9 represents students' scores for the reasoning test.

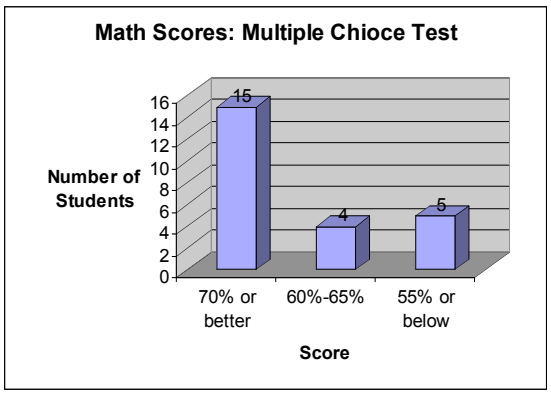

Figure 8: Multiple Choice Test Scores

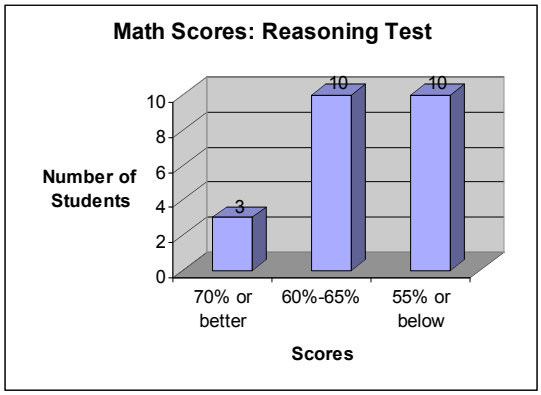

Figure 9: Reasoning Test Scores

This data is extremely revealing and somewhat alarming. Of the 24 students tested (at that time in the year, I taught an extra four students for math instruction from another class), over half received a score of 74% or better on the multiple choice. Seventy percent is the number which the district feels meets grade level standards. The students did not do so well with the reasoning test. In fact, the majority of the students received a score of 65% or less which does not meet grade level goals. Figure 10 shows an example of a student who excelled on the multiple choice exam, but not on the reasoning test. I was shocked to see the difference.

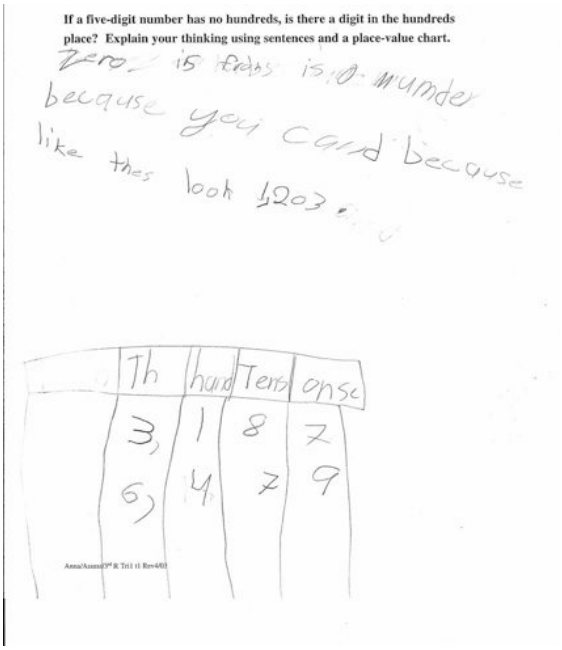

Figure 10: Student Sample-Reasoning Test

I specifically chose this example because it represents one of the lowest reasoning tests that the students produced. This is an EL student and the inability to create complete thoughts and sentences leads me to believe that English grammar and sentence structure create a barrier. However, the student did make a diagram to convey her thinking. In addition to a language breakdown, the picture shows a misunderstanding of the prompt in general. In the writing, the student creates a number with a zero in it, even if it is not in the hundreds' place as the question asked about. The picture, however, shows a different number that does not include a zero in any place value. I find it intriguing how a student could struggle so hard with this aspect while excelling on a multiple choice exam.

Beyond the individual student, this example displays a common issue that was seen throughout the students' tests. The students were better able to choose the right answer than to demonstrate their conceptual understanding of place value in an open-ended writing task. This could be due to a number of circumstances including, but not limited to, a lack of academic language, conceptual understanding of the concept, a second language barrier (that stops the formation of simple sentences, let alone mathematical reasoning in a second language), or the fact that the format of all instruction, practice, and homework is primarily procedurally based and is much more similar to that of what the multiple choice assessment asks of the students.

I wanted to dig deeper into this discrepancy between multiple choice and reasoning tests. So, during a math lesson, I collected some observational data by asking all students three different questions relating to the algorithmic processes and properties of addition. I chose

the topic of addition to correlate with the Addition and Subtraction chapter that was currently being taught from the Houghton Mifflin Mathematics program. As students responded and answered the questions orally, I wrote down their answers verbatim on an overhead transparency for all students to see. I also noted which students had made the comments. All recorded responses were saved. The next day, I wrote the same three questions on an overhead transparency and had the students write their answers. No prior discussion or review was given before the students were asked to write. The student responses were collected and observed. The three questions/prompts from both days were:

1. 8 + 2 + 6 =

   Find 3 ways to find this sum. Is one way easier than the others? Explain your thinking.
2. Why is o.k. to change the order of addends in a number sentence?
3. 89 + 73 = 162.

   When finding this sum, why is regrouping necessary?

The day before the written expression was required; students were answering the questions with accuracy, using mathematic vocabulary. For example, a student verbally responded to question 2 by saying, "Because it is addition and the sum would still be the same." I then compared the oral responses to the written responses to the same questions. If they answered similarly, it was tallied as a "match." If the student came up with two opposite answers between their oral expression and written work, they were tallied as a "no match." The student mentioned above was considered a no-match since she responded to the same question by writing, "I don't know," for the same question. Figure 10 (below) shows

how many of the nine students who shared oral responses were able to respond similarly in their writing. This indicated to me that there was a definite breakdown between oral and writing skills. Some conceptual understanding existed, yet could not be expressed as well through writing.

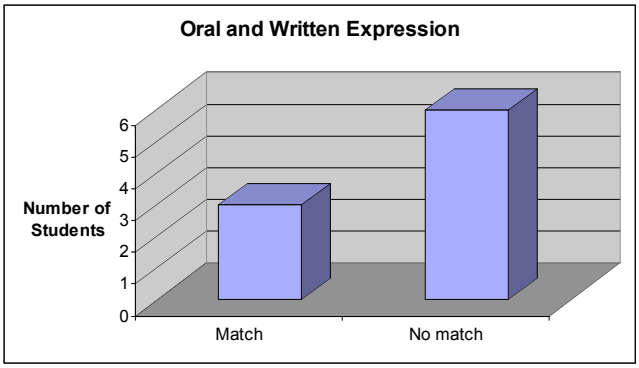

Figure 11: Oral vs. Written Expression

Scores on reasoning tests are reflected on student report cards. They are heavily dependent on the student's writing ability, not to mention mathematical understanding. My class was struggling with meeting the level they were expected to achieve with the reasoning tests. Therefore, I planned to implement an intervention that incorporates writing into every math lesson along with strategies to promote conceptual understanding and provide scaffolds for EL students and I decided to pursue the following research question:

What happens to students' conceptual understanding and ability to communicate about mathematics when I incorporate writing and a strategy for promoting academic vocabulary into every math lesson?

Aside from the issues that my students are demonstrating, there are many other reasons to bring writing into daily math instruction. According to Thomas Gunning (2005), writing is not only a method of communication, but a way of learning as well. Furthermore, writing is an active process and activities that engage students in manipulating information can lead to an increased amount of recall and deeper understanding. This is true for all writing, regardless of the subject matter. However, more specifically related to why writing and mathematics instruction make a great team, is the fact that, "testing alone in math is not an appropriate answer to improving student learning" (Van De Walle, 2007). Van De Walle also states that writing provides for a means of ongoing assessment of students. Daily feedback and student interaction help students clarify ideas and become more independent as learners. Writing provides ongoing assessment, providing teachers with information about student understanding to assist them in making immediate and effective instructional decisions. Finally, The National Council of Teachers of Mathematics (NCTM) has released their own set of national *Principals and Standards for School Mathematics* (NCTM, 2000). Within these standards exist five process standards, one of which is that students "communicate mathematically." Writing about mathematics helps to achieve this and the California Grade Level standards.

Considering the fact that half of my students are ELs, there are benefits for them to participate in writing about math, too. As pointed out by Garrison (1997), many educators believe that mathematics is culture-free and ideal for transitioning EL students into English instruction since it utilizes symbols. Needless to say, this is a misconception. I feel that writing about mathematics will also help my EL population by serving as a "rehearsal" for

whole class discussion. I find that many times, allowing EL students to talk privately with a neighbor or pre-thinking an answer largely increases their desire to participate in a public situation, such as a whole class discussion.

Intervention Overview

What we teach in our school is tightly controlled by district administrators. I am expected to be upholding curricular integrity and fidelity at all times. Unfortunately, the curriculum lessons are structured to teach computationally as opposed to conceptually. Also, only one hour is dedicated to math instruction each day. To implement an intervention was a sticky situation. However, I noticed that the text has an "explain your thinking" section to many of the lessons, which included opened-ended questions that are extremely similar (and in some cases identical) to the questions asked on the reasoning tests. Therefore, the daily writing revolved around this section of the lesson. Since division was the concept that the students were studying during the intended time of the intervention, all questions were related to division. Taking advantage of the "Explain Your Thinking" questions in the text allowed me to keep curricular fidelity while implementing the intervention.

Daily Writing

For my intervention, I intended to begin each math lesson with 10 minutes of review and direct vocabulary instruction to scaffold for EL students (detailed below), followed by 10 minutes of writing about the concept taught the day prior and a brief oral discussion. The rest of the lesson would follow the curriculum layout of direct instruction through an overhead, guided practice activity in which the students use white boards to show understanding, and independent practice if guided practice showed positive results.

After the first day of intervention in which I collected baseline data representing students' abilities to communicate about math through writing, I planned to spend time modeling strong responses to math through writing and showing strong and weak responses in order to clarify my expectations for their writing. I also planned to continue this modeling once a week for the duration of the intervention.

There were a few reasons for placing writing at the beginning of the next day's lesson instead of on the same day, directly after the students had a chance to explore the topic. First, the curriculum places the "explain your thinking" section in between direct instruction and guided practice, which is closer to the beginning of the lesson. So, this kept some fidelity in the district's structure of a math lesson. Also, it served as a chance for students to recall concepts taught the day prior in order to apply them with the current lesson. Lastly, there is no telling what may happen throughout a lesson. If the writing were left for the end, I envisioned running out of time and having to rush the process or skip it completely. This would negate all purpose for the inquiry and intervention.

Instructional Strategy

Due to a high level of EL students in my class and the rapid pace in which we teach the concepts, I felt it necessary to incorporate a strategy to scaffold for these students. The implementation of this strategy was also likely to benefit struggling, English-speaking students. I chose to use elements for a strategy called "Academic Language Scaffolding" (Herrell & Jordan, 2004) This strategy is usually associated with subjects such as

mathematics, science, and social studies due to the content specific vocabulary each discipline requires. Therefore, this strategy supports the students in acquiring Cognitive Academic Language Proficiency (CALP) (Cummins, 1986). The teacher uses a series of scaffolding strategies such as contextualizing academic language using visuals, gestures, modeling academic language, and demonstrations. What separated this strategy from others is the emphasis on engaging students in active learning activities to promote the use of academic language. The main idea is that the use of the language needs to be non-stressful.

The steps involved in this strategy could occupy an entire math lesson without even getting to the content. Therefore, I condensed the elements to fit in the 10 minutes I dedicated to vocabulary instruction. The elements of the strategy are:

1) Identify academic vocabulary and language structures
2) Designing and teaching an introductory activity
3) Practicing in pairs or small groups
4) Guiding and monitoring the practice
5) Reviewing the vocabulary and language structures

The majority of what I took from this strategy was steps one, two, and five. This consisted of an activity that engaged students in a non stressful way and allowed for academic language to be introduced. I modeled language usage and since the academic language for division is complex, I created a word wall displaying academic vocabulary as a reminder to students of the words we have discussed. The word wall was not part of the instructional strategy as laid out by the literature, but I felt it would help to give students a reference to use when trying to recall all the language being expected of them. The academic

language that made it up to the wall consisted of words that I felt were crucial for kids to know in order to be able to write about division like a mathematician. The word wall was an evolutionary piece of the intervention that unfolded and developed throughout the study (see Appendix B for pictures of how the word wall evolved).

Since my time for implementing these strategies was limited, I only had room for strategies that proved to be highly effective for my students. When I felt, through the daily assessment of daily student writing, that an instructional strategy was not proving to be effective, I would switch to a new strategy so as to better serve my students and their needs. I delineate the adaptations I ended up making when I detail how the intervention unfolded in an upcoming section.

Gathering Data and Timelines

Student Work/Achievement Data

To explore my research question I used several data sources. To track student achievement, I analyzed students' mathematics writing and evaluated their work on tests. I also collected their writing every day to document their engagement during instruction. In this section I provide details of my data collection and analysis

In order to gauge growth in writing, I administered a "cold write" in which students were asked to write about a mathematical concept that they should have known prior to the implementation of the intervention. This documented how well the students could write about something without any writing instruction served as the baseline data for this intervention. At the conclusion of the intervention, students wrote about the concept we

learned throughout the inquiry to provide a pre and post comparison. Also, district-generated, multiple-choice assessments were administered at the conclusion of both multiplication and division, which marked the end of the intervention. Table 1 displays the rubric I generated to interpret and analyze my students' mathematical writing.

Table 1: Writing Rubric

Understanding			
0	1	2	3
No display of understanding through words, pictures, **or** numbers.	**Very little** display of understanding through words pictures, **or** numbers.	**Some** understanding exists among words, pictures, **or** numbers.	**Full** understanding of question is demonstrated through words, pictures, **and** numbers
Add a "w" to score if student used **words** in answer. Add a "p" to score if student used **pictures** in answer. Add a "n" to score if student used **numbers** in answer.			
Academic Language			
0	1	2	3
No use of academic language.	**Very little** use of academic language.	**Some** use of academic language.	Academic language **always** used whenever appropriate.
Add a "g" to scores with use of academic language **given in prompt**. Add an "e" to scores with use of academic language **extra** to what provided in prompt. Add an "eg" to scores with use of given **and** extra academic language in prompt.			
Clear Communication of Thinking			
0	1	2	3

No explanation or justification of thinking for answer.	**Very little** explanation of justification of thinking for answer	**Some** explanation or justification of thinking for answer, but no fully.	**Complete** explanation and justification of thinking for answer.
Note: • Thinking or reasoning does not need to be correct to receive a score of 1, 2, or 3 so long as they are communicating *what* they were thinking. • An answer of "I don't know will receive a score of "0."			

I created this rubric to serve two purposes. The first is to help me identify whether students were growing or struggling with the individual areas. Secondly, I wanted to help students have greater success on their reasoning tests. Therefore, the rubric focused on words, numbers, and pictures in order to align with what the district expects from students.

Observational Data

I observed "time on task" of students during the writing portion of the math lessons. The first observation was during the "cold write" to see how engaged the students were with a topic that was familiar and comfortable. This observation served as baseline data to compare to other time-on-task observations.

Intervention Description

My initial intervention plan turned out to be an overly ambitious framework. The final result turned out to be much different than I had anticipated. For the official list of prompts and the dates administered, see Appendix A. Also, for a table illustrating my initial (and over zealous) intervention, see Appendix C. Below I detail what transpired during the intervention.

Week 1 (Dec. 12- Dec. 14)

The intervention began on a Wednesday. This was not only the first day of the intervention, but also the kick-off into the world of division. As far as I could gather from student responses and conversations, they were unaware of what division actually was. In fact, I sensed a little fear from them regarding the topic. We had just wrapped up a two-month run of becoming mathematicians who could multiply. The confidence level of my students was high regarding multiplication and it showed. The prompt was,

"Can you multiply the factors of a multiplication sentence in any order? Use words, numbers, and pictures to explain your answer."

As I administered the first writing question, I noticed that most students got right to work, eager to show off their knowledge. They were counting on their fingers, looking into their heads with their eyes to dig out information from their brains, and were writing diligently. Not all were on task, however. I noticed about four students who were either continually disengaged or looking at their neighbor's paper for ideas or confirmation about their own. Overall, the students had taken well to the first of many writing routines. Below is a sample that shows what most of the students were able to produce.

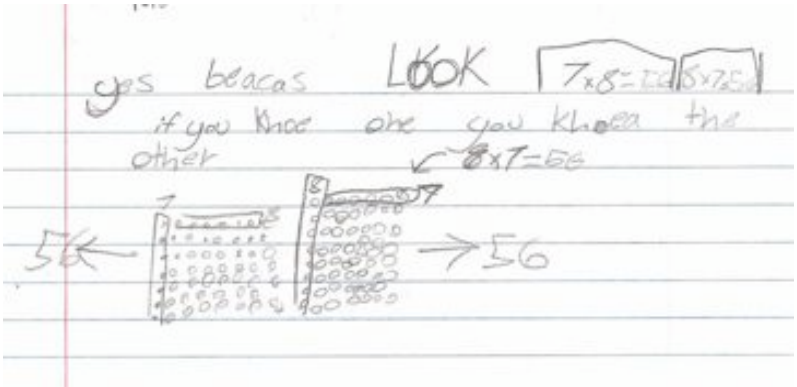

Figure 12: Student Sample, Prompt 1

After the first prompt (which served as baseline data), I began the first lesson on division. The pacing guide supplied by the district recommended one day for the introductory lesson which modeled division. It took me two. I still feel that much more time

could have been spent introducing the concept. Nonetheless, since I had planned to have students write about the concept taught within each lesson once it was completed, Friday marked the first real writing sample the students were to produce. It was:

"Describe two ways to divide 8/4 = 2. Use words, numbers, and pictures to explain your answer."

Let's just say my students' confidence was diminished. It is an understatement to say that my class had a much harder time. It was hard to believe that they were the same set of students who had two days prior been persistently thinking about math and writing to show what they knew. I noticed one student who had given up entirely and was doodling pictures on his blank sheet of paper which quickly progressed to drawing on a piece of paper stashed sneakily in his desk. He was not the only one. Many students were looking hopelessly at blank papers and then back up at me with a "Why are you doing this to me?" look.

Then the chatter began. Students were whispering to each other while some had the courage to speak their minds. One of my top students said, "I don't know what it means." Another proclaimed, "It's like the answer is in my head, but it's locked up." The final comment I heard before ending their misery was, "That one we did the other day was way easier." The student sample below conveys the frustrations that were felt and expressed by many students.

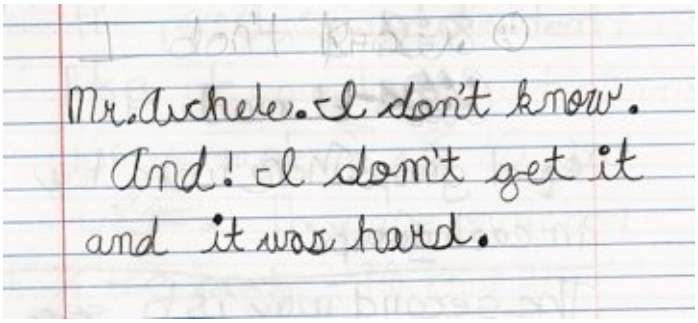

Figure 13: Student Sample, Prompt 2

It was at this point that I decided to have them turn over their papers and we began to come up with an answer together, so as to model what I was expecting of them (as I had planned). I was doing my best to have the students create the answer while I wrote it down in a simple format on the overhead for all to copy.

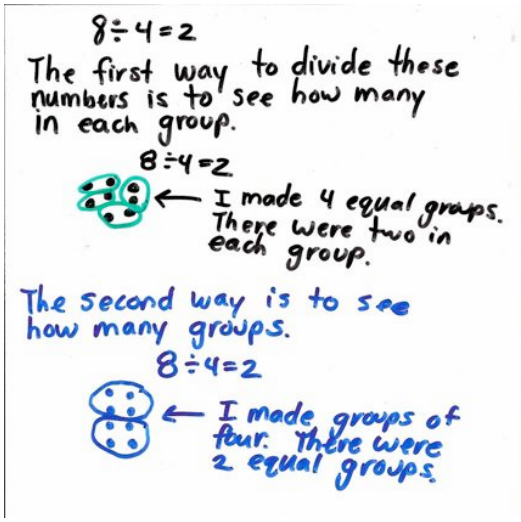

Figure 14: Modeling of Prompt 2

However, seeing how their division "chops" were not so great, I did most of the talking. This process of writing and modeling took a little over a half hour much longer than the ten minutes I had allotted to this activity and, since Fridays are early release days, it took the entire chunk of math time and took us to the dismissal bell. What a way to end a week. Poor guys.

Week 2 (Dec. 17- Dec.21)

This was going to be the first "real" week of intervention and I had high hopes to accomplish much before the students were going to leave for winter break. I had intended to teach two lessons and also go through two more writing prompts. I got nowhere close. To put it simply, this week was an eye-opening experience that completely changed my original plans and timelines.

First, there was no school on Monday so teachers could conduct parent conferences regarding the first trimester report cards. Although, I must note that conferences were convenient in that they provided me with an opportunity to talk to parents face to face about what their students were embarking upon, including each parent to some degree. During these discussions, I brought up how their student was doing in terms of writing about mathematics, where I expected them to get to, and how they, the parent, could help at home to foster success with their students. The notion of the intervention was generally received well. Most of my parents have other children in the school in higher grades. Over and over, I was observing relief that somebody was going to be assisting students with this part of their math grade. I guess it was not only my class that was struggling with reasoning tests.

Second, every day for the rest of the week was an early dismissal, also for the before-mentioned reason. This cut out about fifteen minutes of my math time, making my lessons a little over a half an hour each, forcing me to cram the material into a short time. Lastly, Friday was "winter carnival." This is an age-old tradition in which students in the choir sing Christmas songs to the rest of the school and other classes do the same. Now, I mentioned that this is an annual event, yet no one could give a straight answer as to what winter carnival was, what time of the day it would be, how long it would last, and what to expect. On the day prior, I learned that it would be midday and that I would have the last hour to myself with my students. Would you believe me if I told you that mid-song, our fire alarm went off? It was not a drill. We spent a large amount of time outside, lined up, waiting for clearance from the fire department to go back into the classrooms. It turned out that our preschool

facilities were the culprit. Luckily, no fire had actually started and nobody was injured. When we finally returned to the classroom, I felt it much more appropriate to decompress and enjoy some games and activities as opposed to math instruction before letting out for break.

That left me with three thirty-minute periods to continue the intervention throughout the middle of the week. I was able to teach a lesson and go through a writing prompt, so not all was lost. On Thursday, I had planned to start with a writing prompt, have a brief discussion and move on to the next lesson. The prompt was:

Look at each number sentence. Why are the product and the dividend the same in each sentence?

This prompt started off much like the last one. I could see students tuned out and doodling or looking quizzically at their papers and then to the overhead projector screen, biting their lips in frustration. I was expecting an onslaught of questions, but something strange happened. All of a sudden the room was quiet and *every* student was writing. I noticed that many were looking up at the division bulletin board that was home to the academic language we had been learning so far (for images of the division bulletin board, see Appendix B). Then a hand went up and I thought to myself, "Here it comes." The question… "How do you spell multiplication?" Then I noticed students counting the colored circles I had drawn as part of the prompt and it was then that I realized that these kids were engaged in writing about division. The way they all took their writing so seriously knocked me off guard. Not to say that all students answered correctly, but they gave it their best shot. Below is a sample of student work that sums up the effort students put into their writing.

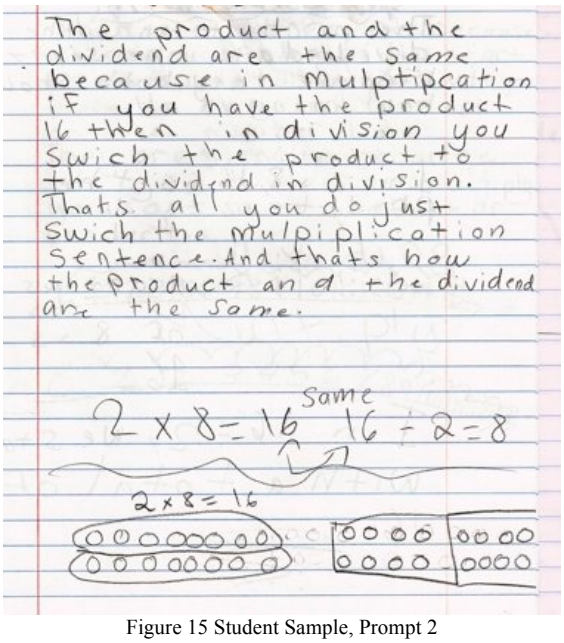

Figure 15 Student Sample, Prompt 2

I had only planned to model writing an answer every couple of prompts so as to not take too much time away from instruction. However, when the time was over for writing, I began to disassemble the overhead station and the students went into an outrage and demanded, "What about writing the answer?" When I asked the class, "would you like me to write the correct answer for you to see?", and I got an overwhelming choral response of, "YES!" I was blown away. The students were invested in this task and wanted closure. For them to want the correct answer was huge for me. It was then that I realized that this intervention was going to be much different than I planned. It was going to take longer to implement not because the students were not necessarily getting the concept, but because they wanted more than what I had planned to provide. I could not deny the students of such knowledge. Also, I was confident that this would not be the end of crazy-time consumers such as early dismissals, winter carnivals, and fire drills.

Week 3 (Jan. 7- Jan. 11)

I was very concerned that I had to schedule my intervention with a two-week pause for winter break. However, overall, it did not seem to make much observable difference at

all. We returned on January 7th, a Monday. I was able to refresh students on division knowledge and teach the next lesson. So, Tuesday marked the fourth prompt in the intervention and the first prompt since returning from break, simultaneously. The prompt was:

How is using a number line to divide similar to using a number line to multiply? How is it different?

This should have been a familiar concept for the students, because using a number line was one of the main strategies the curriculum used for modeling multiplication and division. When the prompt went up, so did the hands, and an abundance of call-outs. Numerous "I don't get it" and "I don't remember" grumbles could be heard over the clamor of other confused students. After five minutes, many papers were still blank. It was almost as if the initial shock of having to do something on their own in general set them off track (or was it writing about math specifically that caused the breakdown?). However, I am glad I rode out the wave and continued to have the students write because after another five minutes, the majority of students had found a groove and were diligently writing. Again, I modeled what I expected by composing answers to the question through class discussion and some teacher direction. Once more, the writing had taken an entire math lesson, and not just the 20 minutes I had allotted to it in my proposed intervention timeline.

Wednesday consisted of the next lesson in the text. At this point, we had moved from division concepts and into division facts. Therefore, Thursday's writing prompt that followed the lesson allowed for a procedurally-based answer and success did not hinge as

much on having a deep understanding and ability to express it through writing. The prompt was:

Can you divide 27 into equal groups of 5? Explain why or why not.

Immediately, students had some type of answer written on their papers. There were no questions, no grunts. Just students heavily engaged with their pencils, paper, and brains. Remember, prior to this prompt, this whole process of students writing and then modeling a correct answer took approximately 45 minutes. After 6 minutes, all students were finished. In fact, I was getting called to individual desks by many raised hands. However, it was not to answer questions or clear up misconceptions. It was because they were proud of their answers and wanted to show them off. It made me wonder if starting with this type of question at the beginning, introducing the more conceptual prompts later, would have changed things. We finished off the week with a lesson from the text on Friday.

Week 4 (Jan. 15- Jan 18) No School Monday

Within my districts math pacing, a teacher is allotted a specific amount of "flex days" within each trimester. Say there are 50 days of instruction in a trimester but only 41 math lessons to be taught. This means there are 9 flex days during that trimester. The teacher is given free reign on these days to use at their leisure for review, re-teaching, or, in my case, spending days writing about math. Well, my flex days were wearing thin and my chapter assessment score deadline was fast approaching and there was still plenty more to teach before that test had to be administered. Therefore, I took a short break from writing and to teach some lessons back-to-back. I did fit in one prompt on Thursday, however. It was:

1. Which of the division rules could help you find 295 ÷ 295?

2. Which of the division rules could help you find 486 ÷ 1?

My initial thought was that it would be another quick prompt in that the students only needed to rewrite the division rules that had been put up on our division bulletin board (see Appendix B for division rules posted to bulletin board) and, as expected, the students did not take very long. Less than ten minutes as a matter of fact. While short, it was intense. Within the first few minutes, I received on onslaught of "I don't get it" call-outs. Then, as they began to understand what was expected of them, they began to ask questions regarding how to form their sentences in their answers. They seemed uncomfortable with simply writing the division rule and unable to figure out how to add their own words to make their answer a complete sentence. During the last few minutes of the writing time, students were silently writing, looking up at the division bulletin board from time to time. Some even got up out of their seats and got closer to read and copy the words.

Jan. 22 – Feb. 6 (Intervention Break)

As stated below, my flex days ran out. I had to get back to teaching strictly content and move on to the next lesson so as to give the students a fair shot at doing well on their chapter assessments. So, practicing writing about math was put on hold.

Feb. 4 – Feb. 8

On Wednesday of this week, I administered the second and final district assessment on division. I was also able to get slightly ahead on my pacing which allotted me another flex day in which to administer my final writing prompt. This writing served as my post data. I had planned for many more writing prompts throughout the intervention, but we had come to a close with division and therefore a suitable place to end the intervention since the pre-data took place at the end of our study of multiplication. The prompt was almost

identical to the pre-data prompt as it pertained to the commutative property for this operation. The prompt was:

Can you switch the order of the dividend and divisor when you divide? Why or why not? Use words, pictures, and numbers to explain your answer.

The prompt went up, and students got to work. There were no major questions. One student was squinting at the board, obviously confused. As I observed, I saw her eyes go wide, her posture straighten, and pencil erect to be perpendicular to her paper, and got to work. I could have heard a pin drop; it was so quiet. All students were on task, with the exception of a new student who looked wildly confused to be writing about math, and they were done within five minutes.

Results

Baseline Data

Before discussing the results, it is important to know that I could only include thirteen of my twenty students in the data set that analyzes pre- and post-intervention results. I excluded students if they had either no baseline data, post-intervention data, missed large chunks of the intervention due to poor attendance, or any other circumstance, such as moving away or arriving as a new student mid-intervention.

As stated before, the first prompt served as the baseline data. It was intended to show how well the students could write about a mathematical concept that they were supposed to be well versed in: multiplication. As shown in the figure below, there were some general strengths and weaknesses.

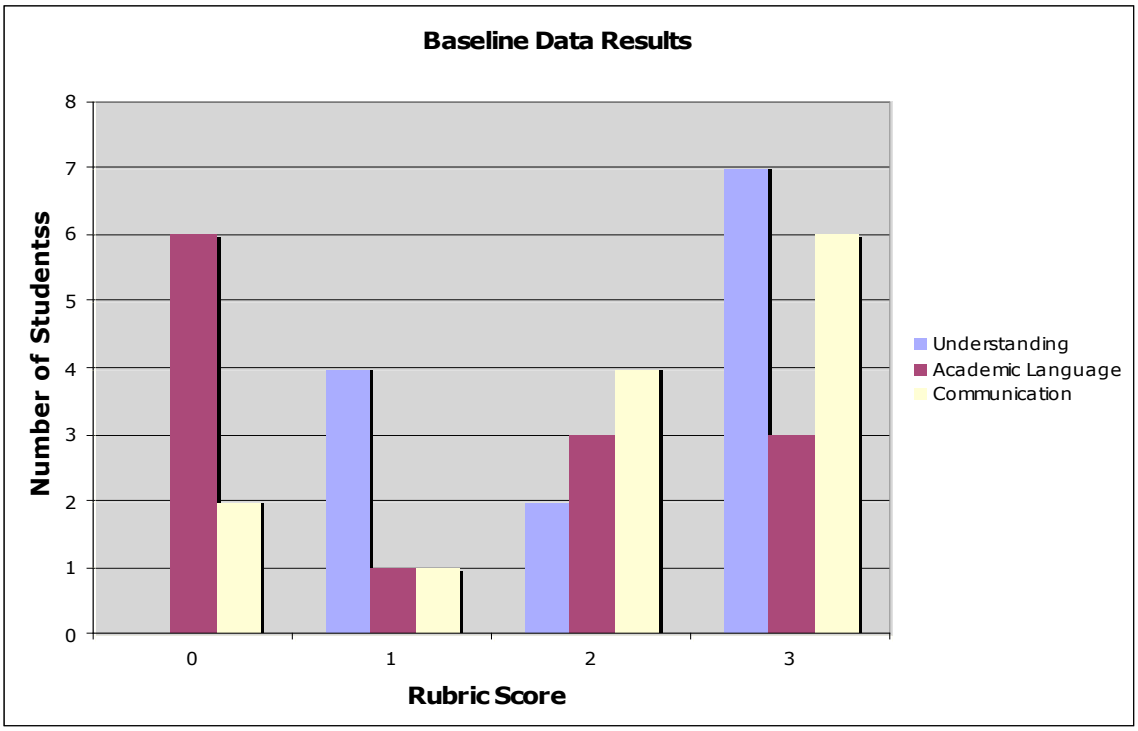

Figure 16: Baseline Data Results

In terms of understanding, and communication, the majority of students scored well. It showed me they understood the concept and communicated it through their writing. However, their academic language usage was the flashing red light. While many of them knew what they were talking about, they were not using the language that I knew they were capable of using since I would hear them use it orally on a regular basis.

Post-Intervention Data

Once the intervention had concluded, I saw a dramatic difference in many ways. The post-intervention data prompt engaged students to write about division and the commutative property (whether or not they knew it was the commutative property) the same way they were asked to write about multiplication. Below is a figure that shows how the students scored for this writing prompt.

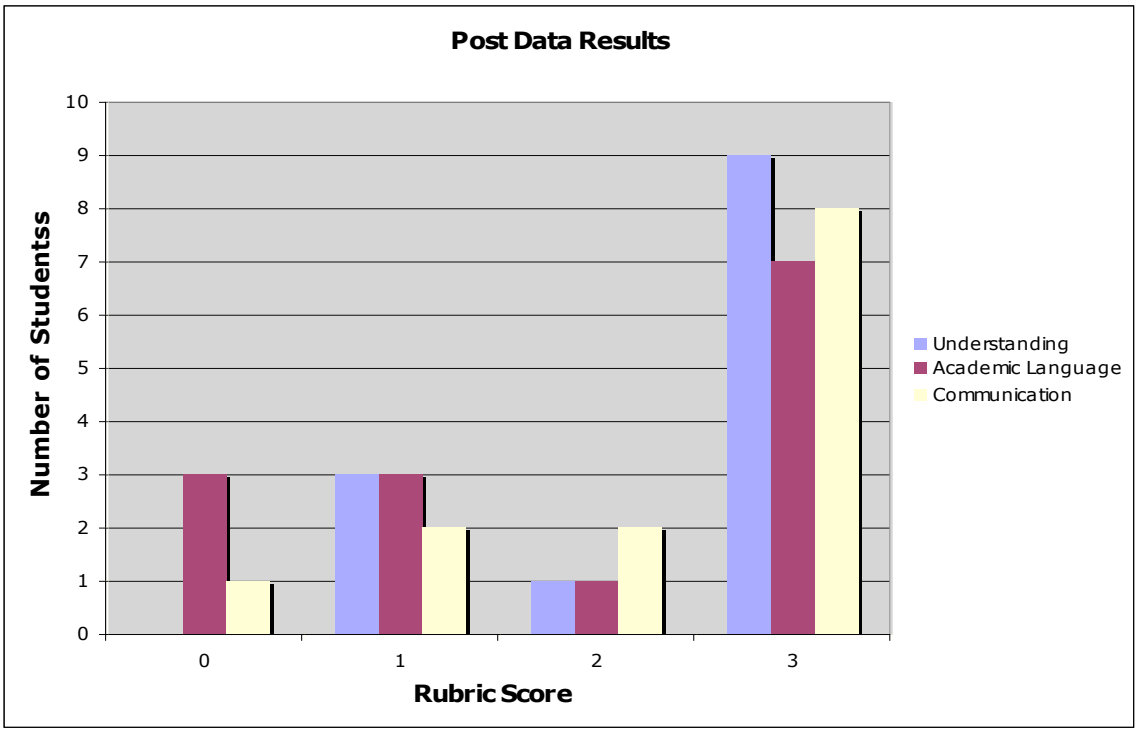

Figure 17: Post Data Results

It was obvious to me the growth they had made as a class with their abilities to write about math in all three categories. Below is a closer look at the results of each.

Pre- and Post-Intervention Data Comparison

Understanding and Communication

I felt it appropriate to discuss both of these categories together since they were already strong points for the students and because they both showed similarly slight amounts of growth. Below, figures 18 and 19 illustrate the change in both understanding and communication.

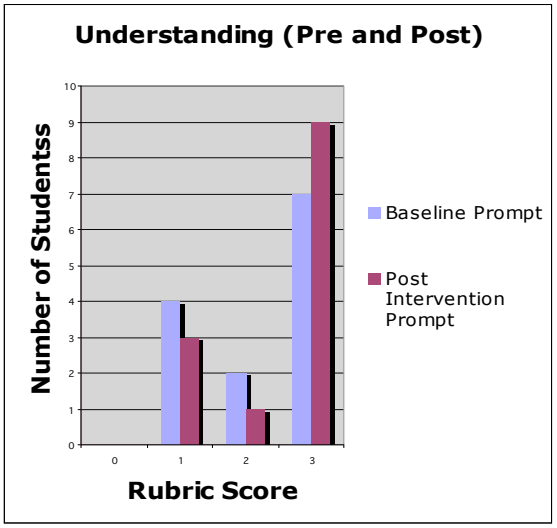

Figure 18: Understanding

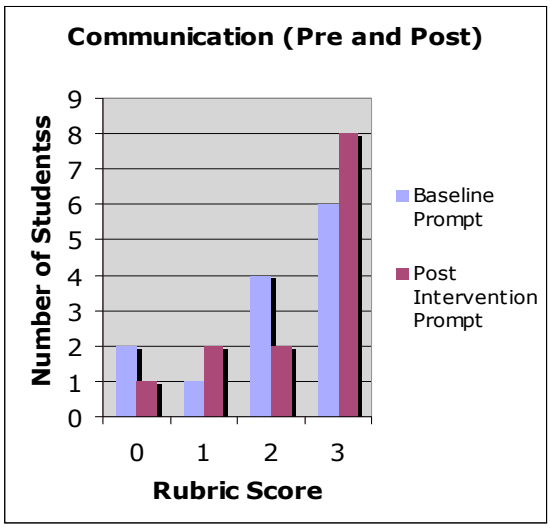

Figure 19: Communication

In understanding, two students had moved up to the highest rubric score of a three. This may not be a dramatic climb, but it was improvement nonetheless. It was a similar story for communication. I was pleased to see an increase (even if slight) of two students receiving the highest rubric score possible.

Academic Language

The category in which the most dramatic change took place was the use of academic language. Below, figure 20 demonstrates the dramatic difference in the correct use of academic language.

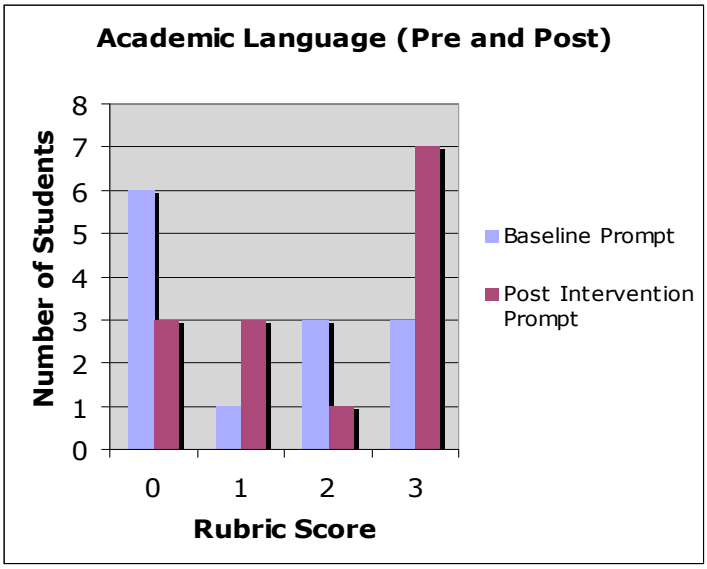

Figure 20: Academic Language

In the pre-intervention data set, the majority of students used no academic language whatsoever. The post-intervention data set is almost a mirror reflection in the opposite direction. At the conclusion of the intervention there were now four more students receiving the highest score possible for academic language usage. Examples of their writing are discussed in an upcoming section.

District Assessments

As stated earlier, district-generated, multiple-choice tests were administered at the conclusion of both multiplication and division. Figure 21 and 22 illustrate the difference in student achievement on these two tests.

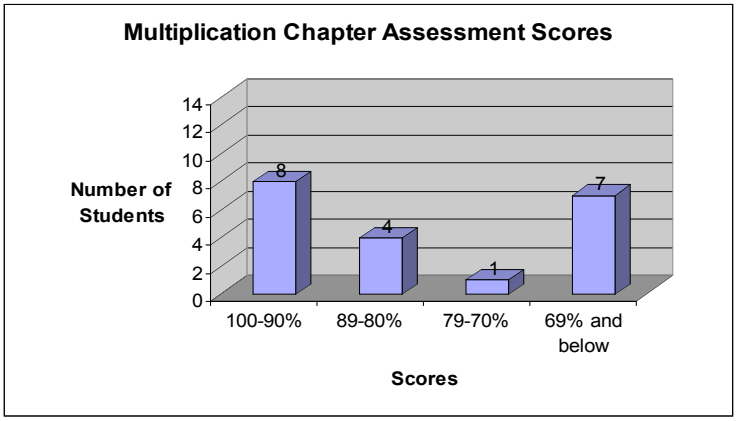

Figure 21: Multiple Choice Assessment Scores (Multiplication)

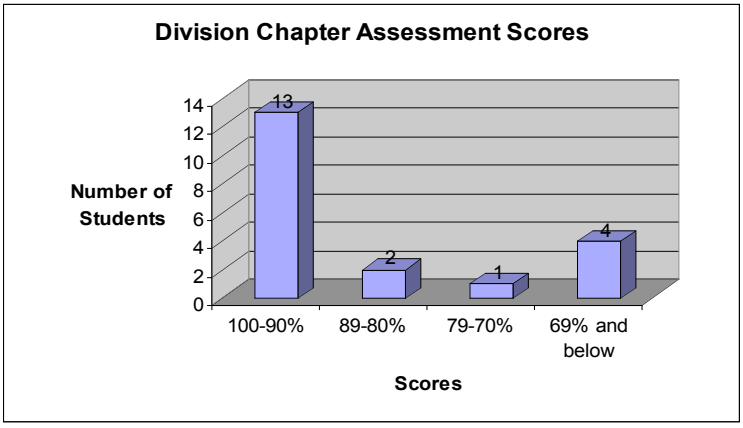

Figure 22: Multiple Choice Assessment Scores (Division)

As the data shows students did much better on the division assessment administered at the conclusion of the intervention than they did on the multiplication assessment administered at the beginning of the intervention. It is also worth noting that on the multiplication assessment, only three of the eight students that were in the 90-100% bracket received a score of 100%. However, on the division assessment, nine of the thirteen students in the same bracket received a score of 100%.

Focus Students

While as a class I observed overall growth in the three categories, there were also some general themes I was seeing as I interpreted individual student growth (or lack thereof) throughout the course of the intervention. Below is a discussion about what I had observed.

Student 1:

This student is an EL student whose primary language is Russian. She comes from an orthodox Christian family, so her long blonde hair is always pulled back in a pony tail, and even though we enforce a dress code, her clothing and garb always seem a little more basic and plain than the other students. She has learned to speak fast and softly to cover up her inadequacies with English. When asked to slow down her speech, her lack of specific words to describe things is evident. However, she has a positive disposition and is dedicated to learning and doing her absolute best. I will often notice in class, during math instruction especially, her writing on a little spiral bound pad of paper that fits in the palm of her hand. She writes on it secretly, with her hand and paper nestled inside the opening of her desk. When I first noticed her doing this, I figured she was doodling and asked her to put it away. After school, I checked the pad which she leaves in her desk. Page after page was filled strictly with academic content. I no longer have an objection to her "note taking." In fact, whenever I catch her doing this, she looks much like a young journalist to me, writing down all of her observations. It always brings a smile to my face.

I chose this student because she was one who made dramatic growth throughout the intervention. Below figure 23 illustrates how she responded to the baseline data prompt on multiplication.

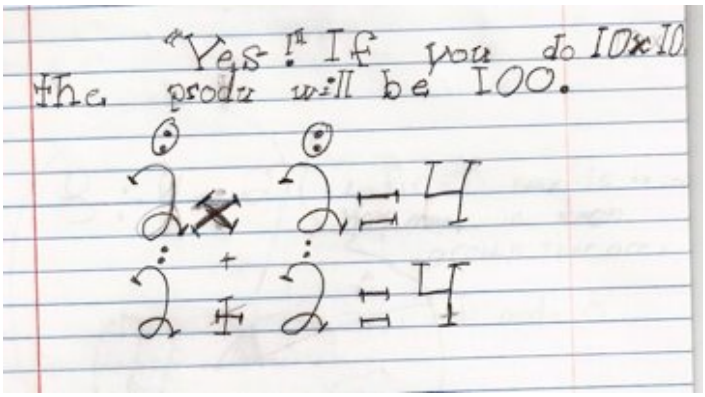

Figure 23: Student 1 Baseline Prompt Response

This first prompt consisted of a score of "1" in understanding and a "0" in both communication and academic language. A quick glance at this writing sample indicated little command over the operation of multiplication or at least what was being asked of her. However, she scored well on her multiple-choice test on multiplication that she took within days of this writing prompt. My guess is that her struggles with English were holding her back from showing how much she really knew.

Within a few prompts, her communication and understanding dramatically improved and stayed consistently strong for the most part throughout the rest of the intervention. Her usage of academic language crept at a much slower rate. However, by the end of the intervention, she was able to correctly use key academic terms to relay her thoughts and knowledge about division. Figure 24 illustrates her improvement with her post-intervention data prompt response. In this response she used the terms "divide" and "negative". While her assertion that $3 \div 12 = 0$ is incorrect, she does know that division is not commutative.

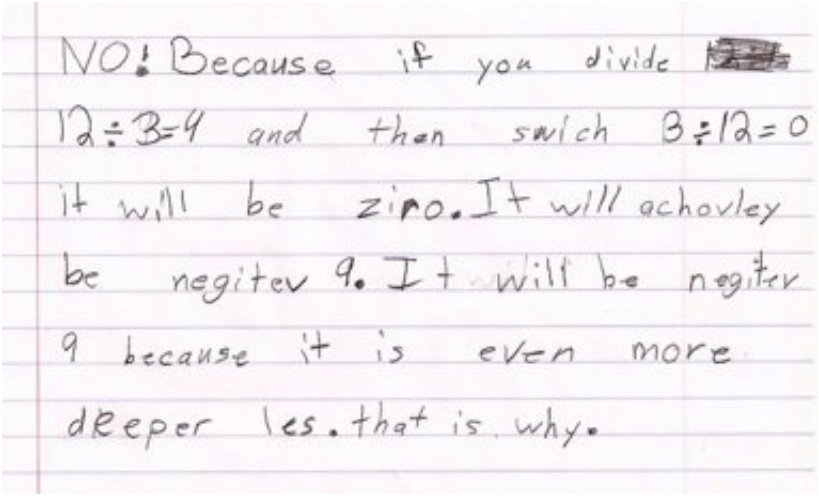

Figure 24: Student 1 Post Prompt Response

Student 2:

The second focus student showed a lot of growth in a specific area. In his case, it was academic language. While each student was different, there were quite a few who made dramatic changes within one of the categories being assessed. This student is one such case.

He is a skinny little guy with a bushy, overgrown hairdo. He is extremely artistic, drawing pictures that far exceed my abilities and he has a knack for origami. In fact, he has a miniature piano made out of paper that stays erect on his desk. This student was born in Mexico, speaks and understands the Spanish that other students speak, yet is not classified as an EL student. I have since discovered that it is due to the fact that his grandparents have taken legal custody of him and when they enrolled him in school, they checked the box that English is his primary language. Therefore, no further action was taken. However, I have observed that he struggles with the same things that other EL students have a hard time with, such as a short delay before he speaks, using prepositions correctly, and properly conjugating verbs. He usually takes a long time to complete any type of assignment, but will usually stay

focused and work hard until it is finished. He is also a student who has been steadily improving his test scores all year long. Figure 12 shows his response to the baseline data prompt. He answered the prompt with accuracy and successfully incorporated numbers and pictures to justify his response. The use of academic language, however, was non existent.

This student had no observable trouble understanding the concepts and then being able to put them in writing. Even with the second prompt in which the majority of students struggled, this student showed that it made sense to him. However, his usage of academic language was non-existent at first. Then, it started to show. With the exception of one prompt, once he began using academic language, he continued to do so with accuracy. Figure 25 illustrates how, by the end of the intervention, his communication and understanding were still strong and he had begun using academic language. He correctly used the terms, "dividend" and "divisor", and his example showed a strong understanding of division.

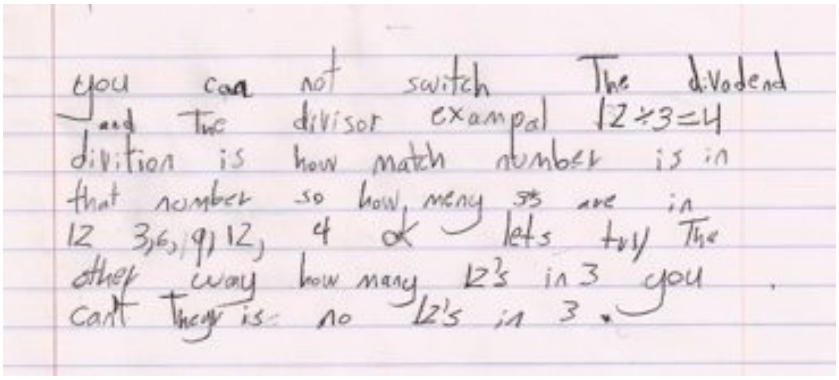

Figure 25: Student 2 Post Prompt Response

Student 3:

The final focus student that I would like to highlight was a student who showed little or no growth throughout the intervention. She is a Hmong student who has been with me for

the entire year. However, she would spend the majority of her day with what our district calls an "E-lert." This is an acronym that stands for English Language Resource Teacher. She received one-on-one instruction from the beginning of the day until after lunch. Therefore, she was always in my classroom for math instruction. Her growth in English was so rapid that at the end of the first trimester the E-lert and I decided that after winter break, we would try to see how she did as a full-inclusion student. So far, she has been doing well.

She is a tiny, little student with a lot of spunk and attitude. She is consistently able to crack jokes with her hoarse, scratchy voice that makes the entire class giggle. She is energetic and enthusiastic about participating in class, even though she struggles with a language barrier. Her English is at a level to where most of her oral sentences consist of a noun followed by a verb. Articles and prepositions are almost non-existent in her speech, but she is able to get her point across and communicate at a sufficient level.

There were a total of five students who had similar results. It is important to note that they were not all students who started off with zeros and remained in the zero category. Some showed no growth because they received the highest scores from the beginning and continued to do so throughout the intervention. Others stayed within a range of ones or twos. This student, however, was one who did not fair well and whose data shows that the intervention may not have been the best way to address her specific needs. Figure 26 shows her response to the baseline data prompt that was administered.

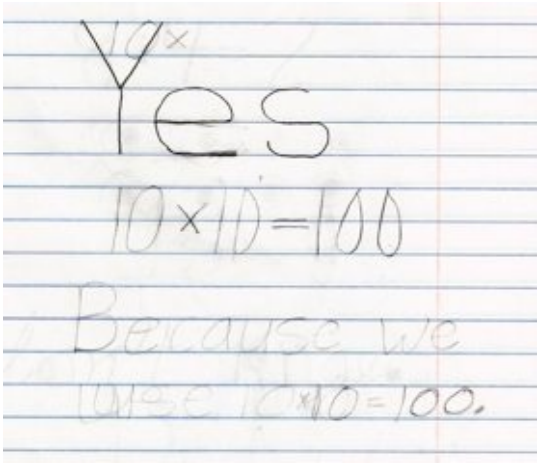

Figure 26: Student 3 Baseline Prompt Response

She answered with a big giant "yes." The answer is correct, yet there is no communication as to why she thinks this is the correct answer. I also wondered whether she came up with the answer herself because her erased reasoning has matched the example her neighbor, focus student 1, used as an example for her prompt answer (see figure 23). Figure 27 shows her response to the post-intervention data prompt.

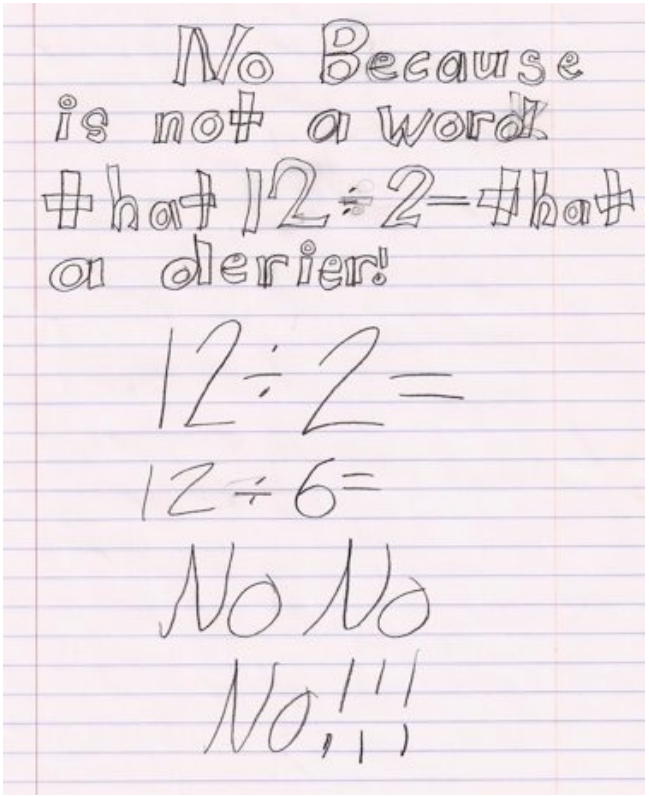

Figure 27: Student 3 Post Prompt Response

While her efforts to communicate improved, it was still hard to figure out what she was trying to communicate. While I could make assumptions about what she was trying to convey, it is difficult to determine understanding through what she was able to produce on paper. Lastly, the use of academic language was non-existent in both prompts, as was true with the rest of her writing. For students just beginning to develop conversational English, it may be inappropriate to expect them to produce academic language in their writing. Perhaps symbols and pictures should be sufficient.

Student Attitudes:

Probably the most powerful part of the intervention was observing how student's attitudes toward math and writing about math changed. During the long break at the end of the intervention and also once it had ceased, I constantly received questions about when we were going to practice our math writing again. They wanted to write about math. Before the intervention, I would have to constantly ask students to sit up straight or have to hear grunts and groans as we transitioned to math; now students have started writing on their own during math instruction! It was simply amazing to me. I recall looking up at one point during a recent math lesson and noticed about eight students with paper out, diligently writing down everything we were talking about (much like they did when we would hold discussions to model the correct answers to the prompts) without me asking them to do so. Some even made their own visual aids at home and (against my wishes) taped them to their desk. Seriously, I do not know how they do this stuff under my nose without me noticing.

Conclusion/Reflection

In this case, I found that when I incorporated writing and a strategy for promoting academic vocabulary into every math lesson, my students were better able to incorporate academic language into their communication about their mathematical understanding. One reason for such a dramatic growth in strictly academic language could be that understanding and communication were already in place for students (hence the strong baseline data and slight growth shown with post-intervention data), therefore allowing students to improve on *how* they communicate their understanding through writing with academic language. Another reason is that it seemed that stressing academic language worked for my students. Being engaged in pre-lesson activities, having the word wall as a resource, modeling correct usage, and simply expecting them to use it seemed to produce a profound effect on them. I had noticed that students were even beginning to use academic language that was not provided in the prompts. Figure 28 demonstrates the usage of extra academic language.

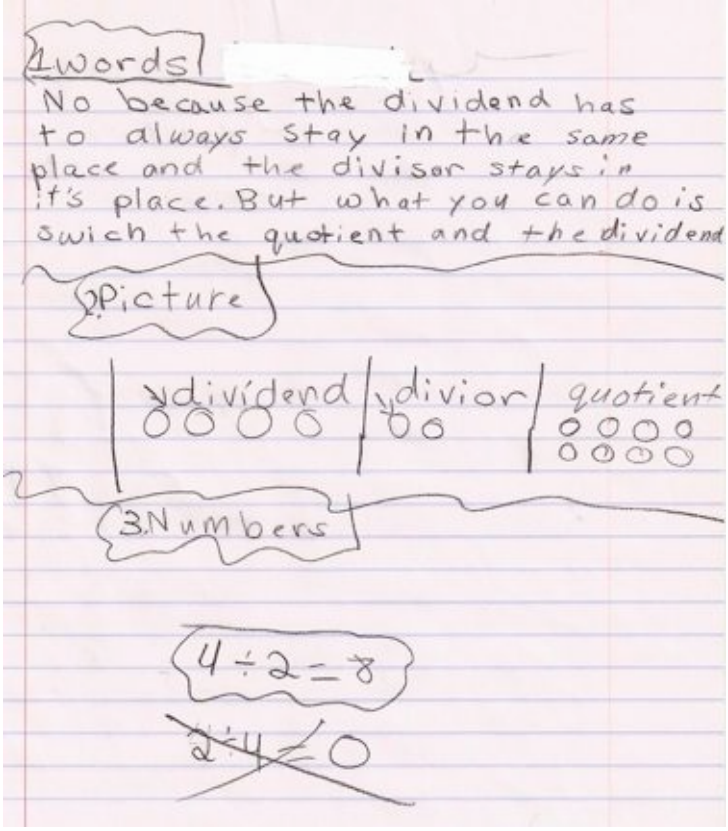

Figure 28: Extra Academic Language Usage

The academic words provided in the prompt were "divide," "divisor," and "dividend." The student incorporated the academic term "quotient" in addition to the others that were provided to her.

I wonder how the results would differ, for better or worse, if the difficulties I faced throughout the intervention had not been present. Primarily, the strict regime set by the district was the most difficult of all. Deviating from the curriculum had me constantly afraid of someone popping into the classroom for an unannounced visit/observation. It was this fear that kept me from veering too far from the curriculum, even if students were demonstrating a need for a change in instruction. The next largest difficulty was student absences. While this was an issue that was out of my control, students not in attendance

stopped me from being able to include more of them in my data set for a more encompassing view of the effects the intervention had on all students.

Also, the study did not go as planned. The most relevant difference being the time spent between the sixth and seventh (final) prompt being administered. This had much to do with the above-mentioned strictness of pacing set by the district. While post-intervention data scores may have been even higher if the students were given the prompt earlier, there is an upside to such a long break between the last prompt and the post data prompt. The amount of time provided evidence of retention of what students learned throughout the course of the intervention.

If I was given an opportunity to redo the intervention, I would do two things differently. First, I would likely spend **much more time** teaching the students to write *about* math**.** I would likely plan lessons about writing throughout the course of the intervention. This intervention was primarily: teach content, write about it, and quickly construct an answer with the time we had left. Beyond teacher modeling, I would have liked to teach such things as complex sentence structure so as to form complete answers to questions as well as teach conventions and organization in order to create clearer answers and not streams of consciousness in which the students strictly wrote exactly what they were thinking. This leads me to the second thing I would change. I would throw the curriculum out the window in terms of coming up with the writing prompts. Not to say that the curriculum is bad for students, just bad for my intervention. It was the curriculum's lack of practicing writing about math that was failing them in terms of effectively taking their reasoning tests in the

first place. I felt boxed in by trying to stick as closely to the curriculum as possible to create fidelity in case I would have to defend my decisions to slightly deviate. The main issue I had with the prompts was that some were procedural and others were conceptual. Nonetheless, they all had a specific answer. I would have liked to prepare open-ended prompts that allowed the students to write what they knew about a lesson or concept so I could more easily see where the breakdowns in understanding were occurring for students. Using the prompts from the curriculum only led students to answer correctly, incorrectly, or with "I don't know."

I learned much from conducting this study, scheduling issues and constraints considered. I agree with Gunning in that writing is not only a form of communication, but a tool for learning as well (Gunning, 2005). I think that giving the students a chance to write about what they learned helped them see whether they themselves had retained the information. Then, creating the modeled answers may have served as an opportunity to clear up any confusion. This is demonstrated by the division multiple choice test scores I administered at the end of the intervention, which were dramatically higher that the scores for multiplication. There are a number of possible explanations for why the students did so much better. One possibility is that one test was easier than the other. However, it is my opinion that they were of equal caliber. Another reason may simply have been time on task. As a result of the intervention, we spent more time on division than on multiplication. However, I feel that the addition of writing about math may have played a role in the increase of student achievement. I also found, as earlier stated by Van De Walle, that the writing served as a great assessment tool for me as a teacher (Van De Walle, 2007). I was able to see

which students understood, did not understand, or had a misconception about the concept. Figure 29 shows an example of how I was able to see that students were not grasping a concept, prompting me to spend a little more time ensuring a better understanding.

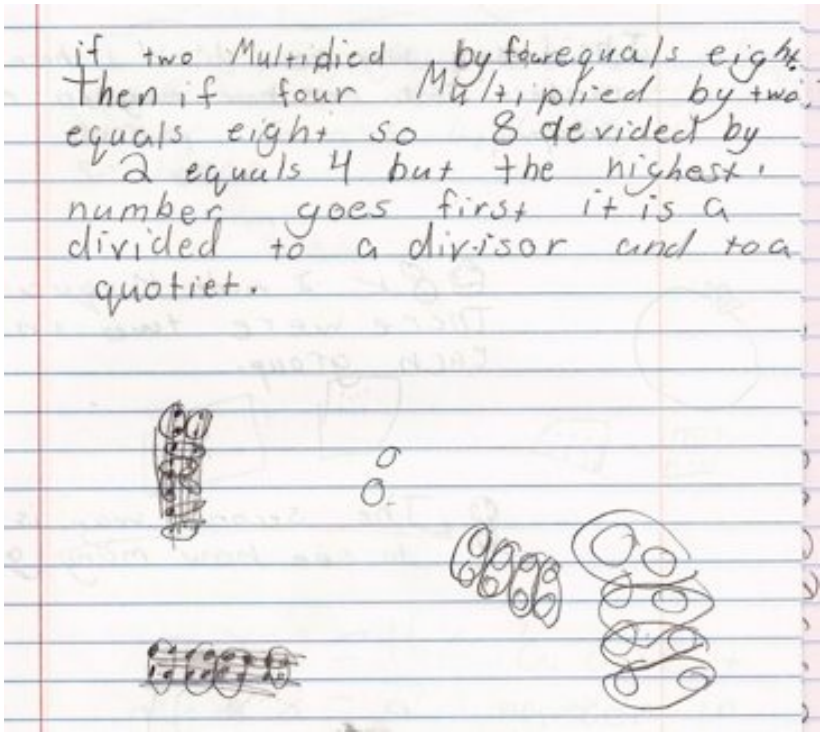

Figure 29: Ongoing Assessment

This student was being asked to show two ways to view division. The answer was "how many in each group" and "how many groups." She was not the only student that had a misunderstanding. Therefore, I found it appropriate to review this concept the following day.

Before, I was only receiving feedback through chapter tests, which are administered after the concept is through being taught. If the students scored poorly, there was no time to change the following lessons to help them. By then, it was already time to move on. If there is one thing that other teachers could take away from this study is that writing is a powerful tool on many levels. It will help assess, teach, and all around empower your students.

While this study is through, my quest is not over. I still plan to continue exploring different ways to boost student understanding about mathematics. For example, I mentioned

that I would like to try teaching students specifically how to write about math. I wonder if this type of instruction could bridge the gap between what students know in their heads and what they can put onto paper in other math topics such as geometry, which is much heavier in terms of academic language. I still want to end the mathematician's writer's block.

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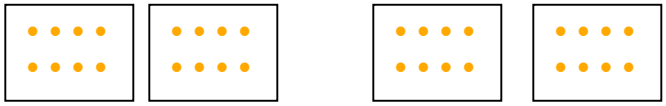
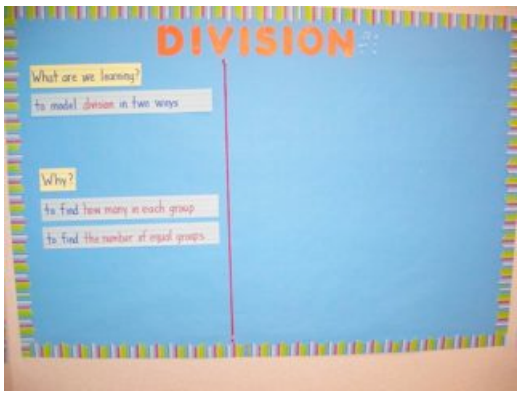
Appendix A

Intervention Writing Prompts

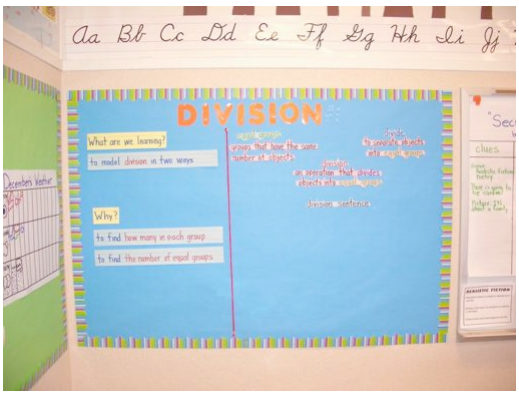
Prompt#	Date	Prompt
1 (Baseline Data)	12-12-07	Can you multiply the factors of a multiplication sentence in any order? Use words, numbers and pictures to explain your answer.
2	12-14-07	Describe two ways to divide 8/4 = 2. Use words, numbers, and pictures in your answer.
3	12-19-07	Look at each number sentence. Why are the product and the dividend the same in each sentence?  2 X 8 = 16 Product 16 ÷ 2 = 8 Dividend
4	1-8-08	How is using a number line to divide similar to using a number line to multiply? How is it different?
5	1-10-08	Can you divide 27 into equal groups of 5? Explain why or why not.
6	1-17-08	Which of the rules above could help you find 295/295? Which of the rules above could help you find 486/1? (See lesson for rules)
7 (Post Data)	2-7-08	Can you switch the order of the dividend and divisor when you divide? Why or why not? Use words, pictures, and numbers to explain your answer.

Appendix B

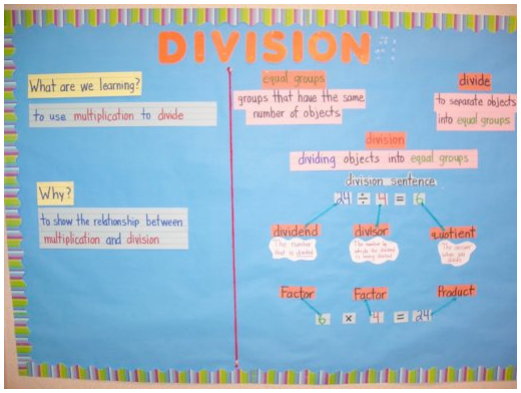
Division Bulletin Board Images



12/12/2007



12/14/2007



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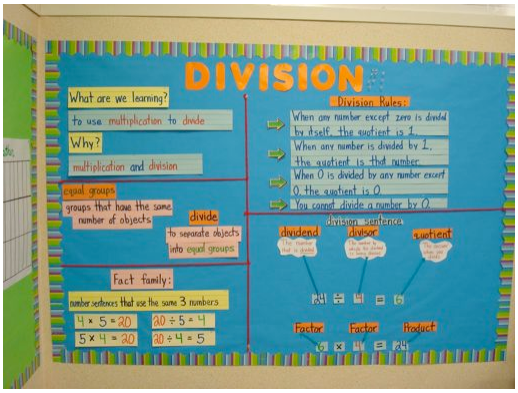

1/17/2008

Appendix C

Original Intervention Timeline

Date	Lesson	Concept	Writing Prompt
12/12	8.1	Modeling Division	• Baseline Data Collection Multiplication Concept
12/13	8.1	Modeling Division	None (lesson not finished)
12/14 (Minimum Day)	8.2	Relate Multiplication and Division	• Describe 2 ways to divide 8 objects into equal groups. • Model writing
12/17	No School - Parent Conferences		
12/18 (Minimum Day)	8.2	Relate Multiplication and Division	None (lesson not finished)
12/19 (Minimum Day)	8.3	Divide by 2	2 X 8 = 16, 16 = 2 X 8 (display arrays) • Look at each pair of number sentences above. Why are the product and the dividend the same? • Model writing
12/20 (Minimum Day)	8.3	Divide by 2	None (lesson not finished)
12/21 (Minimum Day)	8.4	Divide by 5	• How is using a number line to divide similar to using a number line to multiply?
12/24 – 1/4	Winter Break	Winter Break	Winter Break
1/7	8.4	Divide by 5 (general review)	None (lesson not finished)
1/8	8.5	Problem Solving	• Can you divide 27 into equal groups of 5? Explain why or why not. • Model writing
1/9	8.6	Division Rules	• How does

			knowing that 5 X 4 = 20 help you find 20/5?
1/10	8.7	Divide by 3	• Which of the rules above could help you find 295/295? • Which of the rules above could help you find 486/1?
1/11 (Minimum Day)	8.9	Divide by 4	• Can you divide 19 into 3 equal groups? Explain why or why not.
1/14	No School – Professional Development Day		
1/15	8.9	Divide by 4	None (lesson not finished)
1/16	8.10	Problem Solving	• How are the dividends, divisors, and quotients related in the problems 16/2 = 8 and 32/4 = 8?
1/17	Final question (post data collection)		