MATH JOURNALING IN
THIRD GRADE

by

Julie L. Jones

An Abstract
of a thesis submitted in partial fulfillment
of the requirements for the degree of
Education Specialist
in the Department of Elementary and Early Childhood Education
University of Central Missouri

May, 2018
ABSTRACT

by

Julie L. Jones

The purpose of this research was to investigate the effect of using math journals in a third-grade classroom on the third Mathematical Practice, construct viable arguments and critique the reasoning of others. This mathematical practice was assessed with a pretest and posttest. The students were assigned journal questions throughout the semester. A rubric was designed with three categories: problem solving, reasoning and proof, and communication. Each category was assessed with a rating scale of one to four. The results were then analyzed with descriptive statistic and with a T-test. The mean change for Problem Solving was 2.0 out of 4.0. Reasoning and Proof had a mean change of 1.7778 out of 4.0. The change for Communication was 1.3333 out of 4.0. The total mean change was 5.1111 out of 12. The T-test results were significant with a 2-tailed score of .000 in each of the three categories and the total. The research supported the conclusion that math journaling has a positive impact on the ability to construct viable arguments on mathematical problems, thereby improving mathematical learning.
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CHAPTER 1
NATURE AND SCOPE OF THE STUDY

Statement of the Problem

Many of our students today are not learning the mathematics they are expected to learn or need to learn, as cited in the National Council of Teachers of Mathematics’ (NCTM) Principles and Standards for School Mathematics (NCTM, 2000). They offer various reasons for this deficiency—which include an absence of equitable opportunities for all students, weak curriculum that lacks student involvement and commitment, and an insufficient overall quality of mathematical instruction. “There is no question that the effectiveness of mathematics education in the United States and Canada can be improved substantially,” (NCTM, 2000, p. 5).

Many students in our public schools are taught mathematics by rote learning, memorizing facts, and learning standard algorithms to solve for the “right” answer using the “right methods.” The instruction and teaching frequently places the emphasis on the correct completion of the problem. Often, grading systems are also focused and based upon the number of correctly completed problems a student has finished on a given task.

Mathematical instruction and teaching that lacks student involvement and commitment leads to an absence of comprehension and the inability to express the mathematical thinking process. Students are not able to easily relate one concept to another, build on their prior knowledge, or make the learning their own. They do not gain a deep understanding of mathematical concepts needed in today’s world.
Background

As mathematical educators and education move forward, it is imperative that the focus on mathematical instruction and teaching move from rote calculation to a deeper understanding of mathematical concepts. Students need to participate and be actively engaged in their mathematical learning. They should be able to explain their reasoning and demonstrate their mathematical thinking. They need to develop a sense of responsibility and ownership in their thinking, the processes they use, and the ability to communicate their thinking to others.

To assist mathematics teachers in this effort, the National Governors Association Center for Best Practices and the Council of Chief State School Officers (2010) have jointly published eight Standards for Mathematical Practice. The Standards for Mathematical Practice are designed to move instruction, teaching, and learning from mere memorization of processes and algorithms to thinking deeply mathematically with an understanding of the mathematical processes and methods used.

To “Construct viable arguments and critique the reasoning of others,” is the third standard of the Standards for Mathematical Practice. This standard focuses on a student’s ability to explain or justify their solutions to a given problem while showing an understanding and the ability to use assumptions, definitions, and previous results. Proficient students can make conjectures and analyze situations, while using counterexamples in those analyses. In addition, they are capable of justifying their work in ways that they are able to teach other students, and students can understand the mathematical thinking being explained. Finally, this standard includes the ability of students to be able to compare multiple possible solutions.

Math journals have been found to show a difference in a student’s ability to demonstrate mathematical thinking and communication (Kostos and Shin, 2010). Math journals provide
students with an opportunity to develop deep mathematical thinking by encouraging them to communicate their ideas. This ability to improve thinking and the communication of mathematical ideas falls directly in the parameters of standard number three, constructing viable arguments and critiquing the reasoning of others. Journaling provides opportunities for students to use mathematical vocabulary when explaining and justifying solutions. It provides students opportunities to experiment and show multiple methods and solutions to solving problems. When journaling, students communicate their ideas and compare their own thinking with that of their peers.

Journaling provides for individual differences among students. They are a non-threatening way for students to communicate. They give each child the “think time” that may be required for them personally. Journaling also provides students with the opportunity to work at their own level. Students can use manipulatives, charts, diagrams, illustrations, words, and a variety of other means to communicate their mathematical thinking. Journals provide opportunities for student to ask questions, as well as reflect on their own learning and understanding.

**Purpose of the Study**

The propose of the study is to determine if using math journals to write, explain, illustrate, and demonstrate the mathematical thinking a third-grade student used when solving a given problem will improve his or her ability to construct viable arguments on mathematical problems, thereby improving their mathematical learning.

**Research Question**

What can improve students’ mathematical thinking and their ability to construct viable arguments? Would writing in math journals assist in this endeavor? These questions are the
driving force behind this project and the following research question: Does the practice of using math journals positively impact a third grader’s ability to construct viable arguments when solving mathematical problems?

**Organization of Remaining Chapters**

The remaining chapters will focus on this research question. Chapter Two, The Review of Literature, provides some background and techniques on mathematical journaling that others have used. Chapter Three describes the methodology used for this project including the participants, the test question, and the rubric used to show if there were improvements in the students’ mathematical thinking and their ability to construct arguments. The results are given in Chapter Four and Chapter Five consists of the discussion of this research.
CHAPTER 2
REVIEW OF LITERATURE

The teaching of mathematics has been a topic of much debate over the years. Who should be taught? Just a select few that are “capable” of mastering mathematics or all students? What should be taught and when should it be taught? Are there certain mathematical skills that should be taught in isolation? Should learners understand the “why” of mathematics? How should mathematics teachers best teach mathematics? What are the best practices?

In this study, third grade students were asked to keep a math journal for one semester in which they responded to various mathematical problems several times each week. The students were assessed with a pretest and posttest question where their ability to construct viable arguments was measured with a rubric. The ability to construct viable arguments included the student’s ability to accurately solve the problem, show multiple strategies when solving the problem, and to clearly communicate their findings in writing.

This chapter has been divided into three main sections. First, the need for effective teaching is addressed. This movement from rote memorization to higher levels of thinking will lead to learning with a deeper level understanding of mathematics. This is followed by a closer look at the mathematical practice of constructing viable arguments and critiquing the reasoning of others and how this practice will promote mathematical success. Finally, math journaling is discussed as a positive classroom strategy to promote and accomplish this desired level of mathematical understanding.
Effective Teaching Leads to Learning with Understanding

Today’s practices need to be improved for the effectiveness of mathematics education to meet the demands in this changing world. The National Governors Association Center for Best Practices and the Council of Chief State School Officers led an initiative that resulted in a set of mathematics standards. Published in 2010, the Common Core State Standards for Mathematics (CCSS-M) include both content standards and mathematical practices standards to promote mathematical education. The NCTM is an organization that is committed to helping mathematics teachers reach these new levels of mathematical understanding that are vital today. The work of this group established the foundation for the Common Core State Standards.

There are eight standards for mathematical practice that have been published to assist with this movement towards a richer and deeper understanding of mathematics. According to Conley, Trinkley, and Douglass (2014), the (CCSS-M), is a list of rigorous guidelines that outlines “what” content to teach, whereas the Standards for Mathematical Practice provides understanding into “how” to teach mathematical content (p. 99). This difference will lead to students having a better understanding of mathematical concepts and becoming mathematically proficient learners. As outlined in the CCSS-M, The Standards for Mathematical Practice include:

1. Make sense of problems and persevere in solving them. This standard focuses on explaining the meaning of a problem and describing possible approaches to a solution. Students should also consider similar problems to gain insight in solving the given problem. The use of concrete objects or illustrations is also encouraged. Monitoring and evaluating their progress and changing strategies is another element of this standard. Finally, learners should be able to check their answers using a
different method than they used to solve the problem, (Van De Walle, Karp, & Bay-Williams, 2013).

2. Reason abstractly and quantitatively. For this standard, learners should be able to explain the relationship between quantities and write expressions or equations that fit the problem. They should also be flexible in their ability to use different properties of operations and objects, (Van De Walle, Karp, & Bay-Williams, 2013).

3. Construct viable arguments and critique the reasoning of others. This standard assists the learner to understand and use assumptions, definitions, and previous learning to explain or justify their solution. Students should be able to make conjectures, analyze the situation, and use counterexamples. They are expected to justify conclusions, communicate them to others, and compare arguments, (Van De Walle, Karp, & Bay-Williams, 2013).

4. Model with mathematics. Proficient students apply mathematics to everyday life and they can make assumptions and estimations on problems. They identify important quantities and use tools to demonstrate their relationships. They also reflect on the reasonableness of their solution, (Van De Walle, Karp, & Bay-Williams, 2013).

5. Use appropriate tools strategically. In this standard, a variety of tools are used to assist the learner in their problem solving. Estimation is encouraged to check for the reasonableness of a solutions. Technology is used to visualize, explore, and compare information, (Van De Walle, Karp, & Bay-Williams, 2013).

6. Attend to precision. This practice indicates students can communicate clearly using definitions and mathematical language. They state the meaning of symbols, units of measure, and use correct labels, (Van De Walle, Karp, & Bay-Williams, 2013).
7. Look for and make use of structure. This standard includes the learner’s ability to explain patterns and structures in mathematical contexts. A proficient learner can see problems as single objects or as being composed of several different objects and can explain why properties of operations are true and in which contexts, (Van De Walle, Karp, & Bay-Williams, 2013).

8. Look for and express regularity in repeated reasoning. Mathematically proficient students can solve problems by noticing repeated calculations, use general methods, justify the methods, and can utilize shortcuts in their problem solving, (Van De Walle, Karp, & Bay-Williams, 2013).

Mates (2016) states that it is important to consider what teaching these standards looks like. In addition, it is believed that these standards present an opportunity and a challenge to change the kind of teaching practice that will enable students to become mathematically proficient (Mates, 2016). These standards require a shift in thinking about what instructional techniques are used and how they are used. These standards “offer the chance to reflect on the way mathematics is taught and provide a focus on developing students who are ‘practitioners of the discipline of mathematics’ and not just consumers of mathematics” (Mates, 2016, p. 99).

Instructional planning needs to support the development of the mathematical practices by attending to the students’ thinking and reasoning in the classroom (Mates, 2016).

In addition to the Standards for Mathematical Practice, the NCTM, in *Principles to Actions Ensuring Mathematical Success for All* (2014) outlined Mathematics Teaching Practices to “provide a framework for strengthening the teaching and learning of mathematics” (NCTM, 2014, p. 9) The Mathematics Teaching Practices include:
1. Establish mathematical goals to focus on learning. Establishing clear goals, having goals within the learning progression, and using them to guide instructional decisions will lead to effective teaching.

2. Implement tasks that promote reasoning and problem solving. Students should be engaged in solving and discussing problems. The tasks should promote reasoning and problem solving.

3. Use and connect mathematical representations. Effective teaching encourages students to make connections, deepening their understanding of mathematical concepts and procedures.

4. Facilitate meaningful mathematical discourse. Students build shared understanding of mathematical ideas by comparing the approach and arguments of others.

5. Pose purposeful questions. Effective teaching poses questions that will advance a student’s reasoning and assist them in making important decisions about mathematical relationships and ideas.

6. Build procedural fluency from conceptual understanding. Students will be able to build on previous understanding and will be able to use procedures on a variety of math problems.

7. Support productive struggle in learning mathematics. Effective teaching provides students with tasks they will not easily solve but supports them in completing the tasks.

Regular tasks should be selected that engage high-level thinking. In the classrooms that promote these types of tasks, student learning is the greatest (NCTM, 2014). NCTM (2014) has defined higher-level cognitive tasks as those activities that allow for inquiry, exploration, or the use of procedures that are connected one to another in meaningful ways. Lower-level tasks encourage students to use procedures, formulas, or algorithms in ways that are not meaningful; these tasks encourage the use of memorized facts (NCTM, 2014). “For students to learn mathematics with understanding, they must have the opportunities to engage on a regular basis with tasks that focus on reasoning and problem solving and make possible multiple entry points and varied solution strategies” (NCTM, 2014, p. 23).

Representations includes the drawing of diagrams and using words to show meaning of a mathematical question. “When students learn to represent, discuss, and make connections among mathematical ideas in multiple forms, they demonstrate deeper mathematical understanding and enhanced problem-solving abilities” (NCTM, 2014, p. 24). Using representations, in the form of words, illustrations, charts, diagrams, and symbolic representations deepens student understanding.

Mathematical discourse includes the purposeful exchange of ideas through classroom discussion and written communication (NCTM, 2014). Discourse gives students opportunities to share ideas, clarify understanding, construct viable arguments, develop language, and learn other perspectives (NCTM, 2014). Providing opportunities for students to discuss, write, and share their mathematical thinking will lead to more effective teaching, and deeper thinking and learning.

Many educators can and will move their instruction toward a student-centered learning environment where the learning is meaningful, deep, and rich. Students who preform
mathematical tasks with little understanding and memorized facts or procedures are often not sure when or how to use what they know (NCTM, 2000). Effective teaching and learning connects prior knowledge to the task at hand, making the new knowledge more meaningful and useful (NCTM, 2000). Providing challenges for students with opportunities of exploration, comparisons, and reflection will further enhance student learning. “The kinds of experiences teachers provide clearly play a major role in determining the extent of quality of students’ learning.” (NCTM, 2000, p. 21).

Construct Viable Arguments and Critique the Reasoning of Others

This study focuses on the third standard for Mathematical Practice, construct viable arguments and critique the reasoning of others. Exploring this Standard for Mathematical Practice will give additional and more detailed information on the importance of constructing viable arguments. Promoting the practice and strengthening the discussions will also be addressed. Sharing ideas, investigating what is not a viable argument, and how preservice teachers experience this standard will be discussed.

The ability to construct viable arguments has been found to be a useful skill in developing mathematically proficient students. Rumsey and Langrall (2016) state, “We view mathematical argumentation as a process of dynamic social discourse for discovering new mathematical ideas and convincing others that a claim is true” (p. 414). Students provide evidence and reasoning to convince others that their claim is true (Rumsey and Langrall, 2016). Rumsey and Langrall found that presenting false claims was effective in teaching students that these invalid claims could be modified and improved; they also encouraged student to use precise language when validating a claim. “Encouraging students to ask, ‘What if__?’ enabled them to take ownership of the questions under investigation and lead the discussions that ensued
(Rumsey and Langrall, 2016, p. 414). With these processes, the instruction is diverted from the textbook and teacher to the students (Rumsey and Langrall, 2016), making a positive effect on the students and producing mathematically proficient learners.

Hintz (2014) states, “I wanted to promote a classroom that encourages problem-solving strategies and inquiry; where those discussions, arguments, and statements are the foundation of instruction” (p. 319). To promote this type of environment, she investigated several activities with students. “I learned that particular components of strategy sharing place noteworthy demands on students; specifically discussing mathematical mistakes, sharing strategies, and listening to classmates’ solutions” (p. 320). Along with strategy sharing, she found that, “Investigating errors provides a unique opportunity to examine mathematical principles, and children can collectively work toward a sound solution” (p. 320). Listening to peer solutions was also found to be important (Hintz, 2014). Listening to other’s solutions gave students the opportunity to compare their own solutions with that of others. Strategy sharing, discussing mistakes, and listening to others are all ways in which an instructor or teacher can promote constructing viable arguments.

“Students can construct their own understanding of problem-solving strategies,” according to Miller (2000, p. 136). By having the students research the problem-solving process itself, they can uncover ways to solve problems for themselves and construct viable arguments for their solutions. To begin, Miller (2000), had her students research a problem by having three individuals solve a mathematical problem. The students then convened to review and share with the class what strategies each of their subjects used (Miller, 2000). The third and final step in this activity was to have the students themselves make sense of each strategy and use it to solve their own problems, using any of the strategies listed on the board (Miller, 2000). Miller (2000) wrote:
This procedure increases the chance that problem-solving strategies will make sense and be useful to the students. Moreover, each student has an opportunity to think about her or his own presence of mind when solving problems, thereby developing metacognitive and reflective habits that serve them well as they continue their study of mathematics (p. 138).

Adams, Ely, and Yopp (2017) explain and define the characteristic of viable arguments and compare them to arguments that are not viable. For an argument to be viable, it must include the important mathematical idea to ensure that the mathematical learner understands the critical piece of the problem and it must explain how the relationships lead to the correct answer (Adams, Ely, & Yopp, 2017). “In mathematics, acceptable arguments are based on mathematical structures and relationships, and the rules of formal logic, not human behavior” (Adams, Ely, & Yopp, 2017, p. 298). Arguments are not viable if a narrative link does not explain the argument, nor if the mathematical idea is not identified. Furthermore, arguments are not viable if they fail to make use of the mathematical relationships or structures. Adams, Ely, and Yopp (2017) conclude that for an argument to be viable, it identifies the mathematical structures and explains how the correct answer resulted.

Johns (2016) asked preservice teachers to solve a mathematical problem and then share their strategy. Others, who were listening, were instructed to ask clarifying questions, and reflect on the others’ solutions. Most of the teachers had not had such conversations in their mathematics classrooms as elementary students. After the preservice training, Johns (2016) found that the teachers agreed that communication, asking clarifying questions, and reflecting on others’ solutions helped them gain a deeper understanding of the mathematical questions.

Constructing viable arguments is an important standard in moving mathematics instruction from low level thinking to higher level thinking. This standard emphasizes deep student thinking, while requiring a full explanation of the strategy employed. With the focus of
instruction and teaching moving from the teacher and textbook to the students, mathematically proficient students will more likely emerge.

**Math Journaling**

Math journals have many benefits. Lanley (2016, p. 6) writes, “Writing about math stimulates a different part of the brain than simply working the arithmetic alone, by using multiple parts of the brain during the learning process, the understanding is deepened and retention is increased” (p. 6). Burns (2004) cites, “Writing is a way to work yourself into a subject and make it your own” (1988, p. 16). According to Burns and Silbey (2001), “When children write in journals, they examine, express, and keep track of their reasoning; which is especially useful when ideas are too complex to keep in their heads” (p. 18). Burns (2004) writes, “Mathematics instruction should engage students in applying a variety of strategies for solving problems and teach them to monitor and reflect on their problem-solving processes. Writing enhances both skills” (p. 31). Pugalee (2016) cites four additional benefits to writing in mathematics:

1. Writing in the mathematics classroom promotes a deeper understanding of concepts and procedures. Writing helps students extend their critical thinking abilities well as the ability to link a new idea to relevant prior knowledge.
2. Encourages students to create their own problem-solving knowledge.
3. Promotes a metacognitive framework that extends students’ reflection and analysis.
4. Student’s mathematical knowledge is extended as a result of their writing in mathematics and reflects changes in their understanding of mathematical concepts changed over time. (p. 3)

The age and needs of students are considerations when deciding how to use math journals (Burns & Silbey, 2001). The uses of a math journal fall into three main categories that include assessing attitudes, assessing learning, and assess processes (Watson, 2017). Math journals can be used to evaluate students’ progress and recognize their needs and strengths (Burns & Silbey, 2001). Keeping journals and logs create an ongoing record of learning experiences, according to
Burns (2004). Journals can be used for daily assignments, to reflect at the end of class, to complete an assignment, or for special problems (Burns & Silbey, 2001). Burns (2004) suggests that not all journal writing must be on a math problem, but rather could focus on students’ learning during math class and what they enjoy, their strengths, or things they still do not understand. Lanley (2016) adds drawing to illustrate math problems or concepts and math vocabulary list to the possibilities of uses for math journals.

The frequency of writing in math journals varies. Whitin (2004), suggests that the first experiences with journals are done for several consecutive days, then as students become familiar with the process have them journal an average of two times a week. He also proposes to use journals at the beginning of a unit of instruction, in the middle, and then at the end of a mathematical unit to monitor student learning and understanding.

Many agree on the process of reading, responding, and grading journals. Burns and Silbey (2001) offer the suggestion to use journals to learn more about the thinking of students. They suggest avoiding generic comments when grading journals and encourage teachers to focus on making suggestions to nurture further thinking. Whitin (2004) suggests teachers read the journals once a week, and limit responses to reflect upon the student’s thinking. Whitin (2004) believes that grading should be based on the students’ thinking not necessarily on the correct answer. Lanley (2016) recommends reading the journals to gain an insight as to what your students understand and as an avenue to discover and address any errors in their thinking. Watson (2017) concurs by stating that reading the journals is far more important than assessing them.

To begin the math journaling process, Watson (2017), recommends a lot of modeling, and then the composition of several prompts done as a whole class prior to students writing on
their own. For a smooth and successful transition to math journaling, Burns (2004) suggests that there be a discussion time prior to the students’ writing, that writing prompts could be used, and the students share their writings in pairs or small groups. Maymind (2005) adds the suggestion of brainstorming a list of mathematical vocabularies during the whole group discussion. The students can reference this list as they write. Peer editing after writing will assist the students in make revisions that will help to clarify their thinking.

Math journals can provide valuable information on student understanding, learning, and development. They can assist students in becoming deep thinkers and mathematically proficient students. Williams and Wynne (2000) state, “We believe that journals are a valuable form of assessment for both students and teachers” (p. 135). Kostos and Shin (2010) found there to be a statistically significant difference on students’ overall scores after math journaling for five weeks. Math journaling is a means to creating and teaching competent high level mathematical thinkers.
CHAPTER 3
METHODS

This study is designed to explore the benefits of using math journals in a third-grade classroom to improve the students' abilities to construct viable arguments when solving mathematical problems. A mathematical problem will be given as a pretest and posttest question. The third graders will respond to the problems and be assessed on their problem solving, reasoning, and communication abilities of their mathematical thinking when solving the question. This chapter will focus on the specific methods used to conduct this study.

Setting

The setting for this research was a third-grade classroom in a small mid-western town. The population of the elementary school is approximately 350 students and included in the school were the grade levels Kindergarten through fourth grade. The district's total population is approximately 1300 students in Kindergarten through grade 12.

Participants

The participants were all the students that participated in the regular mathematics instruction from a single, third grade, regular education classroom. Additionally, the participants and their parents were required to sign consent and assent forms prior to the study. There were 19 students in the targeted classroom. However, data from only 18 students was obtained because one student was not in the classroom during journal writing. Of the remaining students, there were eight males and ten female participants. The students ages ranged from eight to nine. The majority of the students were from middle-class income families. The ethnic backgrounds of classroom participants included ten Caucasian, three African-American, three Hispanic, and two of the students being of other backgrounds. Generally, the students were physically healthy.
There were five students included in this study that had been identified as at-risk in mathematics by the district but that did not have an IEP for mathematics.

**Measurement Instruments**

A pretest and posttest design was used for this study. The pretest and the posttest consisted of the same subtraction word problem. The students were asked to solve it in multiple ways, explaining their mathematical thinking. The question was created by the researcher and selected for its capacity to use a variety of methods to solve it. The students could showcase the depth of their mathematical thinking by using multiple methods and arguments to analyze, justify, and compare how they solved the problem. See Appendix A for the original pretest and posttest question.

A rubric created specifically for this study was utilized to measure the students’ success. The rubric evaluated the students’ work in three areas: problem solving, reasoning and proof, and communication. Assessing the student’s work in these areas provided information on the student’s ability to construct viable arguments and their ability to support his or her thinking. Each of the three areas received a numeric rating ranging from one to four, with one being “Below Proficient” and four being “Proficient with Distinction.” This numeric rating system was chosen due to its compatibility with the school district’s current grading system. See Appendix B for the rubric.

**Procedure**

Each student received a paper with the word problem and was instructed to write the number previously assigned to them on the paper. Student work was analyzed using this number code in order to maintain confidentiality. The students were then asked to physically separate one from another and place dividers between them. The students were given the identical
question in August and again in December. The question asked the students to solve the subtraction word problem using as many strategies as they could while incorporating illustrations, diagrams, and a written explanation of their thinking and the strategies they utilized during the solving of the problem. There was no time limit set on the pretest or posttest to ensure every student was given sufficient time to complete the test question to the best of their ability. Upon completion of the question, the students’ work was analyzed using the rubric.

The students participated in a wide variety of math journaling activities during the time between the pretest and the posttest. During the instruction time, the students were asked to journal two to three times per week (See Appendix C for journal questions). To begin the math journal writing process, several of the prompts were modeled during whole class instruction by the teacher-researcher. The prompts ranged from reflective questions on mathematical understanding to mathematical concepts that had been previously taught. Students could use manipulatives, charts, diagrams, illustrations, number sentences, and words to communicate their mathematical thinking. Number talks were also included during the instructional period several times each week. Number Talks are quick, mini math lessons that allow the students to mentally solve problems in multiple ways and then share their thinking aloud to their classmates. These talks served as additional examples of deep mathematical thinking that orally reinforced the students’ abilities to construct viable arguments and to critique the reasoning of their classmates.

**Considerations of Ethical Concerns**

The students were separated while taking the pretest and posttest. They used numbers for identification and not their names. Data collection was confidential. The investigator collected the data and was the sole person with access to the identifiable information about the study’s
participants. The investigator will be the only one with access to the code key. The tests were stored in a locked cabinet.

**Data Analysis**

The pretest and posttest were scored using the specifically designed rubric. The rubric evaluated the students’ work in three areas: problem solving, reasoning and proof, and communication. Each of these areas received a numeric rating ranging from one to four, with one being “Below Proficient” and four being “Proficient with Distinction.” The scores were analyzed using the overall total score. The pretest and posttest scores were compared using a t-test and descriptive statistics.
CHAPTER 4
RESULTS

This study was designed to investigate the impact of incorporating math journals on the mathematical thinking of third grade students. Pretests and posttests were given to the students to compare the depth of their mathematical thinking, their use of problem solving strategies, and their ability to communicate their methods in writing at the beginning and then at the end of the semester. This chapter will present the results of this research study designed to determine if math journals assisted students in their ability to construct viable arguments and deepened their level of mathematical reasoning.

Pretest and Posttest Percentages

Each student participating in the study was administered a pretest and posttest to compare their ability to construct viable arguments when completing a mathematical question. The pretest and posttest total percentages are given in Tables 1 and 2. The pretest scores were void of any student scoring in the Proficient with Distinction rating in any of the three categories. Likewise, the posttest was void of any student scoring in the Below Proficient rating in any of the categories. The greatest percentage of students scored in the Approaching Proficiency rating in all categories on the pretest with Below Proficient being the next most frequent. On the posttest, the greatest percentage of student scores were in the Proficient with Distinction rating and the next most frequent in the Proficient rating. These percentages show a positive effect on a third grader’s ability to construct viable arguments after a semester of participating in math journaling.
Table 1

Pretest percentages of Problem Solving, Reasoning and Proof, and Communication

<table>
<thead>
<tr>
<th></th>
<th>Problem Solving</th>
<th>Reasoning and Proof</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proficient with Distinction</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Proficient</td>
<td>0%</td>
<td>6%</td>
<td>17%</td>
</tr>
<tr>
<td>Approaching Proficiency</td>
<td>78%</td>
<td>72%</td>
<td>72%</td>
</tr>
<tr>
<td>Below Proficient</td>
<td>22%</td>
<td>22%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Table 2

Posttest percentages of Problem Solving, Reasoning and Proof, and Communication

<table>
<thead>
<tr>
<th></th>
<th>Problem Solving</th>
<th>Reasoning and Proof</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proficient with Distinction</td>
<td>78%</td>
<td>61%</td>
<td>50%</td>
</tr>
<tr>
<td>Proficient</td>
<td>22%</td>
<td>39%</td>
<td>39%</td>
</tr>
<tr>
<td>Approaching Proficiency</td>
<td>0%</td>
<td>0%</td>
<td>11%</td>
</tr>
<tr>
<td>Below Proficient</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Problem Solving Data

The Problem-Solving Category was scored with a numeric representation of 1-4.

Proficient with Distinction (4) was defined as: The correct answer was given and more than one strategy was used. Proficient (3) was described as: The correct answer was given and a relevant strategy was used. Approaching Proficiency (2) was explained as the student had a partial understanding of the problem and some relevant work was shown. Below Proficient (1) was in cases where little or no evidence of understanding was given.
The descriptive statistics show a mean score of 3.78 on the posttest and 1.78 on the pretest with a standard deviation of .43 (see Table 3).

Table 3

<table>
<thead>
<tr>
<th>Results of Problem Solving Category (N=18)</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Problem Solving</td>
<td>3.7778</td>
<td>.42779</td>
</tr>
<tr>
<td>Pretest Problem Solving</td>
<td>1.7778</td>
<td>.42779</td>
</tr>
</tbody>
</table>

A t-test was used to compare mean scores on the pretests and posttests. The T-test showed a t-score of 14.28 with the degrees of freedom being 17, and the two-tailed p-value was .00 (see Table 4).

Table 4

<table>
<thead>
<tr>
<th>T-test results of Problem Solving Category (N=18)</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Problem Solving</td>
<td>14.28</td>
<td>17</td>
<td>.000</td>
</tr>
<tr>
<td>Pretest Problem Solving</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reasoning and Proof Data

The Reasoning and Proof category was scored using a four point scale. A score of 4, Proficient with Distinction, indicated all mathematical reasoning and justifications presented were correct and more than one strategy was used. A score of 3, Proficient, was described as correct mathematical reasoning and justifications were present for at least one strategy. A score of 2, Approaching Proficiency, was used when some mathematical reasoning and justifications...
were used. Lastly, a score of 1, Below Proficient, was given to responses in which no mathematical reasoning or justifications were used.

The descriptive statistics show a mean score of 3.61 and a standard deviation of .50 on the posttest and a mean score of 1.83 with a standard deviation of .51 on the pretest (see Table 5).

Table 5

*Results of Reasoning and Proof (N=18)*

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Problem Solving</td>
<td>3.6111</td>
<td>.50163</td>
</tr>
<tr>
<td>Pretest Problem Solving</td>
<td>1.8333</td>
<td>.51450</td>
</tr>
</tbody>
</table>

A t-test was used to compare mean scores on the pre-tests and posttests. The T-test showed a t-score of 11.66 with the degrees of freedom being 17, and two-tailed p-value was .00 (see Table 6).

Table 6

*T-test results of Reasoning and Proof Category (N=18)*

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Problem Solving</td>
<td>11.662</td>
<td>17</td>
<td>.000</td>
</tr>
<tr>
<td>Pretest Problem Solving</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Communication Data**

The scoring guide descriptor for Proficient with Distinction (4), in the Communication category, indicated the use of formal math language, terms, and symbolic notations throughout the explanation of the solution. A 3, Proficient, rating included at least two formal
mathematical terms or symbolic notations. A score of (2) was given when at least one formal mathematical term or notation was used. Below Proficient, (1), was scored when no mathematical terms or symbolic notations were used.

The descriptive statistics show a mean score of 3.39 and a standard deviation of .70 on the posttest and a mean score of 2.06 with a standard deviation of .54 on the pretest (see Table 7).

Table 7

Results of Communication (N=18)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Problem Solving</td>
<td>3.3889</td>
<td>.69780</td>
</tr>
<tr>
<td>Pretest Problem Solving</td>
<td>2.0556</td>
<td>.53930</td>
</tr>
</tbody>
</table>

A t-test was used to compare mean scores on the pretests and posttests. The T-test showed a t-score of 9.52 with the degrees of freedom being 17, and the two-tailed p-value was .00 (see Table 8).

Table 8

T-test results of Communication Category (N=18)

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Problem Solving</td>
<td>9.522</td>
<td>17</td>
<td>.000</td>
</tr>
<tr>
<td>Pretest Problem Solving</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pretest and Posttest Total Data

A total score for each student was calculated by adding the scores on Problem Solving, Reasoning and Proof, and Communication. This total score was used to compare the pretest and
posttest scores of each student. There was a possibility of twelve total points on the rubric for the given mathematical question.

The descriptive statistics show a mean score of 10.78 and a standard deviation of 1.17 on the posttest and a mean score of 5.67 with a standard deviation of 1.08 on the pretest (see Table 9).

Table 9
Results of Pretest and Posttest Totals (N=18)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Problem Solving</td>
<td>10.7778</td>
<td>1.16597</td>
</tr>
<tr>
<td>Pretest Problem Solving</td>
<td>5.6667</td>
<td>1.08465</td>
</tr>
</tbody>
</table>

A t-test was used to compare mean scores on the pretests and posttests. The T-test showed a t-score of 16.96, with the degrees of freedom being 17, and two-tailed p-value was .00 (see Table 10).

Table 10
T-test results of Pretest and Posttest Totals (N=18)

<table>
<thead>
<tr>
<th></th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest Problem Solving</td>
<td>16.964</td>
<td>17</td>
<td>.000</td>
</tr>
<tr>
<td>Pretest Problem Solving</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 5
DISCUSSION

This study was designed to investigate the impact of math journaling in a third-grade classroom and its effect on student performance, specifically on the third mathematical practice. There was a pretest given at the beginning of the semester and a posttest given at the semester’s conclusion. A rubric was designed to measure a student’s ability to construct viable arguments and to critique the reasoning of others. Three categories were scored on a scale of one to four. The categories included Problem Solving, Reasoning and Proof, and Communication. It was determined the there was a significant difference in the students’ pretests and posttests scores in all three categories and on their total scores.

**Discussion of Pretest and Posttest Results**

When analyzing the total scores of the pretests and posttests, there were obvious differences. It was easily shown that there was a significant difference between the total scores of the two tests with the mean posttest score of 10.78 and the mean pretest score of 5.67. There was a significant difference in the total scores on the pretest (M=5.67, SD=1.08) and scores on the posttest (M=10.78, SD=1.17); t(17), p=0.00.

There was a significant growth in the area of Problem Solving when comparing the scores of the pretests and posttests. All of the students were able to provide the correct answer to the mathematical problem on the posttest and provide at least one relevant strategy earning a score of 3 or 4. A score of 3 or 4 indicated every student successfully solved the given problem after the math journaling exercises. In contrast, the pretest scores were either a 1 or 2, meaning that none of the students provided the correct answer nor were they able to demonstrate a partial understanding of the problem. The mean posttest score on this section was 3.78 out of 4.0 and
the mean pretest score was 1.78 out of 4.0, thus presenting sufficient growth in the student’s ability to solve the problem and provide a relevant strategy. This area, problem solving, exhibited the greatest amount of growth of the three categories. There was a significant difference in the Problem Solving scores on the total scores on the pretest (M=1.78, SD=0.43) and scores on the posttest (M=3.78, SD=0.43); t(17), p=0.00. The results clearly indicate that the students were able to solve problems with more accuracy and provide relevant strategies at the conclusion of the study.

When comparing the pretest and posttest scores of Reasoning and Proof, there was also significant growth. On the posttest, all of the students scored in the Proficient (3) or Proficient with Distinction (4) areas. There were no students who scored in the Approaching Proficiency (2) or Below Proficient (1) areas on the posttest. However, on the pretest 72% of the students scored in the Approaching Proficiency (2) and 22% scored in the Below Proficient (1) area. These scores show a sufficient upward movement on the rubric from the pre-test to the posttest. There was a mean score change of +1.78 when using descriptive statistics. There was a significant difference in the Reasoning and Proof scores on the pretest (M=1.83, SD=0.51) and scores on the posttest (M=3.61, SD=0.50); t(17), p=0.00. The results indicate the students sufficiently improved their ability to reason and justify their responses to the given mathematical problem.

With regard to the last category, Communication, this showed the least amount of growth; but remained able to show a significant difference in the students’ performances on the two tests. There was a significant difference in the Communication scores on the pretest (M=2.06, SD=0.54) and scores on the posttest (M=3.39, SD=0.70); t(17), p=0.00. The students
beginning pretest scores were higher in Communication than the other categories, therefore less growth was expected in this area.

Limitations

There were several limitations of this study. First, the sample size was small and limited to one grade level. Only one third grade class with eighteen students was used for the sample. The setting was in a rural, small district restricting the diversity of students. The study was limited to one semester of time. The results of the study may not generalize to other settings.

Additionally, the same person that collected and analyzed the data was also the interventionist. Therefore, possible biases existed when administering the pretest and posttest, when selecting the journal questions, and when discussing the students’ performances on the selected mathematical problems. The scores were generated with a rubric that was designed by the researcher/interventionist. The results may not be able to be generalized to other classes or other student populations due to these limitations. The study could be improved upon by addressing these limitations.

Recommendation for Future Research

Research has been addressing the eight mathematical practices and the impact they can have on student learning. Math journaling studies have shown to make a positive effect on student’s mathematical thinking and reasoning. Further research might include a longer duration of study. An expanded, larger, and more diversified sample of students would also be recommended. A scoring guide that was standardized or some form of tested measurement could also be used to ensure equitable and reliable scoring. Future studies might also include looking at the effects math journals might have on the other mathematical practices.
Conclusions and Implications

The research found that the use of math journals had a positive effect on students’ abilities to construct viable arguments and critique the reasoning of others. The students improved their ability to communicate their mathematical thinking using formal mathematical language and symbolic notations. Their mathematical reasoning and justification improved, as did their ability to use more than one strategy to solve a given mathematical problem. The most significant and dramatic growth was in the area of problem solving.

Math journaling improves student learning by assisting the teacher in understand how and what the students are thinking when solving mathematical problems. When a teacher gains this knowledge, the students’ problems or misconceptions can be addresses in a timely manner and on an individual basis. These guiding principles that are discovered thorough the student’s journals truly enhance their understanding and learning.

In conclusion, math journaling provides opportunities for students to solve problems in multiple ways, to justify their thinking, and to communicate in an understandable way their mathematical thinking on a given problem. This propels students into a deeper level of thinking than merely using given formulas, memorizing facts, or using standard algorithms. The more students are able to construct viable arguments and critique the reasoning of others, the greater and deeper their understanding of mathematics will become.
REFERENCES


Retrieved from https://hubpages.com/education/mathnotebooking


Mathematics, Teaching in the Middle School, 22(2), 92-99.


APPENDIX A

TEST QUESTION

Jones Pretest and Posttest Question:

How many strategies can you use to solve this story problem? Include illustrations and explanations for your strategies.

There were 58 students on the bus. Some students got off at the first stop. There are 19 students on the bus now. How many students got off the bus?
## APPENDIX B

### RUBRIC

<table>
<thead>
<tr>
<th>Problem Solving</th>
<th>Reasoning and Proof</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4</strong> Proficient with Distinction</td>
<td>The answer is correct. More than one strategy is used.</td>
<td>All mathematical reasoning and justification is correct and used in more than one strategy.</td>
</tr>
<tr>
<td><strong>3</strong> Proficient</td>
<td>The answer is correct. A relevant strategy is used.</td>
<td>Correct mathematical reasoning and justification is present for at least one strategy.</td>
</tr>
<tr>
<td><strong>2</strong> Approaching Proficiency</td>
<td>A partial understanding of the problem. Some relevant work is shown.</td>
<td>Some mathematical reasoning and justification is used.</td>
</tr>
<tr>
<td><strong>1</strong> Below Proficient</td>
<td>Little or no evidence of understanding.</td>
<td>No correct mathematical reasoning nor justification is used.</td>
</tr>
</tbody>
</table>
APPENDIX C
JOURNAL QUESTIONS

August 24: Round 68 to the nearest 10. How do you know your answer is correct?

August 25: Round 234 to the nearest 100. How do you know?

September 7: Write a story problem for this number sentence and solve. 13+5=_____.

September 8: It was 82 degrees on Monday and 87 degrees on Tuesday. How much warmer was it on Tuesday? Explain the steps you used to solve the problem.

September 12: Sam read 6 more pages than Pam. Sam read 58 pages. How many pages did Pam read? Explain how you found your answer.

September 14: Sam has 27 baseball cards. His friend Jack has 9 fewer cards than Sam has. How many cards does Jack have? How do you know?

September 18: Jan is 8 years older than her sister. Jan is 12 years old. How old is her sister? How do you know?

September 25: How does knowing your addition facts help you to solve your subtraction facts?

Solve 15-8 using addition.

October 2: 7,285-3,429=3866 and 5,128-4,534=9,662 Tell what is wrong in each problem.

October 5: Write a story problem for 23-__=15 and solve.

October 16: Last year we made $678 at our family garage sale. This year we made $856 at our garage sale. How much more money did we make this year? How do you know?

October 19: Make a list of 5 numbers that round down to 400. Explain your choices.

October 23: Valery bought an ice cream sundae for $2.34. She gave the cashier a $10 bill. How much change should she get back? Write the steps you used to solve the problem.
October 30: Tim found a box of jump ropes. He took 14 out and left 18 in the box. How many were originally in the box?

November 2: Tim and Karen have cows on their farm. They bought 27 more cows and now have 60 cows altogether. How many cows did they have to start?

November 3: To make room for their new cows, Tim gave 24 sheep to Jamie. Now Tim has 38 sheep. How many sheep did he have to start?

November 6: Jamie has 34 horses. He has 6 fewer males than females. How many are females?

November 27: Karen found a bag of jerseys. She put 17 more in the bag and now there are 30. How many were first in the bag?
APPENDIX D

APPROVAL

Full Review

7/12/2017

Protocol Number: 840

Dear Julie Jones:

Your research project, ‘Math Journaling in Third Grade’, was approved by the University of Central Missouri Human Subjects Review Committee on 7/12/2017. You may collect data for this project until 7/12/2018. Your informed consent is also approved until 7/12/2018.

If an adverse event (such as harm to a research participant) occurs during your project, you must IMMEDIATELY stop the research unless stopping the research would cause more harm to the participant. If an adverse event occurs during your project, notify the committee IMMEDIATELY at researchreview@ucmo.edu.

The following will help to guide you. Please refer to this letter often during your project.

- If you wish to make changes to your study, submit an “Amendment” through Blackboard under the “Amendment and Renewals” tab. You may not implement changes to your study without prior approval of the UCM Human Subjects Review Committee.

- If the nature or status of the risks of participating in this research project change, submit an “Amendment” through Blackboard under the “Amendment and Renewals” tab. You may not implement changes to your study without prior approval of the UCM Human Subjects Review Committee.

- If you are nearing the expiration date for collecting data for this project (7/12/2018) and you have not finished collecting data:
  1. submit your project application via Blackboard under the “Amendment and Renewals” tab (include any revisions and/or amendments approved since you submitted your application initially)
AND

2. submit a “Renewal Report” through Blackboard under the “Final/Renewal Report” tab.

- **When you have completed your collection of data, please submit the “Final Report” found on Blackboard under the “Final/Renewal Report” tab.**

If you have any questions, please feel free to contact me at researchreview@ucmo.edu.

Sincerely,

Kathy Schnakenberg

Program Administrator/Research Compliance Officer

Office of Sponsored Programs and Research Integrity

University of Central Missouri

cc: mccoy@ucmo.edu