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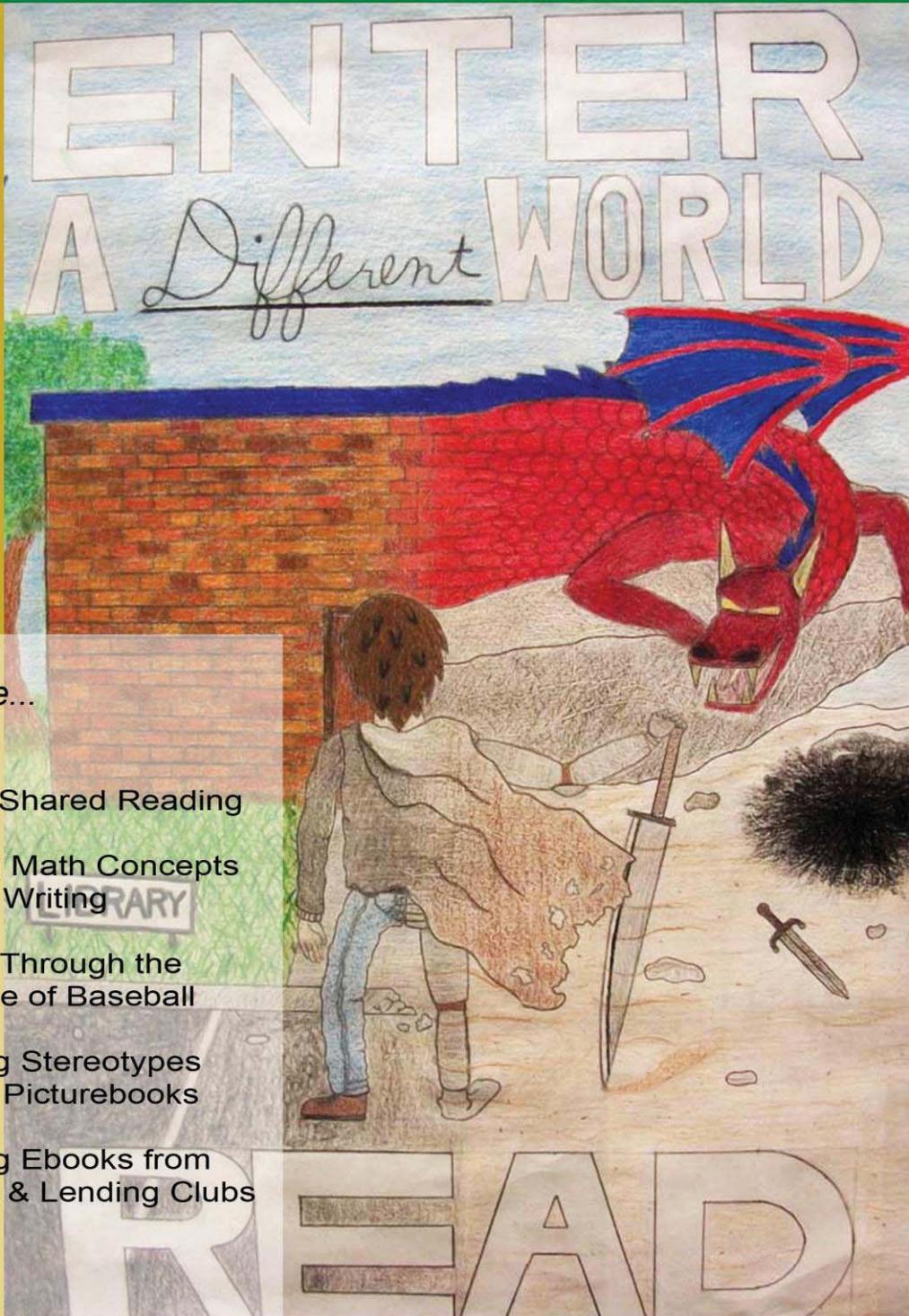
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It All Adds Up: Utilizing Writing Strategies in Mathematics

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Abstract: As the emphasis on mathematics increases across the country, so does the need for a better understanding of teaching methods that effectively reach students and increase their math achievement. To this end, an action-research study was conducted during a third- grade mathematics class. The goal of the study was to determine if the implementing writing strategies in mathematics would increase students' knowledge of the particular math skills being taught. Three research-based writing strategies- journal writing, strategy cards, and quick write- were implemented over a nine week period, each for three- week phase. Following each phase, the method was reviewed and students progress assessed based on teacher-made rubrics and pre- and post-testing of the taught math concepts. The results indicate using writing strategies, these students' math achievement increased.

Introduction

Students' writing in the content areas gives the responsibility of learning back to the student. They become responsible for questioning what they have learned, making clarifications for what they have learned, and writing to explain what they have learned (Gammill, 2006). This also gives teachers a more realistic view of what students actually know. Writing in the content area should not become a writing lesson, yet the students should be writing to learn (Duke & Pearson, 2002; Fisher & Frey, 2004). "Mastery of content is demonstrated not only through reading but also through writing" (Knipper & Duggan, 2006, p. 462). It is important to remember when implementing writing in a content area that the main focus is writing to learn not learning to write (Fisher & Frey, 2004). The students should be writing to improve comprehension and understanding of content and knowledge presented in the classroom through strategic strategies, not partaking in a writing lesson. Gammill (2006) states writing to learn make the students more active learners, not passive learners. The issue for this paper is, "Will student writing during mathematics instruction increase math achievement?"

Literature Review

Writing in the Content Areas

Langer and Applebee stated that although writing might slow the flow of the class, it allows valuable opportunities for students to write what they learn in their own words and extend their thinking (1987). As stated by Knipper and Duggan (2006), writing in the content areas gives the students the chance to "recall and clarify" information that is new to them and that they are processing. When writing is implemented in the content area, students comprehension is not only increased, but the ability to recall, describe and truly understand the material is also increased (Knipper & Duggan, 2006; Meltzer, 2010). Writing is a bond between reading and comprehension (Britton, 1972). The students can write their points of confusion as well as any areas about which they have further questions. This process of writing in the curriculum also assists students to reflect on their learning and to "think critically" about the material (Gammill, 2006; Knipper & Duggan, 2006). Quick Writes, Journal Writing / Learning Logs, and Strategy Cards are all examples of writing to learn strategies (Fisher & Frey, 2008; Fisher & Frey, 2004; Meltzer, 2010).

A research study conducted by Boscolo and Mason (2001) showed how writing in the curriculum increased student achievement in science and history. The subjects in the study were fifth- grade students, who were being observed to see if writing was a means of thinking and reasoning. There were four results Boscolo and Mason found in this study: 1) students were able to write and manipulate the information that supported history; 2) writing assisted students in a better, more increased understanding of history topics; 3) writing in history transferred to writing as a tool to learn in science; and 4) students who were able to transfer the writing from history to the writing of science had a deeper conceptual understanding of new material. Boscolo and Mason showed that writing is a major tool for learning, which can transcend all content areas within education.

Working Memory

Meltzer (2010) states that working memory “enables students to hold auditory, written, or visual information in the mind long enough to understand a sequence of words and ideas, and allows students to retain facts so they can be formulated into expressive language in the form of verbal statements, written sentences, or coherent paragraphs” (p. 113). Meltzer (2010) states that working memory has a major impact on students’ academic achievement. Meltzer states that working memory can be improved with specific strategies, such as Quick Writes where the students take a minute during instructional time to write down key points or ideas that are implemented into and throughout the content areas.

Meltzer (2010) stresses the importance writing has on working memory and a child’s increase comprehension. Writing and increased comprehension were researched by Block and Parris (2007) to be interrelated with one another. Block and Parris (2007) stated that working memory was a component of

increased comprehension.

Quick Write

Fisher and Frey (2008) state a Quick Writes is a writing to learn process that will assist in the enhancement of a child’s comprehension. This is an activity that will be beneficial and appealing to lower achieving, exception students due to the fact that they are only required to write for a short time (Mason, Benedek-Wood, & Valasa, 2009). This strategy is flexible and widely accessible to both teachers and students, and easy for teachers to use. It can be used at the beginning, middle, and end of the lesson to assess the students’ progression through the content (Mason, et al., 2009). Quick Writes in mathematics can be done while a new concept is being introduced and taught to a class. The teacher can stop every periodically to allow the students one minute to write all the key concepts that were just introduced.

Cain, Oakhill, and Bryant (2004) performed a study that supports the use of working memory and increased comprehension ability. The participants in the study were eight, nine, and eleven year- old students. The purpose of the study was to see the connection between working memory and reading comprehensions. The students were give two working memory assessments looking at digit working memory and sentence span, as well as comprehension tests. The results of the study showed that there is a direct connection between comprehension monitoring and working memory, but that comprehension monitoring does not fully rely on working memory (Cain, et al., 2004).

Learning Logs / Journal Writing

Another strategy to enhance comprehension in mathematics is structured learning logs / or journals (Fisher & Frey, 2004; Smith, Rook, & Smith, 2007). Several researchers and teachers are encouraging the use of learning logs in the math class to show students’ ability to justify

and explain problem solving (Quinn & Wilson, 1997; Pugalee, 1997). Learning logs with structured prompts guide students through the recall, question / clarification process to keep them on task (Knipper & Duggan, 2006). Journal writing gives the responsibility of learning to the student as well as gives them the opportunity to reflect on their own learning (Smith, et al., 2007).

Questions or prompts in both learning logs and journals are not meant to drill the students, yet they are in place to explore the students learning through guiding them to be higher order thinkers instead of just students who just recalls the basic facts (Smith, et al., 2007; Knipper & Duggan, 2006). Posing open-ended questions allows for students to have diverse journal entries outlining what they actually know, not just giving simple / expected responses (Whitin & Whitin, 2000). As Brandenburg (2002) states, it is important to provide a rubric to students so they are clearly aware of the expectations set forth.

A study done to see the affects of journal writing in mathematics was implemented by Lim and Pugalee (2004) from York University and the University of North Carolina Charlotte, respectively. This study was conducted from February to June of 2004. The purpose of the study was to see what connection there was between learning math and journal writing. The subjects were tenth-grade students in Ontario. The questions posed by this study were: 1) what effect does expository journal writing have on students' learning of mathematics? 2) What are students' views of journals? During the study, the students were given a notebook with 32 pages in it. The students were to write in this notebook for ten minutes numerous times a week at the end of their math class. The writings were scored by a set rubric, and the students were given specific questions to address. The students' results, as measured by the rubric, all increased. Due to the results of the study, the classroom teachers continue to

use math journals with their students. Even though the study was done with tenth grade students, the researchers stated they believed journal writing in math would be effective throughout all grade levels.

Strategy Cards

Another writing strategy that increases comprehension in mathematics is the use of strategy cards (Meltzer, 2010). This strategy allows the students to not just write what they have taken away from the content they have been provided, but it also allows them to draw a picture, or write how they will be able to later recall the information. Meltzer (2010) states this is a great way to assist the brain with the working memory process and, additionally, gives students a way in which they can think about how they will later recall the information. Swanson et al. (1999) stresses that drawing a visual can be a form of "chunking" which is easier for students to process and store for later use as well as being easier for them to recall. Chunking is highly effective in increasing the children's memory ability since the children do not have to retain a large amount of information, just "chunks" that will assist with recall (Swanson et al., 1991).

Writing in mathematics increases a students' working memory which will in turn increase their comprehension ability of a specific skill taught. When students are actively participating in their own learning, progress will be made. Three main writing strategies which have been studied in other content areas in which students actively participated are now implemented into mathematics.

The Study

School Setting

This study was conducted at Northeast Elementary school in Lakeland, Florida. This is a school located in an urban area of central

Florida in one of the largest counties in Florida, Polk. Northeast was ranked an A school as measured by FCAT scores as mandated by No Child Left Behind, NCLB in 2008-2009. In the 2009 – 2010 school year, Northeast dropped to a B school and in the current school year, 2010 – 2011 Northeast has fallen to a C school. Northeast currently has five third grade units all at maximum capacity of 18, as mandated by the class size amendment in September 2010.

Class Description

The participants were Mrs. Thompson's third-grade inclusion class. Her class had eighteen students, eleven girls and seven boys. In this third-grade class, three boys and one girl were identified with special needs, two boys were awaiting psychological testing after having been through the Response to Intervention (RtI) process and two others, one boy and one girl, were beginning the RtI process. This class did have one retaineer in third grade due to her failure on the previous year's FCAT scores. An Exceptional Student Education (ESE) teacher spends half the day with the class.

Participants

Two high, two middle, and two low students were chosen for this research based upon their Discovery Education test scores from August 2010. These scores represent the students' knowledge of third grade material they have not yet been presented with or learned. Pseudo names have been given to the

students. The high group consists of Antoine, who scored 61% and Gail, who scored 57 %. The middle group consists of Allison (35 %) and Brittany (39%). The low group consisted of Sarah (22%) and Reese (26%). During the period of implementation of these three specific writing in mathematic strategies, two additional Discovery Education tests were given. The second round of testing was given in December 2010, and the third round was given in February 2011 (see Table 1).

Mathematics Curriculum

On a daily basis in Mrs. Thompson's third-grade class, her students received their mathematics curriculum instruction from GO! Florida Math series (Houghton Mifflin, 2010). This was a new series to the county which was adopted at the end of the 2009-2010 school year. The math block of time was an uninterrupted sixty minutes a day. Mrs. Thompson, and the ESE teacher, Ms. Pitts co-taught math during whole group instruction and pull small group instruction as needed for the remainder of the block time. The students also received math mini lessons focusing on specific math skills for thirty minutes a day and were quizzed regularly and progress was monitored each Friday. All third grade students in the county are receiving the same instruction with these scripted lessons.

Table 1. *August and December 2010 Discovery Education Scores*

Student	August 2010	December 2010
Antoine	77%	93%
Allison	47%	73%
Gail	70%	83%
Sarah	23%	30%
Reese	30%	37%
Brittany	47%	43%

Data Collection

Data has been collected in numerous ways: (a) Artifact data of students’ actual products: journals, Quick Writes, as well as Strategy Cards, (b) The pre and post tests, and (c) observations.

All students in the class were given all materials; the six chosen for the study were closely watched. After each concept was taught using a specific strategy, it was documented how well the students did through anecdotal notes by both the primary observer and the participant observer, our ESE teacher.

During the period of research, three different research- based writing strategies were implemented for two weeks at a time. The three types of writing strategies included: Quick Writes, Learning Logs or Journals, and Strategy Cards (Fisher & Frey, 2004; Meltzer, 2010). Before any strategies were modeled and implemented, a pre-test with all mathematic skills that were covered were given to all students. The pre-test covered three different skills that were taught in the mathematics curriculum: multiplication, division, and fractions.

The students’ success on the post test, which was given after each skill, was taught and subsequently three weeks after the skills were taught, was assessed and compared to the pre-test. By looking at how well the students did on a topic in which one specific strategy was utilized, the researcher was able to determine which strategy was most beneficial.

Data Analysis

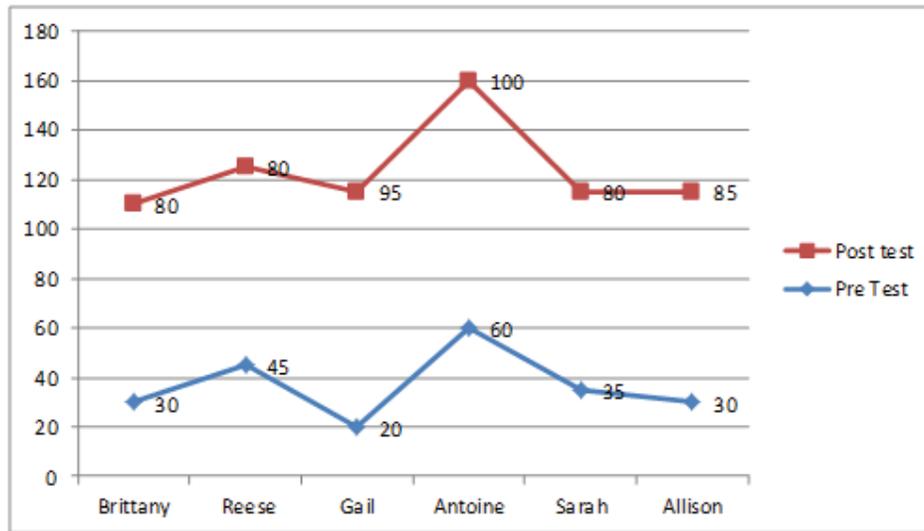
Data from the writing strategies in the mathematics curriculum were collected and assessed. The students’ journal writing was analyzed along two dimensions: summarization and organization. Their Quick Writes were analyzed across three dimensions: meaning, organization, and summary; and their Strategy Card along three dimensions: graphic, legible handwriting, and summarization. These aspects were used for analysis because summarization is a focus of the school. Meaning was also found to be important so that the teacher would know if the student was taking accurate meaning from the lesson. For the Strategy Card, legibility was picked so that the teacher would be able to clearly interpret the drawing and that the graphic had some relation to the topic. All math tests given, for multiplication, division, and fractions, were analyzed to determine which strategy was the most beneficial to the student’s math achievement.

Table 2. Students’ Mathematics Journal Writing Rubric Scores

	10/11/10		10/15/10		10/18/10		10/22/10		10/25/10		10/29/10	
	M	O	M	O	M	O	M	O	M	O	M	O
Brittany	1	1	2	1	2	1	1	1	2	1	2	1
Reese	1	1	1	1	1	2	1	2	1	1	2	2
Gail	1	1	1	2	2	1	2	2	1	2	3	2
Antoine	2	1	2	1	2	1	3	1	3	1	3	1
Sarah	1	2	2	2	2	2	2	2	2	3	2	3
Allison	1	2	1	2	2	2	2	2	2	3	2	3

Note: M = Meaning O = Organization

Figure 1. Pre and Post Test Multiplication Scores



Results

The results of the analysis indicated that journal writing increased the mathematics comprehension of my students in mathematics more than the other strategies. As seen in Table 2, while some of the organization scores remained consistent, all students showed gains in their meaning scores. This is supported by the students’ achievement on their multiplication test. As shown in Figure 1, all participants in the study increased their scores on a post multiplication test at the end of the three week implementation period. Antoine scored the highest on both the pre and post test with a 60 and 100 respectively. He also scored the highest on his Discovery Education assessment, which was at 61% of third grade

material known previously to beginning the year (Discovery Communications, 2011). The next greatest increase in scores was from Gail who scored 20 and 95 on her pre and post test respectively, which is an increase of 75%. Both Antoine and Gail scored the highest on their journal writings in meaning, both receiving a 3.

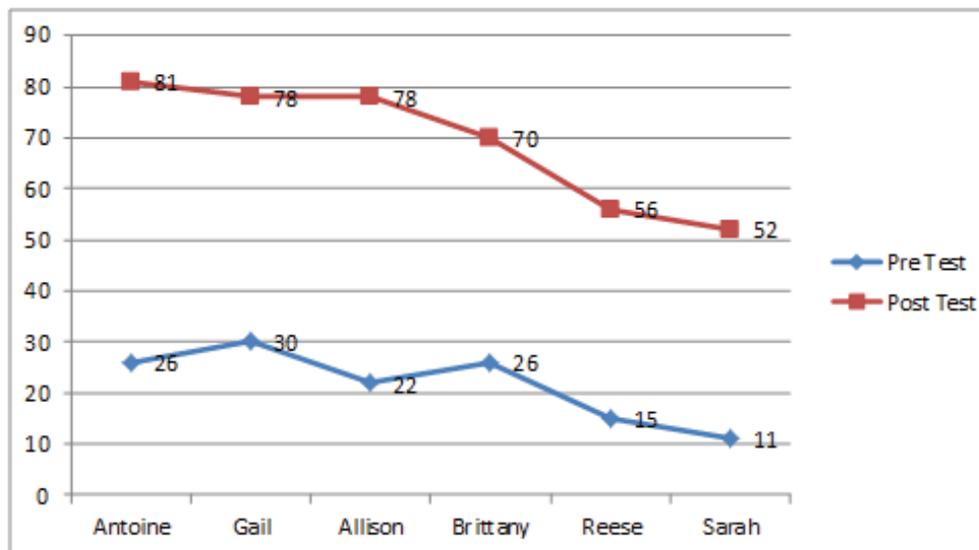
The Quick Writes strategy was implemented for division. The students in the lower achieving group, Reese and Sarah, struggled with making them meaningful and having thorough summarizations as scored by a teacher made rubric (as seen in Table 3). The organization of the Quick Writes was also a problem due to the fact that the students were asked to write as much as they could think of and many of the thoughts written were not easy

Table 3. Students’ Mathematic Quick Writes Rubric Scores

	11/15/10			11/17/10			11/29/10			12/1/10			12/6/10			12/8/10		
	M	O	S	M	O	S	M	O	S	M	O	S	M	O	S	M	O	S
Brittany	1	1	1	1	1	1	1	2	1	2	1	1	2	1	2	2	2	2
Reese	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1	1	2
Gail	1	1	2	2	1	2	2	2	2	2	2	3	2	2	3	2	2	3
Antoine	1	1	2	1	1	2	2	1	3	2	2	3	2	2	3	2	1	3
Sarah	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2	1	1	2
Allison	1	1	1	2	1	1	1	2	2	2	2	3	2	2	2	2	2	3

Note: M = Meaning O = Organization S = Summarization

Figure 2. Pre and Post Test Division Scores



to follow. Gail, Allison, and Antoine were all able to score a 3 in summarization by the end of the three week implementation period (as seen in Table 3). These scores correlate to the high scores they received in mathematics on the Discovery Education test and the multiplication post test (Discovery Communication, 2011).

Antoine and Allison both had an increase of 60 points on their pre to post test, while Gail had a 50 point increase (as seen in Figure 2). These three students also made the highest mathematics gains according to their Discovery Education (2011) testing in both December 2010 and February 2011. The least amount of gain was made by Sarah with only a 32 point gain (as seen in Figure 2). Sarah also had the lowest increase in scores on both her December 2010 and February 2011 scores in mathematics.

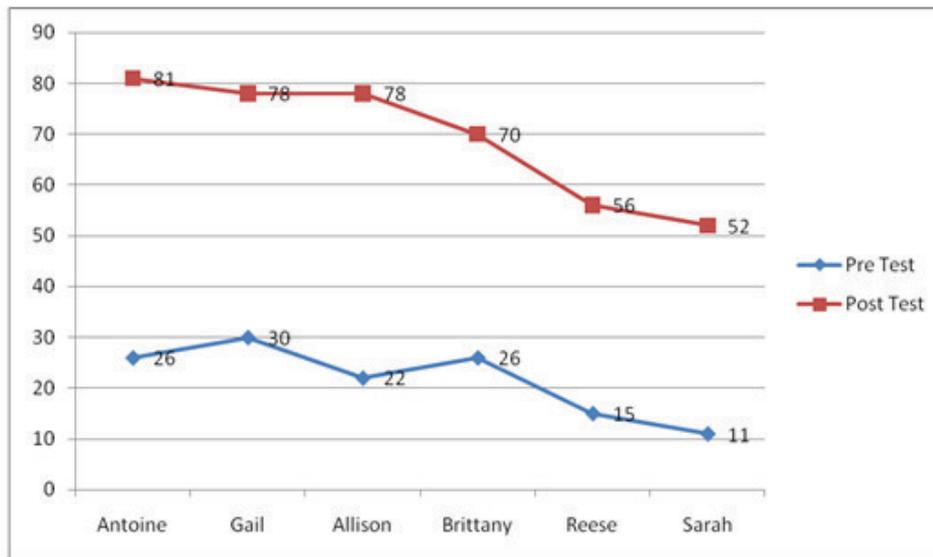
The third writing in mathematics strategy that was implemented and assessed was the use of Strategy Cards. By the end of the implementation period, only Gail and Allison were able to score a 3 in the summarization category on the teacher made rubric (Table 4). Brittany, Reese, and Sarah were still all producing work that resulted in a 1 based on the rubrics scoring for summarization for their lack of details given on the topic of fractions that was being taught for that particular day. Looking at the pre and post implementation fraction test, Allison made the most gain with an increase of pre and post test scores of 56% as shown in Figure 3. Antoine was close behind with an increase in scores of 55%, followed by Gail with 48% (see Figure 3).

Table 4. Students' Mathematics Strategy Cards Rubric Scores

	1/18			1/20			1/25			1/27			2/1			2/3		
	G	L	S	G	L	S	G	L	S	G	L	S	G	L	S	G	L	S
Brittany	1	2	1	1	2	1	1	2	1	1	3	1	1	3	1	1	3	1
Reese	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1
Gail	1	2	2	1	2	2	1	3	2	2	3	3	2	3	3	2	3	3
Antoine	1	1	2	1	1	2	2	1	2	2	2	2	2	2	2	3	2	2
Sarah	1	1	1	1	2	1	1	2	1	1	2	1	1	2	1	1	3	1
Allison	1	2	1	1	2	2	1	3	2	1	3	2	1	3	3	2	3	3

Note: G = Graphic L = Legible S = Summarization

Figure 3. Student's Pre and Post Test Fraction Scores



Discussions / Implications

An overall conclusion that can be drawn from this study is that all scores from the pre test to the post test increased for all participants. The greatest increase for the participants based on the pre and post multiplication test scores were achieved by Antoine and Gail. I would conclude that the more thought and detail they each put into answering their own prompt is what led to the dramatic increase in their test scores. The more thought placed on what was learned made the skill more meaningful to them. This is similar to the study performed by Lim and Puraglee (2004). In their study, the participants who wrote in their journals had an increase in their scores on their skill specific assessments as well.

The increase in grades from the division pre to post test (Quick Writes strategy) as compared to the multiplication (Journal Writing strategy) could be due to the fact that division and multiplication are inverse operations of each other and having the background knowledge and being able to associate the two could have caused the improved scores and comprehension of the topic. Both Reese and Sarah have struggled overall because the memorization of basic facts, such as addition

and subtraction, which still present an issue for them. Because Gail, Allison, and Antoine were able to manipulate and comprehend the math they had been taught, they were able to do well with division and the Quick Write strategy.

As Cain et al. (2004) found in their study, my students were actively engaged with the Quick Writes strategy. Every few minutes they would write down some key words, or point, that related to the topic that would reinforce what they were learning. I believe this active involvement is what led to Reese's increase of 44 points and Sarah's increase of 32 points on their division pre and post tests. This seems consistent with Mason et al. (2009) when they stated that lower achieving students, such as Reese and Sarah, would be actively engaged and enjoy a strategy such as Quick Writes. While the girls were the most involved with this strategy, this strategy did not lead to improved math achievement for these girls. However, the lower achievement in scores could correlate to the lack of prerequisite skills needed to multiply and divide, such as skip counting that neither of the girls could do on a consistent basis.

Based on the rubrics, the use of Strategy Cards led to the lowest overall growth of the students. All of the participating students'

graphics and meanings were often hard to understand and quite often, very off base from the lesson. Reese, Sarah, and Brittany were always asking the teacher how to make a picture that represented what was just taught. They had a very hard time creating personal links to what was taught and their pictorial representation. Swanson et al. (1999) states that using a visual for the students to recall a specific item learned is a great way the students can chunk information. I do believe if they had had some pre-made graphics that could assist them with the chunking process, as stated by Swanson et al. (1999), this could have been very effective.

Throughout the study, Reese and Sarah were the lowest achieving students on the tests as well as rubrics. Both stated these strategies were something that they had never done before. Reese stated that she had only done worksheets and flashcards and had never been exposed to other methods. Having never before been exposed to mathematics strategies, especially writing ones, and due to the lack of implementation time of each strategy could have led to, not just her lower achieving test and rubric scores, but that could also have played a part in Sarah's as well.

In conclusion, writing in mathematics is important to do. All students incorporated in the study did make gains, even though some may not have been as significant as others. It would have helped if I could have used each strategy longer than I did. As seen in this study, different writing strategies will work well for different children and, as with anything in education, the teacher must know their students. Journal writing was the most effective strategy in this study and closely correlates to what Lim and Puraglee (2004) saw in their study and is a strategy that I plan on continuing to use.

Lori Folsom Thompson is a recent graduate from University of South Florida Polytechnic with an MA in Reading.

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