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The Impact of Journal Writing on Students' Understanding of Rational Number Operations of Eight Seventh Grade Students at Jackson Middle School

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by

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Dedication

To my Lord and Savior Jesus Christ.

Without Him, this would never have been possible.

To my amazing husband, Benjamin, and my precious children,

Andrew and Kaylee, who God has blessed me with in this life.

In honor of my incredible mom, Linda and in memory of my

precious dad, David, who both always encouraged me to strive for excellence.

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First I would like to thank the Lord for giving me the opportunity to obtain this degree. Without His leadership and guidance nothing in the following pages would have been possible. Colossians 3:23-24 says, “Whatever you do, do your work heartily, as for the Lord rather than for men, knowing that from the Lord you will receive the reward of the inheritance. It is the Lord Christ whom you serve.” My prayer has always been and continues to be that even in this endeavor I have presented my best and done it for His approval, not for the approval of man.

My husband Benjamin has walked with me through this process and for that I am grateful. Words cannot express the love and gratitude I have for him. His words of encouragement and belief in me, even when I have doubted my abilities has inspired to be better than I am in all areas. He is my greatest supporter and best friend.

My children, Andrew and Kaylee, have been amazing through this process. When I began this process, they were six and three. Now, three years later, Andrew is nine and Kaylee is six. They have often accepted the phrase, “not right now, mommy’s working on her paper” as a good reason why I couldn’t do something. They have been so supportive and encouraging even at their young age. From my experience, I encourage them to never stop learning.

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Abstract

The purpose of this study was to examine the impact of journal writing on eight seventh grade math students' understanding of rational numbers in a public school in South Carolina. The literature on mathematical understanding and achievement suggests that students should be taught to write about their mathematical thinking to learn the concepts or reasons behind the procedure to consistently and accurately perform operations with rational numbers (Countryman, 1992; Anderson & Little, 2004; Borasi & Rose, 1989; Ganguli, 1989; Johanning, 2000; Lim & Pugalee, 2004; McCormick, 2010; McIntosh & Draper, 2001; Miller, 1991).

During the course of the study, participants wrote about their math thinking and worked to justify the action steps they took to solve problems involving operations of rational numbers. The researcher analyzed the journal entries of the participants, carefully examined both the formal and informal interview data, read and reread field notes, and thoroughly analyzed artifacts that were submitted by the participants.

The results of the study revealed the struggles among the participants with mathematics terminology, misconceptions, application, and written expression. It appears from the data that journal writing had a positive impact on the understanding of rational number operations among the eight seventh grade math students.

Keywords: procedural knowledge, conceptual understanding, instrumental mathematics, journal writing, relational mathematics, rational numbers, mathematical operations

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List of Abbreviations

ESEA.. Elementary and Secondary Education Act

MAP...Measures of Academic Progress

NCLB...No Child Left Behind

NCTM.. National Council of Teachers of Mathematics

Chapter One: Introduction

Defining mathematical understanding and thinking and distinguishing between procedure and contextual understanding have been in debate for many years. In years past, "Mathematics has been viewed as a body of facts and procedures, and the successful mathematics student was one who mastered them. The nature of successful mathematical learning, however is being challenged given widespread globalization" (Pape, Bell, & Yetkin, 2003, p. 179). Skemp (1978) began a pathway that challenged the conventional way of learning mathematics when he distinguished between learning mathematics as just facts and procedures and learning facts and procedures with reason and logic.

In his work, Skemp (1978) described instrumental mathematics as rules without reason (i.e., procedural), while relational mathematics is designated as rules with reason, (i.e., conceptual). Even and Tirosh (2002) adds that while instrumental mathematics, rules without reason, may be easier for students to memorize or grasp, relational mathematics aids in adapting to new tasks and is related to the conceptual structure of learning. Nesher (1986) and Resnick and Ford (1981) would agree that both rules and reason are necessary when teaching the understanding of mathematics.

Statement of the Problem of Practice

Student reasoning and understanding of mathematical concepts have been topics of conversation among mathematics educators for years. Are students gaining a conceptual understanding or reasoning of a particular math concept, or are they just memorizing the rule and moving on? There is evidence that reveals critical areas of weakness in how mathematics is taught. That is, many times educators focus more on fact memorization than problem solving mastery (Good & Grouws, 1987; Chancellor, 1991). Bellanca and Fogarty (1991) asserted that "too often we give children answers to remember, rather than problems to solve" (p. 9).

As a middle level math teacher, the researcher has observed numerous times over the years, students simply want to know the answers but are not understanding the concepts or reasoning behind the answers. For example, many students want to just memorize the rules for adding and subtracting rational numbers instead of learning why those rules work. The researcher also has observed time and time again students memorizing the facts, such as rules for adding rational numbers like integers, only to forget how to apply that same rule to rational numbers such as fractions or decimals.

Skemp (1978) states that many teachers teach simple instrumental mathematics, rules without reason, for several reasons: (a) it is easier to understand, (b) it has immediate rewards that are often more apparent to teachers and students, and (c) answers come more quickly due to less knowledge needed to solve. The researcher observed both students, teachers, and even herself teaching mathematics at the instrumental level because it is easier, quicker, and just surface level; yet, Skemp (1978) goes on to point out what he considers to be at least four advantages to relational mathematics: (a) they are adaptable to new tasks, (b) they are easier to remember, (c) they are an effective motivator for student learning, and (d) schemas create interest in actively seeking and exploring new materials.

Nevertheless, students and teachers are identified by Skemp (1978) to not be in favor of relational mathematics because it may take longer to achieve the answers, may be too difficult and takes too much work, may be connected to another content such as science that teacher nor student is comfortable in teaching, or it could be that all other students and/or math teachers are teaching instrumental mathematics, rules without reason. The researcher in this study experienced the importance of rules with reason over the course of her teaching career. Students who can reason through a mathematical concept rather than just memorize the process are able to excel in mathematics learning when learning in new contexts. On the other hand, the researcher observed students who learn the rules without reason, only memorizing facts or procedures that do not excel, because they have a difficult time transferring the mathematical concept to new tasks and problems.

As a matter of fact, there were eight students taught by the researcher who continued to struggle with consistency in rational number operations. The researcher wondered if students were struggling with rational number operations because they knew the rules but not the reason and concept behind the rules. For example, over a three-month period the researcher taught using traditional lecture, note-taking, and concrete models to teach the operations with integers, positive and negative whole numbers; then, the researcher moved into more complex rational numbers such as fractions and decimals where students must apply the rules of integers to all rational numbers.

While the researcher taught through a traditional method and incorporated concrete modeling to address the relational understanding, these eight students still struggled to accurately and consistently apply the rules they were taught to rational number operations. For example, John continued to struggle with simply adding 3 + -4. He, on more than one occasion, would simply add the two numbers because of the addition sign. He did not seem to understand that the 4 is clearly negative, which creates a different type of problem than 3 + 4. Similarly, Matthew immediately answered 3 for 5 – 8. In short, several students in the researcher's class struggled to demonstrate understanding that when integers are introduced into the world of mathematics, addition signs do not always result in a higher number because one adds, nor does a subtraction sign always result in a lower number because of taking away.

This struggle transferred into their learning of operations with rational numbers such as fractions and decimals. For instance, when Rob tried to add 1/4 + -2/4 he would simply answer ¾ because of the addition sign. Sue would try to add -3.5 + 5.6 by answering with 9.1. In other words, students struggled to conceptualize or understand why they could not simply add these numbers. These examples were only a few that spanned across all operations (add, subtract, multiply, divide) of rational numbers. To improve mathematical understanding, the researcher wondered if journal writing would help students be more consistent and accurate in performing operations with rational numbers in order to gain a better grasp on what Skemp (1978) called relational mathematics.

Research Question

What impact would journal writing have on the understanding of rational number operations among eight seventh grade math students? For the purpose of this study, journal writing is defined by explaining in words one's mathematical thinking or the process of solving a problem.

Purpose of the Study

Therefore, the purpose of this study was to examine the impact of journal writing on the understanding of rational number operations among eight seventh grade math students.

Methodology

The philosophy of action research "focuses on the concerns of teachers and engages teachers" with the result "to improve classroom practice" (Dana, 2014, p. 8-9). A qualitative action research methodological design was used during this study to examine the impact of journal writing on students' understanding of rational number operations.

The eight participants of this study were selected based on their struggle with rational number operations. Each participant was enrolled in two math classes, both taught by the researcher. One course was the regular seventh grade math class, which met daily. The other class was a supplemental math class called math enrichment that met every other day. The purpose of the enrichment class was to review concepts covered in the general math class, to remediate concepts when needed, and to enrich other topics of study as time permitted.

The research site for the study was Jackson Middle School located in a small rural close-knit community just outside a very rapidly growing community in the South. The school population demographic was predominantly white with students from middle to upper class families, which results in little diversity in race or class throughout the community or school. Only about 33% of the students in the school received free or reduced lunch. The demographics of the school were comprised of 0.1%

American/Indian, 0.1% Hawaiian Pacific, 0.5% Asian, 2% Hispanic, 3% Two or more, 4% African American and 90% White (South Carolina Department of Education, 2015). The middle school was known for excellent state test scores over the years, but struggled to meet goals in all subgroups for federal and state guidelines in recent years.

Mertler (2014) described qualitative data as data that is written in words. The qualitative data collected for this study were formal interviews (pre/post), informal interviews, student-participant journals, artifacts, observations through field notes, and the researcher's reflection journal. The observation field notes allowed the researcher to see verbal and non-verbal behaviors and patterns in student's math learning. Student journals provided data that was examined for correct and incorrect answers as it related to computation and the solving processes. These journals also provided the researcher with data on students' mathematical thinking in written form in which the researcher could observe correct mathematical thinking and misconceptions. The formal and informal interviews allowed the researcher to dig deeper into student understanding as well as help determine the attitude a student has about oneself, others, and learning. Data was collected on a regular basis during the study in a very systematic and organized way that resulted in a collection of vital data. This data was used to inductively answer the research question by determining the impact of journal writing on the relational understanding of operations with rational numbers.

Significance of the Study

The fostering of critical thinking clearly plays a role in increasing student understanding in mathematics. As Mertler (2014) suggested, this action research topic, relational understanding of rational number operations, must be significant enough to make a difference in the classroom instruction and learning. If the research topic is not important, then it will lack the necessary momentum to see change in classroom practice.

The researcher of this study observed students struggle to understand math concepts year after year. To state differently, over the last 16 years, the researcher saw the gaps in mathematical understanding expand and increase as students arrive in middle school. The researcher wondered if the gaps were due to students simply memorizing a mathematical concept or procedure for the test but never truly grasping the understanding behind the procedure. This research was significant because it has the potential to help students truly understand the math and therefore close the gaps in learning through students not just memorizing but solidifying that relational understanding.

Countryman (1992), in her work *Writing to Learn Mathematics: Strategies that Work*, shows evidence that incorporating writing in mathematics instruction and learning results in better mathematical understanding and communication. Moreover, she encouraged and expected her students to be active participants in their learning. She shares in her work the different types of writing and use of mathematical language she used in her instruction. That is, she expressed the importance of knowing mathematics being connected to doing mathematics by "exploring, justifying, representing, discussing, using, describing, investigating, predicting, in short by being active in the world" (p. 2).

Johanning (2000) concurred with Countryman's theory as she found that when students used writing in their math learning, they were actively involved and could clarify their mathematical thinking. Van Dyke, Mallory and Stallings (2014) found that that students could move away from the idea of just achieving the right answer and towards deeper thinking about the problem at hand by using writing to reflect on and organize their own mathematical thinking.

Relational understanding of rational numbers is significant to the researcher for several reasons: First, relational understanding has the potential to build confidence and create strong reasoning/thinking skills among student learners. Secondly, relational understanding could clear up misconceptions among student thinking and allow students to retain mathematical concepts.

This study on journal writing in middle school mathematics is centered on Skemp's (1978) idea of instrumental versus relational mathematics. This study seeks to observe patterns in student thinking and understanding through journal writing. Students must be able to transfer knowledge to unfamiliar context to become proficient problem solvers. Mathematical understanding in this study goes beyond the basic facts and rules. Understanding is deeper than just surface level learning, which involves memorizing and recalling math facts and procedures. The understanding that the researcher seeks to observe is relational mathematics, connecting the facts and procedures to the reasoning.

Limitations of the Study

This study is limited to one classroom within one public school in one area of the state. The limitations of this study focus primarily on the small sample size, which is only eight participants. This action research study is naturally limited in the generalizations that can be made to other students, classrooms, or public schools.

Dissertation Overview

Following this chapter, Chapter Two reviews the literature based on historical context, theoretical context, and methodology. The literature review helped the researcher make an informed decision about the focus of the study: writing to learn mathematics.

Chapter Three provides an in-depth summary of the methodology of the research study. This consists of the purpose statement, problem of practice, research question, action research design, methods, procedures, and data analysis strategies. The researcher shares the plan for reflecting with participants and devising an action plan.

Chapter Four organizes and discusses the research findings in relation to the research question of the study. The researcher states what she found after thoroughly and systematically analyzing the data. An interpretation of those results is also presented, as related to the research question.

Chapter Five, the final chapter of this dissertation, provides implications of the study and action steps to be taken considering the research findings. A summary and overview of the study is given and suggestions for future research is provided.

Definition of Terms

For this study, the terms below are defined and are used throughout this study on mathematical understanding and journal writing in mathematics.

Conceptual understanding: the power of comprehending a cohesive web of mathematical connections (Baroody, Feil, & Johnson, 2007).

Connection: to make an association with or development of something observed, imagined, or discussed (Anthony & Walshaw, 2009).

Instrumental mathematics: mathematics instruction and learning that emphasizes rules without reason (Skemp, 1978).

Journal writing: a series of diary like entries pre-planned by the teacher for students to organize and formulate their understanding of mathematical concepts (Nahrgang & Petersen, 1986).

Mathematical operations: mathematical processes such as addition, subtraction, multiplication, and division for deriving one entity from others according to a rule (Webster, 2017).

Metacognition: higher-order thinking that enables understanding and analysis of one's own learning or thinking processes (Costa, 1984).

Problem solving: using critical thinking and processes to work through details mathematically to find a solution to a problem (Webster, 2017).

Procedural knowledge: the ability to perform series of actions or steps to solve problems (Rittle-Johnson, Siegler, & Alibali, 2001).

Rational Numbers: a number that can be expressed as an integer or the quotient of an integer divided by a nonzero integer such as whole numbers, integers, fractions, and terminating and repeating decimals (Webster, 2017).

Relational mathematics: mathematics instruction and learning that emphasizes rules with reason (Skemp, 1978).

Thinking: the action of using one's mind to produce thoughts (Webster, 2017).

Chapter Two: Review of Literature

The principal focus of the following is on how we come to understand math and other related concepts. Student understanding, learning, and achievement is important because it they are how the education system is evaluated. It is imperative that students not just learn material or rules for the moment, but also understand the concepts that can be applied for a lifetime. This is especially true for mathematics, which builds from year to year. Franklin Bobbitt, who played a major role in curriculum development in the early 20th century, and those that follow his curriculum theory view education as preparation for adulthood (Kliebard, 1975, p. 70-71). Taking a step further, John Dewey is credited with saying, "Education, therefore, is a process of living and not a preparation for future living" (Dewey, 1964, p. 230). Although many desire for education to be more than just preparing for the future but also the present, the key is that learning is indeed preparation.

No matter if one sees education as preparation for life or the act of living life, one should see mathematical learning as more than just memorizing a set of facts (Skemp, 1978). For example, although teaching math skills in isolation has an initial instructional purpose, students must make connections with the skill and reasoning through real-world problem solving practice. If students learn to multiply 32 and 33 but never connect the operation of multiplying to a context, like finding the area of a rectangular room to cover the floor with tile, the skill of multiplying will never fully benefit them. As Anthony and Walshaw (2009) argued, "The ability to make connections between apparently separate mathematical ideas is crucial for conceptual understanding" (p. 15). Connections, therefore, are naturally important to conceptual understanding and mathematically preparing students for living in our ever-changing society.

As one will see in the following pages, there is a rich body of research that suggests that writing is connected to understanding across content areas. It is also suggested that one should use writing as an instructional tool as well as a learning aid in classroom instruction. Research has also shown a positive outcome for using writing in teaching problem solving in mathematics instruction (Bell & Bell, 1985; Skemp, 1978; Countryman, 1992; Miller, 1991; Pugalee, 2005; Johanning, 2000; Van Dyke, Mallory & Stallings, 2014).

Mathematical Education in the USA: A Brief History

Over the years, there have been many debates and disagreements over the best way to educate our nation's students, especially in mathematics. In 1961, U.S. President John F. Kennedy said, "Our progress as a nation can be no swifter than our progress in education…The human mind is our fundamental resource" (Peters & Wooley, 2017, par. 1). In 1965, President Lyndon B. Johnson, whose first job was teaching, signed a law called the Elementary and Secondary Education Act (ESEA). ESEA provided funding for schools with low-income students to supply needed materials and programs that would help improve the quality of education across our county. Johnson believed that our priority as a nation should be a "full educational opportunity" (Brenchley, 2015).

Throughout the 20th century, educators have advocated for discovery learning that is child centered and against the systematic practice and instruction directed by the teacher. Advocating progressivist education which focuses on the whole child instead of just the content has been a topic of debate on the agenda of education resulting in an important influence on public schools (Royer, 2003). Over the years, this progressive school of thought has not only created debates and discussions about what content should be taught in mathematics, but also questions the most effective ways to teach the math content to student. An analogy about content (what to teach) versus pedagogy (how to teach) is given by comparing these ideas to one's left foot and right foot (Royer, 2003).

No doubt most educators would agree that content and pedagogy should work together in union to educate our nation's students, not tripping one another up as one foot might do to the other. The conflict and trouble lies in the question: which one, content or pedagogy, should step first? If content comes first, focusing on the student and discovery learning, then there may be limited pedagogy due to the time needed for that type of content. A similar principle seems to be true if one chooses to step first with pedagogy because then there may be limited content available to students. Therefore, the issue that must be addressed is how educators can help create unity with both math content and pedagogy to best benefit the student and society as a whole (Royer, 2003).

Along with content and pedagogy, mathematical understanding, thinking, and communication has been a topic of interest for many years. For example, in the 1940s, many believed mathematical understanding was too difficult to even define. Meel (2003) noted that in 1946, a definition for mathematical understanding was thought to be too difficult to be found or even formulated; however, understanding was multi-layered, consisting of about eight different areas. Polya (1962) identified four levels of mathematical understanding: mechanical, inductive, rational, and intuitive.

Prior to 1978, mathematical understanding was identified only with knowledge. That is, it was "equated with the development of connections in the context of performing algorithmic operations and problem solving" (as cited in Meel, 2003, p. 134). Yet, this idea of mathematical understanding changed when Skemp (1978) published *Relational Understanding and Instrumental Understanding*, which distinguished knowledge from understanding. In that work, it was proposed that mathematical learning should be separated into two categories: instrumental and relational. *Relational mathematics* relates to knowing the reasoning behind the procedure. *Instrumental mathematics* reflects a set of rules with no reasons to support those rules. The terms relational and instrumental can be seen in research as procedural and conceptual, concrete and symbolic, or intuitive and formal (as cited in Meel, 2003).

Relational mathematics connects the rules and procedures to reason through connections, a process that requires "recognition of relationship between the piece of knowledge and the elements of the network as well as the structure as a whole" (Meel, 2003, p. 135). Sfard (1991) proposed a very similar way of thinking, yet uses the terms operational conception (i.e., rules and procedures) and structural conception (i.e. rules and procedures with reason). He further explains that understanding goes beyond just problem solving and suggests that links need to be made from the operational to the structural conception of mathematics learning. Current views on understanding align with the ideas of Skemp and Sfard. However, Meel (2003) does suggest that, "evidence exists that the mathematics education community has not reached unilateral agreement as to the meaning of 'understanding' since various authors approach it from diverse viewpoints" (p. 135).

In 1983, during Ronald Reagan's presidency, a study of the nation's education system was conducted called *A Nation at Risk.* This study revealed grave concerns in education that are categorized in four areas: (a) content, (b) standards and expectations, (c) time, and (d) teaching. Moreover, this study suggested the focus of education should be the "new basics" with an increase in higher expectations, efficiently using instructional time, qualified teachers in the classrooms, and accountability. The roles of parents and students in the education process was challenged when the study stated, "As surely as you are your child's first and most influential teacher, your child's ideas about education and its significance begin with you" (National Commission on Excellence of Education, 1983, p. 120). While this challenge may have been timely and necessary to the future of education, it still did not address the issue of connecting knowledge and understanding or procedure with reasoning.

Although progressive education, educating the whole child has not gone unchallenged. In the 1990s, the cliché "we teach children, not subject matter" was popular, and challenges to the progressive education theory surfaced with more strength. The 1990s posed a decade of contentious mathematics education and policies. This controversy came when new math textbooks were introduced and distributed. These textbooks were said to have drastically reduced content and contained a shortage of basic skills. This led to criticism by parents, mathematicians, and other professionals (Royer, 2003).

Moving forward to 2001, Congress, under the leadership of George W. Bush, reauthorized the ESEA under a new name, *No Child Left Behind* (NCLB). While NCLB (2002) also called for high expectations, qualified teachers, and accountability, the goal was that every child would reach his or her full potential and not one child would be left behind. While this federal initiative had strong bipartisan support, it lacked in showing how teachers were to indeed help each student reach his or her full potential in critical thinking.

Most recently in 2012, the Obama administration began looking for ways to "ensure that all young people are prepared to succeed in college and careers, that historically underserved populations are protected, and that educators have the resources they need to succeed" (Brenchley, 2015, par. 11). In 2015, Arne Duncan, Secretary of Education, outlined a bold vision for another reauthorization of ESEA. This new law purported to "improve access to high-quality preschool, foster innovation, and advance equity and access" (Brenchley, 2015).

The *Elementary and Secondary Education Act* (1965), *A Nation at Risk* (1983), and *No Child Left Behind* (2002), and most recently the new vision for ESEA (2015) have sought to propose ways to best educate the nations young people by focusing on the basics, rules and procedures, of English and Math learning. While these federal initiatives over the years have called our nation back to a focus on the basics, rules and procedures of learning mathematics, there is lack of evidence that education is being challenged to connect rules to reason. On the following pages research is discussed that indicates that writing is one possible way to connect the rules and procedures (what many consider the basics), to reason and critical thinking with the goal of enhancing mathematical learning.

Mathematical Learning and Instruction

In 2007, the National Institute for Literacy noted that when a student's writing skills improve so will one's capacity for learning. Kjos and Long (1994) said, "If we taught music as we teach mathematics, students would practice musical scales for years without ever getting to play a song" (p. 48). This suggests that math needs to be taught with problem solving practice in context to real-world problems. Urquhart (2009) and Alvermann (2012) would add that writing should be at home in mathematics learning to help foster this problem-solving practice and critical thinking in students within this real-world context.

Even and Tirosh (2002) stated that "a rather frustrating phenomenon, often described by both researchers and teachers, is that students who are known to have all the knowledge that is needed to solve a problem are unable to employ this knowledge to solve unfamiliar problems" (p. 225). The researcher wondered if students are not conceptualizing math concepts; therefore, students are unable to transfer knowledge to unfamiliar problem situations. Many students are just memorizing facts and processes but cannot explain or communicate any of those processes mathematically, hence creating the inconsistencies in operations with rational numbers.

Schoenfeld (1992) described mathematics as a living subject seeking to understand patterns in the world and within one's mind by finding solutions, not just performing memorized procedures, exploring patterns, not just using memorized formulas, and creating conjectures, not just completing exercises. Mathematics is mostly based on rules that one must learn, but there must be a time when "students move beyond rules to be able to express things in the language of mathematics" (Schoenfeld, 1992, p.

335). Mason and Spence (1999) claimed that the idea of "knowing to" (knowing that engages students in solving in context and unfamiliar problems) is a critical part of knowledge. Pape, et al. (2003) agreed that reasoning, not just rules, is important in mathematics when they stated, "Too often students are provided straightforward models of solving problems rather than the complicated and strategic thinking inherent in mathematical behavior…" (p. 180).

The following researchers discussed the idea that mathematical learning is more than just the facts and procedures. For example, Kjos and Long (1994) suggests that mathematics is what drives thinking and should be taught in real-life context. Bellanca and Fogarty (1991) highlight the need to develop reasoning skills that will help students' focus to remain on the why and how of mathematics. Countryman (1992) sums it up in her theory of mathematical understanding when she claimed that "to know mathematics is to engage in a quest to understand and communicate" and provides techniques and learning experiences that will help develop students' mathematical understanding (p. 9).

Techniques and learning experiences in mathematics instruction vary in education and "depends on one's conceptualization of what mathematics is, and what it means to understand mathematics" (Schoenfeld, 1992, p. 334). Based on Skemp's (1978) work mathematics techniques and learning are categorized by instrumental and relational mathematics. Instrumental mathematics is based on the idea of rules, procedures, memorization and rote learning. This type of mathematics instruction can be seen in the behaviorism theories of Skinner and Thorndike. Students simply learn by memorizing procedures and apply them to varies word problems. Skemp (1978) points out the advantages to this such as quick answers, easier learning, yet also shows how it is often difficult to transfer this mathematical learning to new and unfamiliar math context.

In contrast, relational mathematics is based on rules with reason. Students are taught not only how to perform the procedure, but also why they are performing that particular procedure with the reason the rule works or the patterns involved. Skemp (1978) suggested that the advantages of relational mathematics learning and instruction are the ease in transferring knowledge to new problem solving situations and the ability to remember mathematical learning because the contextual understanding is present, not just the procedural knowledge.

Anthony and Walshaw (2009) continue to support Skemp (1978) with the idea that students need to make sense of mathematics, not just memorizing. When students begin to make the shift from just rules and procedures to making sense of the mathematics they are learning, they are less preoccupied with answers and more interested in the thinking and reasoning that led to their answers. This shift must be modeled through mathematical instruction multiple times so that it will transfer from teacher instruction to learning among students. Effective instruction allows students to think independently using open-ended and modeling tasks in which they will make sense of the context and mathematics involved in the task (Anthony & Walshaw, 2009).

Journal Writing and Its Link to Mathematics Learning

Miller (1991) suggested that in the 1980s, writing became an effective and practical mathematics instructional tool, student learning aid, and strategy that helped students think more clearly and sharply about mathematics. In 1989, the NCTM also challenged mathematical curriculum to focus on communicating mathematical understanding through writing. NCTM took advantage of the support from the public opinion that basic skill and clear standards should be the focus of mathematics education. Those standards suggested that writing (supported by research) should be done within the math curriculum, not apart from it, and should “encourage and enable students to value mathematics, gain confidence in their own mathematical ability, become mathematical problem solvers, communicate mathematically, and reason mathematically” (NCTM, 1989, p. 123). This challenge asked students to connect procedures and rules to mathematical reasoning and understanding, stating, “Reflection and communication are intertwined processes in mathematics learning…Writing in mathematics can also help students consolidate their thinking because it requires them to reflect on their work and clarify their thoughts about the ideas” (p. 61).

Another important aspect of mathematical understanding is metacognition, which Costa (1984) described as knowing what one knows and does not know and the ability to strategize for “producing what information is needed, to be conscious of our own steps and strategies during the act of problem solving, and to reflect on and evaluate the productivity of our own thinking” (p. 57). Shuell (1986) added that the metacognition of a learner is strengthened when learning is active and meaningful, and learners who are successful have a strong and well-structured metacognitive ability. One effective way that was suggested by Baxter, Woodward, Olson, and Robyns (2002) for creating strong metacognitive ability and increasing understanding and communication in mathematics was by providing “students with opportunities to explain their thinking about mathematical ideas and reexamine their thoughts by reviewing their writing” (p. 52).

There appears to be a compelling link between the learning of math and journal writing. To further address this link, Bell and Bell (1985) found expository writing in mathematics as a tool that can be practical and effective in problem solving instruction. Moreover, Linn's (1987) study with journal writing cultivated active participants in the learning, which in turn increased students' mathematical thinking and communication. In 1989, Borasi & Rose discussed the value and benefits of implementing writing to learn in mathematics courses to allow students an organized way to express and reflect on their math learning. Teachers are then able to use students' journals to improve their daily instruction. Borasi & Rose (1989) stated that one of the best outcomes of journaling among students and teachers is the dialogue that is created.

This dialogue through "writing can provide opportunities for students to construct their own knowledge of mathematics" (Countryman, 1992, p. vi). In a study conducted by Kjos and Long (1994), they found that critical thinking, manipulatives, and writing to improve metacognitive skills should all be part of a mathematics curriculum. A year later, Hackett and Wilson (1995) found that journals gave students opportunities to reflect on learning, share thinking, and verbalize thinking, which had a positive effect on student understanding, again increasing metacognition.

At the turn of the century, research continued to show positive outcomes when using journal writing in mathematics. In a study, Johanning (2000) reported positive outcomes with the use of writing in problem solving and mathematics learning, concluding that writing activated students' understanding and learning. Understanding and learning took place and teacher instruction was enhanced through writing by providing "a way to develop mathematical thinking and help students become more efficient problem solvers" (Johanning, 2000, p. 9).

Lim and Pugalee (2004) also investigated journaling in mathematics learning, and over the course of the study, they saw improvement in both learning and communication. Similarly, Walz (2008) completed a study to explore the connection between math journaling and homework completion and found that students enjoyed writing and felt it was beneficial to their learning. In a more recent study, Kostos and Shin (2010) found a positive effect when using journals in math learning.

Since learning mathematics is a complex task, *Writing Across the Curriculum* suggests that mathematics learning is impacted and individualized when teachers incorporate writing into the daily math lesson. Students can process their thinking in all parts of learning: before, during and after. This curriculum theoretical framework "fosters critical thinking, requiring analysis, application and other higher level thinking skills" (Michigan State Department of Education, 2015, p. 3).

This movement of writing across the curriculum continued to encourage the idea of using journals in mathematics learning. Through writing, students can communicate their understanding through reflecting, reviewing learning, observing gaps in knowledge, dialoguing with teachers, and personalizing learning. McCormick (2010) even claims that writing in mathematics learning helps build a solid foundation of reasoning skills, allows teachers to provide feedback to students that is meaningful, develops the mathematical process standards, and allows students opportunities to deepen understanding by revising their thinking through the writing process.

One specific form of communicating through language that has been incorporated into math instruction over the years is journal writing, to which Lim and Pugalee (2004) claim, "Language and mathematics are intrinsically related. Attention to language is an important component in developing students' conceptual understanding of mathematics" (p. 1). Writing allows students to become engaged in learning by manipulating, integrating, and restructuring current knowledge by accessing and reflecting upon prior knowledge. There is power in using writing to communicate mathematical thinking. Students were said to be focused and able to extend thinking by continuing to build on their mathematical understanding. This way of communicating shows that "writing allows students to make connections, reflect on and synthesize learning, while also engaging in authentic practices of the discipline" (as cited in Lim & Pugalee, 2004, p. 2).

Communicating through writing is described by Murray (1973) as "the most disciplined form of thinking" (p. 22). As previously discussed, research shows that writing to learn is beneficial to students' metacognitive ability, increasing the way one thinks about his or her own thinking, but journal writing specifically provides descriptive feedback between teacher and student. In 1985, Willoughby said, "a characteristic of an effective program for teaching mathematical problem solving is a lot of direct two-way communication between teacher and student" (p. 90). Mathematical learning and thinking will be at its best when there is communication and feedback. Journal writing, when done correctly and effectively, can provide an individual learning opportunity for each student. McIntosh and Draper (2001) suggest that teachers stretch students to provide more than just answers, and that teachers should not accept answers that are partial and seem to lack effort. Walz (2008) said, "Journal writing can be beneficial in providing students with a richer and more in-depth understanding of the mathematics they are learning" (p. 9). Explanation in problem solving in mathematics has great importance and helps aid students' mathematical understanding (Pape et al., 2003; & McIntosh & Draper, 2001).

Explanation through writing was shown by Hackett and Wilson (1995) to increase the usage of mathematical language in students' mathematical understanding and learning. During this study, the number of writing opportunities in the math instruction was increased. Researchers found that students became more aware of the use of mathematical terminology. Walz (2008) found that writing in mathematics learning is helpful in students' understanding of key concepts and creating deeper mathematical thinking.

When reviewing the literature on journal writing in mathematics one can see that many have studied journaling and, although many showed positive effects to mathematics learning and thinking, there were a few that claim writing does not positively affect mathematical learning. Shield and Galbraith (1998) claims that while writing "has been the subject of many publications…little evidence has been presented to support the claims that writing enhances the learning in mathematics" (p. 29). Due to this claim, their work with a group of eight graders sought to develop a coding scheme with the expository writing produced by the students in the study. While one may agree that analyzing student writing is a daunting task, according to the bulk of research it is well worth the time. Journal writing in used effectively has shown positive impacts on learning and challenges students to dig deeper in mathematical learning than just skills.

Conclusion

Mathematical understanding and thinking are complex issues and discussed among many educators. It has been discussed that Skemp (1978), along with others, claim that mathematical knowledge and understanding goes deeper than just memorizing facts and following procedures. There is a part of mathematical learning, conceptual understanding, also called rational understanding, that is often overlooked by students, parents, community and even teachers. Students only want to learn the "how to" (instrumental understanding), for the test or assignment but then lack the "connection to why" (rational understanding) in order to transfer that mathematical knowledge to unfamiliar problems and situations. Meel (2003) states, "Even though researchers now separate understanding from knowledge, evidence exists that the mathematics education community has not researched unilateral agreement on the meaning of 'understanding' since various authors approach it from diverse viewpoints" (p. 135).

Mathematical knowledge and understanding are needed to equip students for the twenty-first century world around them. Literature tries to explain how to get the understanding, what is going on inside the mind of a learner, to be demonstrated so that one can build on current understanding and allow deeper learning to take place. The most common type of writing found in the literature was journal writing. Journal writing has been used with structured prompts, unstructured open-ended prompts and even for students to free-write mathematical thinking. Journals have also been used as a communication tool between teachers and students but also between peers. Research shows that as students write, teachers are able to see misconceptions in their mathematical learning and respond directly to the student, offering feedback to help students strengthen their metacognitive ability.

To increase metacognition, relational learning is key in producing life-long independent learners. When relational learning takes place, the math learner gains the priceless skill of being able to problem solve, with persistence, and become a thinker not just a doer of mathematics. Henningsen and Stein (1997) summed it up well in their research by stating, "In order to develop students' capacities to 'do mathematics,' classrooms must become environments in which student are able to engage actively in rich, worthwhile mathematical activity" (p. 524).

Mathematics learning and writing, how are they connected? Wilcox and Monroe (2011) pointed out that although around 1989 NCTM communicated to the education community that mathematical communication should be a goal for all math learners, "We see few examples of the integration of writing and mathematics in educational literature" (p. 521). He also noted that some teachers are hesitant to integrate writing in the mathematics classroom because of the fear of not honoring both writing and mathematics content with integrity. To ease teacher hesitation, he suggests incorporating both writing without revision (impromptu writing) and writing with revision (more formal writing) to emphasize math content. While much research has been conducted on writing in mathematics to increase students' understanding and reasoning, more research is needed on how integrating writing in the math classroom impacts students' learning.

Chapter Three: Action Research Methodology

Problem of Practice

After teaching a unit on operations with rational numbers to seventh grade students, the researcher noticed that students struggled to perform operations with rational numbers accurately and consistently. This study focused on students' understanding of operations with rational numbers through journal writing. Students' inconsistencies in operational procedures of rational number operations was identified as the problem of practice. Students often memorized a rule or procedure, but as evidenced through the inability to consistently and accurately apply the rules of operations with rational numbers, it seemed many of them struggle to grasp the reasoning of why that rule or procedure works mathematically, which was defined by Skemp (1978) as relational understanding. The researcher wondered if gaining relational understanding, as described by Skemp (1978), of these operations with rational numbers, would help students master operations with rational numbers.

As previously noted, research claims that mathematical knowledge and understanding is more than memorizing a set of rules and procedures (Skemp, 1978; Sfard, 1991; Countryman, 1992). Writing to learn incorporates writing in the mathematics classroom with the intent of students gaining not only instrumental understanding but also relational understanding (Countryman, 1992; Skemp, 1978). Therefore, this research aimed to examine the impact of journal writing on eight seventh grade students and their relational understanding of rational numbers.

Research Question

What impact will journal writing have on the understanding of rational number operations among eight seventh grade math students?

Purpose of the Study

The purpose of this study was to examine the impact of journal writing on the understanding of rational number operations among eight seventh grade math students.

Action Research Design

The action research paradigm utilized during this study is qualitative in nature. The researcher investigated the impact of journal writing on students' understanding of rational number operations. Through participant journal entries, formal and informal interviews, observations, and artifacts, the researcher sought to examine students' understanding of rational number operations.

Ethical Consideration

The researcher thoughtfully considered the ethical implications of the study. First, the researcher considered how the study impacted classroom instruction. The researcher was aware that while conducting research, her first responsibility is to teach mathematics to her students. This study incorporated writing into the math instruction with the intention to enhance and support math content, not hinder the content covered or not take away from mathematical learning.

The researcher also was careful to consider the safety of students and guidelines of the school district. The potential for harm to the participants was at a no to a very low risk level. The researcher contacted the school district about any guidelines or review process policies that may need to be followed during the research project. The principal gave school approval while the assistant superintendent of instruction gave district approval for this research study to be conducted (Appendix E). Before the study began, the researcher made all classroom stakeholders (i.e., principals, parents, and students) aware of the study. Students were asked to write about specific math content on rational number operations and were never made to share out loud or do anything that would potentially cause them anger, anxiety, or embarrassment among their peers, as is typical practice in the researcher's classroom. To protect the identity of the participants and setting, pseudonyms were used throughout the study.

Setting and Time Frame of Study

Jackson Middle School is an average-size middle school, grades six through eight, with an administration leadership comprised of one female principal and two assistant principals, one female and one male. Jackson Middle School is in a small, rural, close-knit community just outside a very rapidly growing area in the South. The school has little diversity among race or class which mirrors the composition of the community. The majority of the students represent predominantly white middle to upper class families. Over the years, this school has been known for excellence; yet, it often does not meet goals in all subgroups for federal and state accountability measures.

Jackson Middle School is part of an average size school district with a total of fourteen schools: eight elementary schools, three middle schools, and three high schools. In the last five years, the district office has been reorganized. The current organization of the leadership begins with the school board. The school board consists of seven members, four males and three females, with ages beginning in the mid-forties. The board meets monthly and works closely with the superintendent to maintain policies and finances. Also, at the district level there are three assistant superintendents: administration, instruction, and finance. The school board is very active and engaged in daily operations and decision-making of the district with the students as priority.

The time frame for this study was eight weeks during the 2016 fall semester. All eight formal interviews were completed during week one. Students responded to journal prompts and the researcher actively observed students, collected observations, and conducted informal interviews with participants during weeks two through seven. The final week of the study, week eight, post formal interviews were completed.

Participants in the Study

The participants of this study are eight students enrolled in two math enrichment classes that meet on an A day/B day schedule. Four students from each class were identified to participate in the study based on availability and class schedule which indicates different mathematical levels of achievement. Parental consent form (Appendix A) were sent home to parents prior to the study to gain permission to participant in the study. There were two male Caucasian students, three female Caucasian students, one male American Indian, and two male African American students involved in the study. The researcher has provided a description of each participant including age and math ability. John, Beth, Rob, and Sue are part of the A day math enrichment class and Matthew, Courtney, Katie, and William are part of the B day math enrichment class.

A-Day class participants. *John* is a 13-year-old, Caucasian male who is quiet, appears to be unmotivated, and appears to lacks strong work ethic. John was taken out of public school last year to be homeschooled by his mother in January. He was re-enrolled in the public school at the beginning of the current school year. John scored in the second percentile on the mathematics Measures of Academic Progress (MAP) test in September of 2016. He is working significantly below grade level (50^{th} percentile) in mathematics.

Beth is a 13-year-old, Caucasian female on a 504 plan for Attention-Deficient Disorder. The 504 plan allows for accommodations such as preferential seating for close proximity to the teacher, verbal clues to slow down and be neat, small group for standardized testing, and hard copy of notes when needed. It appears that she does not like to speak out in class and does not want to be called on in front of others. Beth scored in the eighth percentile on the mathematics MAP test in September of 2016. She is working below grade level in mathematics.

Rob is a 12-year-old African American male who is extremely quiet and appears to be introverted during class. Rob struggles in math and does will not verbally ask questions. He will respond when asked a question but seems to prefer to not speak in class. Rob scored in the twenty-eighth percentile on the mathematics MAP test in September of 2016. He is working slightly below grade level in mathematics.

Sue is a 12-year-old Caucasian female who appears to be social among her peers, cheers for the football team, and regularly participates in class. She will answer questions when asked and sometimes will volunteer her answer during whole group time. Sue scored in the seventh percentile on the mathematics MAP test in September of 2016. She is working significantly below grade level in mathematics.

B-Day class participants. *Matthew* is a 12-year-old American Indian male who speaks Spanish and is on the highest level on the ESL (English as a Second Language) assessment. He speaks and understands English well. Matthew scored in the tenth percentile on the mathematics MAP test in September of 2016. He is working significantly below grade level in mathematics.

Courtney is a 13-year-old Caucasian female who is very sweet, conscientious, and appears to have a superb work ethic. Courtney does not often volunteer her answers in class but will answer when her name is called. Courtney scored in the fifty-third percentile on the mathematics MAP test in September of 2016. She is working on grade level at this time.

Katie is a 13-year-old Caucasian female who appears to be very introverted, quiet, and often stays to herself. She does not seem to make friends easily and appears a little more mature in her thinking and reasoning than most of her peers. She scored in the thirty-ninth percentile on the mathematics MAP test in September of 2016. She is working slightly below grade level in mathematics.

William is a 13-year-old African American and Caucasian male who is a very vocal student often calling out wrong answers instead of raising his hand to be called. William plays football for the school and seems to be focused on sports more than academics. William scored in the seventh percentile on the mathematics MAP test in September of 2016. He is working significantly below grade level in mathematics.

Research Methods

The data collections instruments used in this study were formal interviews (pre/post), informal interviews, student-participant journals, artifacts, observations through field notes, and the researcher's reflection journal. These instruments were used to collect vital data for this research study to determine the impact of journal writing on students' understanding of operations with rational numbers.

Interviews

The researcher used interviews to determine what students remembered about rational number operations. Mertler (2015) proposed that semi-structured interviews are often used in qualitative studies to allow the researcher the flexibility of asking follow-up questions during the interview. Therefore, the researcher used formal semi-structured interviews (pre/post) during this study to determine the level of understanding of each participant. By using a formal semi-structured interview guide for the formal pre and post interviews the researcher had the flexibility to ask clarifying questions, pursue information not in the original questions, and gather different information from each of the participants when needed.

The formal semi-structured interviews (both pre and post) were recorded using audio and were later transcribed into written form. The formal semi-structure interview guide (appendix B) asked participants a few questions about how they felt about learning math, but focused mainly on rational number operations (i.e., add, subtract, multiply, and divide rational numbers: integers, fractions, and decimals).

Spontaneous informal interviews were used during the study in two different ways. The researcher responded to students in their journals by asking questions, making statements and guiding students to deeper thinking through writing. Periodically throughout the duration of the study the researcher verbally asked questions to students in the classroom based on their previous journal prompt responses and recorded written notes of their responses in her data collection journal.

Student-Participant Journals

The student-participant journal was used by participants to record their responses to the writing prompts related to rational number operations. These journal prompts intended to gage, guide, and encourage participants to explain their thinking of rational number operations. Students have previously studied operations with rational numbers but still struggle to transfer that understanding to new situations and be able to explain the reasoning behind the procedure. The prompts were created as a result of the pre-interview responses with participants. In many of the journal writing prompts, students were asked to justify and support answers.

Artifact

During this qualitative research study, the researcher collected weekly quizzes on rational number operations. Dana and Yendol-Hoppey (2014) suggest that artifacts are selected student work documents related to the topic of the study. The intent of collecting the artifact was to observe any impact that journal writing may have had on student accuracy and consistency in rational number operations.

Action Research Data Collection Journal

The researcher kept an action research data collection journal during the research study. This journal consisted of the field notes page, a daily summary specific to each group, and a weekly narrative reflection on the whole group of participants. The data collection journal provided the researcher with one location for collecting observations and noting reflections throughout the study.

The field note page (appendix D) was used to "capture talk that occurs naturally in the classroom" (Dana & Yendol-Hoppey, 2014, p. 105). The researcher captured what is going on in the classroom, reflected on student behaviors and made notes about student questions while they wrote their journal response.

The reflection piece focused on self-reflection in relation to teaching students about rational number operations during the daily and weekly summaries. After the pre interviews were completed, the researcher wrote a reflective summary of those interviews. During week two to seven the researcher wrote a daily reflection. At the end of each week, after reading and responding to student responses, the researcher also wrote a weekly summary reflecting on any patterns or themes that were found in the journal writings for the week. The daily and weekly summaries were written as a narrative reflection on the researcher's instruction and the thinking of students depicted through the journal writings.

Procedure

The goal of this qualitative study was to examine the impact of journal writing on students' understanding of rational number operations. The researcher carefully conducted the study using procedures that adhere to the action research design model. The procedures for this research study were completed systematically, ethically, and confidentially.

During week one each of the eight participants completed a formal semi-structured interview using the interview guide (appendix B) before journal writing prompts were implemented. Fifteen journal prompts (appendix C) were implemented each day, group A on A-days and group B on B-days, during weeks two to seven. This is a total of six weeks of journal writing. The journal prompts were implemented each day of the week Monday through Friday between 10:30 and 10:45 beginning in week two.

Group A wrote journals on Tuesday and Thursday while group B wrote journals on Monday, Wednesday, and Friday during weeks two, four, and six. Group A wrote journals on Monday, Wednesday, and Friday while group B wrote journals on Tuesday and Thursday during weeks three, five, and seven.

Throughout the six weeks of journal prompts the researcher responded each week to all eight students in their journal by making comments, asking questions, drawing attention to misconceptions and guiding students to deeper thinking through writing. Throughout weeks two, three, four, and five the teacher-researcher informally interviewed two different students each week, a total of eight students by the end of week five, based on their responses to the journal prompts. Once the researcher had informally interviewed each participant, during weeks six and seven, she selected participants based on responses to journal prompts to informally interview in order to establish clarification on journal prompt responses.

During each class while students are writing the researcher observed students and documented these observations on the field notes page (appendix D). Then at the end of the day the researcher wrote a daily summary. At the end of each week the researcher wrote a weekly summary about observations and patterns found in student journals.

The last procedure, post formal semi-structured interview, was completed during week eight. The researcher interviewed each student-participant individually using the same eight semi-structured interview questions used in the pre-interview. The researcher recorded these formal interviews using audio only and transcribed at a later date.

Data Analysis

Data analysis in a qualitative study "involves a process of inductive analysis" (Mertler, 2014, p. 163). To ensure the validity of the results the researcher analyzed the data using this inductive process in a systematic way with integrity during the study and after all data was collected. Parsons and Brown described this inductive process as a systematic way to organize the data to facilitate understanding by using "a three step process for conducting this analysis: organization, description, and interpretation" (as cited in Mertler, 2014, p. 163).

During the study the researcher analyzed student journal entries, observation field notes, informal interview notes, and student artifacts on a daily and weekly basis. After the pre-interviews and post-interviews were complete, the researcher transcribed the interviews and read student responses. She then wrote a summary of these interviews in her action research reflection journal.

The researcher took time each day after students had written their journal entry to read each response and make comments as needed to provide students with written feedback. She also analyzed observation field notes for that day along with any informal interview notes. The researcher wrote a daily reflection summary documenting patterns in thinking, learning, and behavior from the student written responses, informal interview responses, and observation field notes in her personal action researcher journal. Then at the end of each week the researcher re-read each daily summary and composed a weekly reflection summary as well.

During the study the researcher also analyzed the artifact, a weekly quiz, looking patterns, trends, and consistency in student learning and accuracy in rational number operations (Dana & Yendol-Hoppey, 2014). This artifact was used to see how the journal writing impacted student accuracy in operations with rational numbers in various contexts. For example, these weekly rational number quizzes were analyzed to note the accuracy in students being able to simply compute using the operations. These documents were extremely important because they are forms of data that occur naturally in the classroom setting; yet, did not reveal any information about students' understanding of rational number operations.

After all data was collected, the researcher analyzed the data as a whole by using a coding process suggested by researchers (Mertler, 2014; Creswell & Poth 2017; Merriam & Tisdell, 2015). The first step in analyzing qualitative data is the organization of the massive amounts of data. The researcher organized the data into participant journals, interview transcripts, researcher field notes, and researcher reflections (daily and weekly).

The researcher began this coding analysis by re-reading all daily and weekly summaries written in the researcher's reflection journal. She looked for patterns and themes that occurred during the study in participant journal entries, interviews, and observation field notes that the researcher included in these summaries. The researcher then compared the pre interview with the post-interview for each participant, noting any changes in student perspectives about learning rational number operations and journal writing in mathematics over the course of the study. The researcher made notes of themes, patterns, similarities, or differences that surfaced which told the story of the impact of journal writing on students' understanding of rational number operations.

The researcher listed out the themes that surfaced during this thorough read of all the data according to each student participant and then a category of general observations. With this list in an excel spreadsheet the researcher analyzed these codes to simplify into four descriptive themes that described the ideas found in the data. The researcher used the following codes and colors: (a) terminology – green, (b) misconceptions – yellow, (c) application – blue, and (d) writing – orange. With each color in hand the researcher re-read all interview transcriptions, students journal entries, and daily and weekly researcher reflections. As the researcher read thoroughly and carefully through the data once again, she marked each theme with the corresponding color. This process helped identify evidence of each theme in the data collected to support the findings of the study. The final step in the analysis coding process was to describe the data in a narrative form.

During the description stage the researcher described in narrative format the various patterns and themes in learning, thinking, and behavior presented by the students and the impact of journal writing on students' understanding of rational number operations. Dana and Yendol-Hoppey (2009) suggest that in this descriptive stage one tries to simply describe what is taking place through the data in order to begin making sense of the data with the goal of explaining the implications of the research. The researcher's goal in the description stage to describe the impact journal writing had on students' understanding of rational number operations using the commonalities among participants, themes in learning patterns, and mathematical reasoning through the data.

Plan for Reflecting with Participants on Data

The researcher reflected on the data with participants during the study and at the end of the study by meeting with all eight students individually and as a group. Each week, as the researcher read and analyzed student journals, she provided feedback through written conversation and informal interviews. The goal of this interaction was to challenge students to dig a little deeper into their mathematical understanding and reflect on their writing. During the individual post-research meeting with participants the researcher discussed different aspects of the journal writing with students. She then met with the eight participants as a whole to gain feedback for future studies. During this whole group meeting the entire research process was shared and results were discussed. At all times during the reflection process with participants, the identities of each participant were anonymous to protect the privacy of each participant.

Sharing results with the participants was a priority but sharing with the researcher's colleagues was equally important in order to "encourage others to engage in these types of activities in their own classrooms" to better teaching, instruction, and ultimately student learning (Mertler, 2014, p. 246).

Plan for Devising an Action Plan

The idea of action research is that some action will take place as a result of the study (Mertler, 2014). This action research study was conducted by a classroom teacher with the goal of improving instruction and learning of mathematics in the area of rational number operations. The action plan devised by the researcher of this study is based on the results of this study and implications of the impact of journal writing on students' understanding of rational number operations.

Chapter Four: Findings from the Data Analysis

This qualitative research study aims to examine the impact of journal writing on student understanding of rational number operations. Skemp (1978) and Countryman (1992) have shown that mathematical achievement is more than getting a right answer. That is, mathematical achievement also focuses on reasoning and thinking not just procedures. Over the course of the year, the researcher attempted a variety of strategies to teach her students rational number operations, many nevertheless, continued to struggle to consistently and accurately perform operations with rational numbers.

Students' inconsistency and inaccuracy in operational procedures of rational number operations was the problem of practice, which prompted the study. Therefore, the researcher wondered if conceptualizing these operations with rational numbers, understanding the why or reasoning behind the operation through journal writing, would help students master them. This study focused on observing students' understanding of rational number operations through journal writing.

Research Question

What impact will journal writing have on the understanding of rational number operations among eight seventh grade math students?

Purpose of the Study

The purpose of this study was to examine the impact of journal writing on the understanding of rational number operations among eight seventh grade math students.

Findings of the Study

Riessman (1993) stated, "We cannot give voice, but we do hear voices that we record and interpret" (p. 8). The voices and experiences of the participants of this study assisted the researcher and the reader to know what a participant senses, knows, or experiences (Clandinin, 1993). The findings of this study are presented as a narrative with the intention of understanding the process of student thinking with rational number operations in the mathematics classroom.

The data analysis in this chapter is a result of a thematic analysis. From a careful examination of student journal writings, recorded researcher field notes, and interviews, four themes emerged: (a) mathematical terminology (usage and understanding), (b) misconceptions (terms, integers, decimals, and fractions), (c) application (strategies and prior knowledge), and (d) writing (student perception, written expression, and reasoning).

Theme One: Challenges with Mathematical Terminology

Challenges with mathematical terminology was the first theme to emerge from the data. This "refers to "written words that express mathematical concepts or procedures" (Hebert & Powell, 2016, p. 1515). Throughout student journal entries, students were inconsistent as a whole and as individuals in using math terms as they relate to expressing their mathematical thinking and reasoning. Most students chose to use their own words to describe mathematical concepts and processes. These findings revealed the following sub-themes concerning challenges in using mathematical terminology during the study: (a) math terms used, (b) non-math terms used, and (c) student understanding of mathematical terminology.

Math terms used. Some students used appropriate math content vocabulary such as integers, fractions, decimals, adding, subtracting, multiply, divide, numerators, denominators, reciprocal, and equivalent fractions to describe their thinking. For example, Sue used the word reciprocal, a math content term, to describe dividing fractions. She wrote, "So first you have to change it to multiply by the reciprocal." She then correctly demonstrated that she understood the term reciprocal by showing the math work.

Other students could identify and use the phrase "common denominator" in their journal entries when explaining adding and subtracting fractions. For instance, Rob and John both wrote about using a common denominator to describe the bottom number of a fraction. Rob wrote, "Check to see if your denominators are common if they are not you have to make common denominators," while John wrote, "First you have to make the denominator the same and then you get your answer" when describing how to add and subtract fractions. In another journal entry, Rob described how to divide fractions, stating, "You can divide them when they are fractions but you need common denominators." He did use the correct math term but did not follow through to show or explain how he would indeed get the common denominator and divide.

One student, Courtney, used the term equivalent denominators to describe the same math concept that Rob and John stated as common denominators. During an informal interview with the researcher, Courtney verbally discussed getting a common denominator by making equivalent fractions, but she struggled with subtracting 3 – 4 in the numerator. Also, in her writing, Courtney stated two different times that "you have to have equivalent denominators" and "you make the fractions denominators equivalent" to explain how to add and subtract fractions.

Non-math terms used. The data also showed that students often used non-math terms to explain their mathematical thinking or process; that is, students used their own words to describe their thinking and understanding of mathematical concepts. The most used non-math terms were bigger, flip, switch or swap, cancel, jump, top, bottom, and slap or drop when explaining. These non-math terms learned in previous math classes would not be classified by the researcher as mathematical terminology. Students also used previously learned phrases like BB&T (Base, Bottom, Top—the process for changing mixed numbers to improper fractions), inside the thing, outside the box, over powers, move over or pull down, and keep change flip.

For example, the word bigger was used when discussing the outcome of an answer's sign, positive or negative. Sue stated, "If the number is bigger and is negative then the answer is negative. If the bigger number is positive, then the answer is positive." Courtney used the phrase over powers, similar to bigger, to determine how she got the sign when adding integers with different signs, stating, "When you have negative four it over powers the three." While Sue and Courtney did not use the content specific mathematics term of absolute value, the data indicates they were both able to describe how they got the sign of the answer by using the word bigger or the phrase over powers. Throughout the study, Beth also used the word bigger in seven out of 15 journals; however, she was inconsistent in applying the correct understanding of how to determine the sign of the answer. Beth stated, "Take the sign of the bigger number" when accurately explaining how she would add integers with two different signs, but then she repeated, “Take the sign of the bigger number” in another journal to inaccurately describe multiplying and dividing decimals. This made the researcher wonder if Beth truly understands the phrase “take the sign of the bigger number” when performing operations with rational numbers.

When writing about dividing fractions, only two out of eight students used the math term reciprocal, while others, like William and Matthew, used the word flip. William stated, “I’ll flip the second fraction” to describe an operation with fractions. In several journal entries about integers, William used a similar phrase but said “keep change flip” to describe a fraction operation. Matthew also used the word flip several times in his journal’s writings. When asked to describe multiplying and dividing fractions Matthew continued, “multiply the numerator of the fraction then multiply the denominator and simplify if needed.” He then went on to say, “To divide…flip the second fraction and multiply.” Although he did not use the appropriate math content vocabulary, multiply by the reciprocal, he demonstrated correctly how to divide fractions when he used the word flip.

Other non-math terms that were used by two students, John and Katie, was switch or swap to describe two different math concepts. Katie used the word switch several times to discuss changing an operation sign, stating, “Switch the sign and the second number” when describing how she would multiply and divide integers. Katie used this same word when she described adding and subtracting fractions, saying, “I kept the first fraction the same, switched out the sign, and made the positive a negative” to describe how to add fractions with different signs. In an informal interview with Katie, I asked her what she meant when she used the word switched. She described her process as "keeping the first fraction the same, switching out the sign (plus to minus), and made the positive a negative, the opposite." Although she did use the word switched correctly in her writing and verbal conversation with me, her work appears to show that she confused the idea of subtraction, add the opposite, with adding fractions with different signs.

John used the term swap to describe his action with a fraction, not an operation. John said, "When multiplying and or dividing you mite [might] have to swap the numerator and denominator and then you multiply or divide." While this line of thinking is incorrect, the word swap does provide a little insight into John's understanding of multiplying and dividing fractions. By using the word swap, he demonstrated his understanding that something needed to be changed. His work further demonstrated that he knew there was an operation that was connected to inverting or swapping the fraction; nevertheless, he had a lot to learn.

Three students, Sue, John, and Matthew, used the terms cancel and cross out or drew a picture to show canceling out to describe the math concept of one negative and one positive creating what math calls a zero pair. Matthew described subtracting as follows, "For subtraction you leave the first number alone change the subtraction sign to Addition and do the oppisit [opposite] operations so if it is (-) you turn it into a positive, the 1 canceled out and got -1." Sue said, "I got it because you do three yellow (positive) and four (negative) red. Then you have to cross them out the multiples same then you will have one left over which is red so the answer would be negative one." While John did not use the term "cancel out", he drew a picture of integer chips to show understanding of canceling out. All three of these students could demonstrate understanding of zero pairs but did not use what the researcher would consider appropriate math content vocabulary when explaining or justifying their mathematical thinking.

Another example of students using non-math terms, yet demonstrating understanding of a math concept, was when students used the phrase BB&T. As part of the operations with rational numbers in fraction form, students used a previously learned strategy of changing a mixed number to an improper fraction to multiply and divide. Often, students would state that they used BB&T, but did not explain in words the BB&T process. Many times, students only demonstrated it in their math work correctly and incorrectly at times. For example, Sue and Rob referred to this process BB&T in the same two journals. The first journal presented students with $-2\frac{1}{2}-(-\frac{4}{5})$. In her journal entry, Sue wrote, "On the first one you do BB&T then subtract" while Rob wrote "You would do bb&T so you would have $\frac{5}{2}--\frac{4}{2}$." Both students showed in their math work the correct improper fraction (except Rob forgot to make $\frac{5}{2}$ a negative), but neither student explained the abbreviation BB&T. On another journal prompt, Sue wrote, "You have to do BB&T" and Rob stated, "You could do BB&T." In both journals, students demonstrated the ability to accurately apply this strategy, even though he or she used the abbreviation and did not fully explain. On the last prompt, when students had to find the error, fix the error, and provide an explanation to justify the answer, Sue, not Rob, stated, "Well first when she did it she didn't do BB&T Base time Bottom Plus Top." This was only time Sue gave any explanation of this BB&T process, but each time she performed the process correctly.

Understanding mathematical terms. Throughout the interviews, both formal and informal, several times, the researcher had to define math terms in the questions being asked. For example, when the researcher asked students to describe rational number operations, seven out of eight students hesitated until the researcher clarified the word operations by rephrasing the question to say, "What do we do with numbers in mathematics?" Sue answered, "If it's subtraction you add it and put a negative on the second one, and if they are both negative you do the same." She then followed up with listing operations as "addition, subtraction, multiplication, division." Rob answered, "Umm, they're ratios you can turn into fractions," which is an incorrect answer. Then he stated, "PEMDAS." When the researcher asked him to explain what PEMDAS means, he verbally said, "Add, subtract, multiply and divide."

Even after clarifying the word operation, John still did not answer with add, subtract, multiply, and divide. He simply gave two examples, vocalizing, "Like eight minus seven and negative eight plus negative 43." Beth stated, "I can remember some of it but I can't put it into words." William also did not understand the question even after clarifying the word operations, and he gave a very off-topic incorrect answer. Courtney and Katie began to list out the rules for the operations instead of stating the math operations of rational numbers. When the researcher asked the students what rational numbers are, only one student, Sue, said, "Fractions, decimals, whole numbers," but she could not remember what the positive and negative numbers were called.

To summarize. The first theme revealed challenges with mathematical terminology and indicated only a few times that students could demonstrate understanding of rational number operations by using their own words or non-math terms. Bicer, Capraro, and Capraro (2013) found that "keeping a journal in mathematics provides students the opportunity to share their ideas by using their own words" (p. 363).

At times, students accurately described mathematical thinking using their own words, but quite often students struggled to fully express what they were thinking in readable and clear terms, math or non-math.

The researcher's data analysis indicated that students were not able to "describe their mathematical reasoning coherently" using mathematical terms (Tan & Garces-Bacsal, p. 176, 2013). The researcher noticed throughout the data analysis that students did "use mathematics vocabulary and representations with different levels of success" (Hebert & Powell, 2016, p. 1511). It is clear from research and the present study that mathematics terminology does impact student understanding of rational number operations; yet, it was never obvious to the researcher whether students chose to use their own words because they did not know the appropriate mathematics terminology or if they desired to express their thinking in their own words.

Theme Two: Effects of Misconceptions

The second theme to emerge from the data can be characterized as the effects of mathematical misconceptions. A misconception is "a conclusion that's wrong because it's based on faulty thinking or facts that are wrong" (Cambridge online dictionary, 2008). Although in the journal entries the researcher intended for students to explain in words, often students only showed their mathematical thinking using numbers and operations. The researcher was given a glimpse into student misconceptions about rational number operations in their written explanations and math computations. While all misconceptions discovered in the data were interrelated, they are classified into the following subthemes: (a) math terms, (b) integer operations, (c) decimal operations, and (d) fraction operations for the purpose of discussion and analysis.

Math terms. One of the most obvious misconceptions observed at the onset of the study was revealed during the pre-interview. During the interview, students struggled to describe the term rational numbers. Many students only identified either integers or fractions as part of the rational number set but not both. For example, Beth said that rational numbers included "negatives, positives, integers." However, Sue was the only student in the pre-interviews that told the researcher that rational numbers include "whole numbers, fractions, and decimals" but did not discuss or refer to integers or positive and negative numbers. She was the only student of the eight that even mentioned decimals as being part of the rational number set. Seen throughout the journals was this misconception of the rational number set only including fractions or integers without regard to decimals.

Another misconception related to mathematics terminology involved differentiating the different types of numbers involved in rational number operations. For instance, when asked to "describe how you add and subtract fractions," Beth wrote about adding integers, positive and negative whole numbers, and then changed to fractions when she wrote about subtracting. Moreover, Beth used positive and negative whole numbers to describe how to add fractions but never called them integers in her writing. She simply put "first I make the problem." When Beth was asked to write about multiplying and dividing fractions, she described both operations using positive and negative whole numbers. The researcher noted that Beth understood what a fraction is because she used them in describing the operation of subtraction. The question is why she used whole numbers for adding, multiplying and dividing but fractions for subtraction.

During an informal interview, Beth could not explain to the researcher why she used fractions only one time to describe the operations, and she did not seem to understand that the numbers she was using did not fit the prompt involving fractions. The recorded field notes showed that the researcher often observed that Beth wrote her journal with her head down and did not seem very confident while writing. The researcher contemplated if the behavior that was observed while writing relates to the student's misconception and lack of understanding of the numbers in the rational number set.

Student journals revealed other misconceptions in their mathematical understanding of rational number operations, and this was confirmed with interviews and researcher field notes in three areas: (a) integers, (b) fractions, and (c) decimals. However, most of the misunderstandings stemmed from misconceptions within the integer operations. Integer operations focus on the negative and positive whole numbers, yet negatives and positives are seen throughout the whole set of rational numbers including decimals and fractions.

Integer operations. The most common misconceptions within integer operations revealed in the data seemed to occur because students' thinking was not connected to the correct operation. Many students confused the addition and subtraction concepts with the multiplying and dividing concepts of integers. The data collected also indicated that some students could identify their misconception and verbalize the correct concept while others could not relate their misconceptions to correct mathematical thinking.

For example, several students, John, Courtney, and William, described adding and subtracting integers by using the concepts for multiplying and dividing. John said, "I know if it is two positives it is a negative." The researcher noted in the field notes that John was very unfocused in writing and even seemed to struggle to get started in his writing. During an informal interview, the researcher asked him about this misconception, and he could not verbally state the correct way to add and subtract integers. The researcher discussed with John how to connect the correct concept to adding and subtracting and reminded him about the strategy of using integer chips that students had used in mathematics instruction and learning.

Courtney stated something very similar when she said, "When you have different signs there is a law in math that it would be a positive and if you have the same sign it would be a negative." Not only does this misconception indicate Courtney is relating multiplication and division concepts to addition and subtraction; it also shows that even her statement lacks complete understanding. In her statement of thinking, the words positive and negative are interchanged. During the writing time, the researcher recorded in her field notes that for this prompt, Courtney "appeared to be a confident writer." Courtney could explain verbally how to add and subtract integers during an informal interview but only when prompted with questions by the researcher.

William also showed a misconception of adding and subtracting, stating, "But I remember that if there both negatives it becomes a positive. For example: -4 + -5 = 1." Again, the concept of two negatives being a positive in his thinking statement should only be related to multiplication and division of integers. During an informal interview, William could vocalize adding and subtracting integers by modeling with integer chips, which did not connect to his previous statement that "if both integers are negative the answer is positive." The researcher noted that on this particular writing prompt, William was “very slow to start and seemed very unsure and not confident in his writing.” The question arose if his behavior was a reflection or indicator of his misconception.

Another example of students’ misconceptions of rational number operations was when Sue stated, “When you multiply integers you have to change the second number to the opposite.” She restated that same concept for the division of integers. That concept is not for multiplying or dividing integers but for only subtracting integers. One thing the researcher noticed was that while the student’s explanation for this journal prompt was a good explanation, the misconception of changing the second number to the opposite for multiplication resulted in an incorrect answer. Rob’s misconception was the reverse of Sue’s when he stated, “If they are the same color [referring to integer chips] they are positive” when subtracting integers. This concept did not go with subtracting integers but multiplying or dividing integers. In an informal interview, when the researcher asked Rob about his misconceptions of subtracting integers, he was able to verbalize that subtraction was adding the opposite, but he still could not verbalize how his statement of “same color they are positive” related to subtraction or even to integers in general. Rob struggled during an informal interview to discuss how to correct this misconception. He did verbalize that “subtraction means to add the opposite” but could not justify why he stated in his journal the same colors being positive.

Decimal operations. It was evident in the journal entries that most students’ misconceptions with decimal operations related back to signed numbers, as in the integers’ operations. However, there were a few misconceptions about specific operations with decimals not related to signed numbers.

Beth, along with other students, continued to demonstrate a misunderstanding with the positive and negative operations that students learned in integers. When subtracting decimals, she stated, "I subtract and then identify the sign of the bigger number." This indicates a misconception of subtracting with signed numbers (positive and negative), not a misconception of operating with decimals. During an informal interview, the researcher noted in her field notes that Beth "struggled to express any connection with decimals and operations with positive and negative numbers and did not include a very solid explanation while writing."

Another example of a misconception with signed numbers was when Courtney wrote, "When you have two negatives or positive you would get a negative if you have two of the different number you would put a positive" which relates to multiplication or division but not adding and subtracting. Then when she demonstrated dividing decimals, she stated, "I knew it would be one negative plus a positive equals a negative" which is sometimes correct but only in addition. While writing these two entries, the researcher observed that she seemed to be very focused while writing; however, her explanation was unclear, as noted in the field notes.

There were a few misconceptions related just to operations with decimals that showed up in the journal entries about multiplying and dividing decimals. Many of the misconceptions involve procedural understanding of multiplying decimals. For example, Matthew stated, "To multiply and divide you have to line up the decimal and after that you multiply as you would normally." This misconception is not completely wrong, but because he stated "you have to," the researcher wondered if he understood multiplication of decimals. While one can line up the decimals to multiply, it does not have to be done that way. Students must also realize it is necessary to count place value in the end instead of bringing down the decimal in the product answer.

Another misconception for decimal operations was recorded in Courtney's journal entry when she wrote something similar to Matthew: "When you multiply you have to set up the decimal points so you have them right below each other" and "then you can just multiply or divide." Not only did Courtney demonstrate in words a misconception with decimal operations about lining up the decimal, she shows in her math work that she does not know how to divide decimals by making the divisor a whole number. She simply divided the numbers as she stated in her misconception.

One of the most profound and significant findings in the journals about decimal operations was the statement made by William when he was writing about dividing decimals. William stated, "When I'm dividing decimals I put the bigger decimal outside of the box." This misconception is enormous in the world of numbers in general. During an informal interview the researcher noted that "he struggled to describe the process or even perform the steps to complete the problem" when asked to multiply or divide decimals. The researcher asked William about the "divisor" being a whole number, but he did not connect that concept to dividing decimals when he responded, "I don't know." Field notes also indicate that while William was writing this journal, he was unfocused, finished quickly, and erased several times while writing. While this misconception was in the context of decimals, it impacted his understanding of the dividing process with all numbers. It seems that William did not have a solid grasp of the dividing process regarding decimals or any numbers.

Fraction operations. Just as with decimal operations, the data indicated that students continued to demonstrate misconceptions with positive and negative operations that were evident in the integer operations as previously mentioned when given fractional operations. However, the most common misconceptions involved denominators when performing the different operations with fractions.

The misconceptions with fraction operations were more evident in student work than in their writing. Some students explained using words, while others demonstrated their understanding or lack of understanding using math computations. For instance, John and Courtney both knew that when they add and subtract fractions, they must have common denominators. However, when they were presented with subtracting a negative fraction from a negative mixed number, both made signed number errors.

Courtney said, "You make the fraction denominators equivalent… They were both negative so I subtracted them together." This misconception was not a fraction misconception but a subtraction of signed numbers misconceptions, as noted previously in the integer operations. John was also able to get a common denominator for both adding and subtracting fractions but again showed a misconception in his math work when adding two different positive and negative fractions. He made the error again when he was asked to subtract a negative fraction from a negative mixed number. These two misconceptions related to operations with signed numbers were seen quite frequently throughout the student journal entries with fractions.

The most common misconceptions in fraction operations were related to common denominators. The researcher observed these misconceptions numerous times throughout most of the eight student journals. Several students (Matthew, Sue, and William) demonstrated a misconception related to having common denominators when adding and subtracting fractions. Matthew said, “To add and subtract fractions you just add/subtract without changing anything” and went on to give a math example. He added the numbers and the denominators in journal five, yet the researcher noted in her field notes that in journal number seven when presented with $\frac{2}{3} + -\frac{3}{5}$ and $-2\frac{1}{2} - (-\frac{4}{5})$, Matthew stated “I made a common denominator” and did indeed get a common denominator. The researcher wondered why there was inconsistency in his misconception about common denominators.

In her journal entry, Sue stated, “You can add and subtract fractions by adding the denominators” and then demonstrated uncertainty in her statement when she added, “I’m not sure but think you don’t have to have the same denominator to add or subtract fractions.” During an informal interview with the researcher, it was noted in the field notes that Sue could verbally explain that “you never add denominators” and “you must have a common denominator” when questioned about adding and subtracting fractions.

In contrast, William did not explain his misconception of common denominators but demonstrated it clearly in his work and words for adding and subtracting fractions. When asked to complete $\frac{2}{3} + -\frac{3}{5}$ he stated, “I got $\frac{5}{8}$ by adding 2 + 3 which = 5 then 3 + 5 which = 8.” Then, when given $-2\frac{1}{2} - (-\frac{4}{5})$, William again stated, “I got $2\frac{3}{5}$ by subtracting 4 and 1 and got 2 then subtracted 5 and 2 and got 3”. In both math problems, William did not consider the signed numbers in his adding or subtracting, but simply added the numerators and denominators.

In an informal interview the researcher asked William about denominators in relation to adding and subtracting fractions. She recorded in the field notes that “he did not recognize or verbalize that you need a common denominator." When the researcher asked, "For subtraction you add what?" William responded, "denominator." She was trying to get him to recall that subtraction is adding the opposite and connecting back to integer operations. The researcher noted that he could give some correct answers of understanding when prompted but continued to struggle in understanding adding and subtracting fractions and common denominators.

This misconception of denominators creates challenges for students in adding and subtracting fractions because common denominators are foundation for being able to add and subtract fractional pieces of a whole. One reason for this uncertainty of not getting a common denominator could be that in adding and subtracting fractions, one must have common denominators and then add or subtract the numerators, but in multiplication and division, one does not have to have common denominators but simply multiply numerators and denominators.

Another misconception noted in a few of the journal entries related to knowing that one needs to get a common denominator but having incorrect thinking on how that is done. For example, Beth demonstrated that the denominator needed to be changed; however, she took the higher denominator as the common denominator instead of a common multiple. This misconception was evident in several journal entries through her math work and descriptive words. For example, when given the problem $\frac{2}{3} + -\frac{3}{5}$, Beth said, "I take the 5 for the denominator" but never explained why she performed this action. From that point on in the problems, she correctly applied the process of adding or subtracting fractions, making a few errors with signed numbers, then putting the answer over the same denominator she found.

Another way this misconception was demonstrated was in changing the denominator to be the same but failing to make equivalent fractions and change the numerator. Katie, among others, demonstrated this misconception when presented $\frac{2}{3} + -\frac{3}{5}$. She very clearly stated, "Find common denominator" and showed that in her work. Her error and clear misconception was when she did not change the numerators, but used 2 and -3.

To summarize. The theme, effects of misconceptions, revealed various misconceptions and their effects related to all rational number operations. These misconceptions became evident to the researcher "as students struggled to write how they were going to solve a problem" (McCauley, 2004, p. 76). Field notes indicated that while students may seem confident as they wrote and many times wrote an explanation, their misconceptions of integers impacted their understanding of rational number operations. Mohyuddin and Khalil (2016) pointed out that misconceptions, such as with integers, will interfere with student learning when used to understand new experiences, such as other rational numbers. Furthermore, they emphasized that students often "become emotionally and intellectually attached to their misconceptions because they have actively constructed them" (p. 135).

Finally, informal interviews allowed students an opportunity to verbally reflect on their misconceptions through dialogue and connect to prior learning. The purpose of this reflection and dialogue was to "develop a deeper understanding of the mathematical and also [expose] gaps in their knowledge" (Tan & Garces-Bacsal, 2013, p. 175). These misconceptions that emerged in the data effected student understanding of all rational number operations (integers, fractions, and decimals).

Theme Three: Challenges in Applying Strategies and Prior Knowledge

The third theme, challenges in applying strategies and prior knowledge, revealed many learning gaps in students' mathematical thinking and understanding. According to the data, it appeared that students struggled to consistently execute strategies and knowledge of operations with signed numbers. This inconsistency became even more evident in operations with fractions and decimals. As previously discussed there are many misconceptions of integer operations, in which students struggle to understand operations with rational numbers in integer form. The data revealed two subthemes for application: (a) strategies and (b) prior knowledge of positive and negative operations.

Strategies. The researcher noticed that students used several strategies previously learned in mathematics education. These strategies were taught by other teachers or parents with the intent to help them understand and correctly apply operations with rational numbers. However, the two most common strategies used in the journal writing were integer chips and PEMDAS (Parentheses, Exponents, Multiply, Divide, Add, and Subtract). Integer chips are simple round chips; one side is yellow and one side is red. The yellow side represents positive numbers and the red side represents negative numbers. The researcher used integer chips during mathematics instruction to help students visually see how integers as well as positive and negative numbers work within the operations. PEMDAS is a phrase taught in fourth and fifth grades and reviewed in sixth grade mathematics to demonstrate the correct order of operations. This strategy, when applied correctly, helps students remember the order to perform mathematical operations.

Both strategies were shown in the journal entries to be applied incorrectly by several students. For example, Rob and John both used the integer chip strategy to model adding integers but did not correctly apply the strategy for subtracting integers. When describing the integer chips Rob said, “So if they are the same color they are positive” when trying to determine how to subtract two negatives using the chip strategy. John performed almost the exact same application error as Rob with the integer chips strategy, but John only drew the chips and did not explain. Sue, however, used the chip strategy for multiplying and dividing integers but applied the adding and subtracting concepts of putting the chips together instead of grouping as needed for multiplying and dividing.

Another strategy that was used by several students was PEMDAS. For instance, Rob, Beth, and Matthew mentioned PEMDAS for performing the correct order of rational number operations but could not completely execute the order from start to finish. Every single student that mentioned PEMDAS knew and demonstrated that parentheses was the first step in the process. But like Rob who stated several times that you “just go from left to right,” Beth and Matthew either stated or demonstrated performing the operations left to right several times. When students use PEMDAS, they often multiply first and then divide, but they should perform multiply or divide from left to right. Many times, students just recite the order instead of knowing the concept behind the order. This strategy, taught by previous math teachers, could be one reason students continue to be inconsistent in rational number operations.

Prior knowledge of positive and negative operations. The most common and frequent application mistake occurred in journal entries five through 12. As the researcher read and analyzed journal entries five through 12 on the operations of fractions and decimals, it was clear that students were not applying the concepts of positive and negative numbers to fractions. At one time or multiple times, all students either did not apply a positive and negative number concept to fractions and decimals or applied it incorrectly. Often students could apply a fraction or decimal concept but then would error in the application of positive and negative numbers. It seemed that when students were presented with a negative fraction or decimal, there was no connection to operations with positive and negative numbers.

For example, when writing about adding and subtracting fractions, neither Beth, Courtney, nor William once mentioned a connection or application to positive or negative fractions. Then, when asked to apply the operations of adding and subtracting with fractions, Rob and Katie, among others, tried to apply concepts of positive and negative rational numbers but did so incorrectly. Rob demonstrated in his work that $\frac{5}{2} - (-\frac{4}{2})$ would equal negative one. He clearly was not correctly applying the concepts of subtracting positive and negative numbers. Katie incorrectly applied -2 - -3 was a -5 when subtracting the numerators of her fraction.

Another example of students not connecting the concepts of positive and negative numbers to fractions occurred when Matthew clearly explained to "multiply the numerators of the fraction then multiply the denominators…to divide do the opposite operation flip the second fraction and multiply," but he never once mentioned an application or connection to positive and negative rational number operations. John was another student who, like many in the study, did not once mention anything about positive and negative numbers when presented problems that contained positive and negative fractions. John simply completed the process he thought was correct for fractions but never once connected it back to positives and negatives.

When students wrote about operations with decimals, the researcher noticed very similar patterns as with fractions. First, some students used the wrong prior knowledge procedures with decimals. Second, and the most common application error, students failed to connect positive and negative rational number concepts to decimals. When given positive and negative decimals most students simply added decimals if they saw an addition sign and subtracted decimals when they saw a minus sign. When asked to describe how to add and subtract decimals, only two of the eight students tried to connect integers, but they were unsuccessful in the attempt. For example, Rob did connect the concept of subtracting a negative when he gave the example, "0.25 - -0.5 you would do the opposite and it would be 0.25 + 0.5 = 0.30." However, in that same journal, Katie said, to "line up the decimals. Same rules apply as for regular subtraction. Drop the decimal," but she never explained regular subtraction or connected decimals to positive and negative numbers. Like Katie, William described what he knew for multiplying and dividing decimals but did not apply it to positive and negative decimals.

It became apparent to the researcher that students seem to simply add, subtract, multiply, or divide decimals without regard to the sign of the number. For instance, John and Beth worked $0.25 + -2.36$ and $-1.45 - (-2.58)$ very similarly. Both students saw the addition sign and simply lined up the decimals and added the two decimals together. Both students applied the subtraction concept of adding the opposite to create the equivalent addition expression $-1.45 + (+2.58)$. However, after making it an addition expression John simply added the two decimals together never considering the negative signs. Beth, however, demonstrated she knew to subtract because of two different signs but did not fully apply positive and negative concepts when she answered with -1.13.

Student journal entries indicated that the incorrect application of operations with positive and negative rational number impacted operations with fractions and decimals. Many of the students correctly applied fraction and decimal procedures but incorrectly applied concepts of positive and negatives, which impacted the accuracy and correctness of their final answer. For example, when given the problem $(-\frac{1}{2} + \frac{3}{5}) \times (-1.5 + 2.3)$, several students gave a final answer that was incorrect, but their journal writing indicated quite a few things about their thinking and understanding. For example, Sue knew to add decimals and "since you have one positive and the other negative so you get 3.8 positive" but did not subtract the numbers because of the two different signs. Then she incorrectly applied a great strategy, changing the decimal to a fraction, the decimal 3.8 to fraction 3/8. She did, however, apply the correct procedure for adding fractions yet did not apply concepts of positive and negative fractions which resulted in an incorrect answer.

Matthew demonstrated the correct application of fraction and decimal procedures when he got common denominators and added numerators and used the correct decimal procedure of lining up decimals to add; yet, his final answer was incorrect because of incorrect application of positive and negative fractions and decimal operations. Lastly, Courtney, although incorrect in her final answer, correctly used the strategy of turning fractions to decimals. While her adding decimals procedure was correct, she made several errors when applying positive and negative concepts, such as adding instead of finding the difference because of two different signs.

To summarize. The third theme, challenges in applying strategies and prior knowledge, revealed students' inconsistency in applying strategies and prior knowledge of positive and negative numbers to rational number operations. The data showed that students' struggle with the application of strategies and prior knowledge was related to misconceptions previously discussed. Student often applied incorrect concepts of positive and negative concepts, or separated rational numbers into groups without connecting them all together. Student misconceptions of integer operations greatly impacted the students' ability to accurately apply positive and negative operations with fractions and decimals, which belong to the rational number set.

Student entries provided a "window into students' minds and what they are thinking" and applying to their mathematical processes (Freeman, Higgins, & Horney, 2016, p. 285). This window created an opportunity for the researcher to note the connection between misconceptions and misapplications, as students often apply their incorrect understandings to procedural processes (Rittle-Johnson et al, 2001). Skemp (1978) claimed that mathematics learning should involve both conceptual and procedural learning in what he called relational mathematics. It was evident in the data that procedural and conceptual understanding, relational mathematics learning, is needed to help students identify and eliminate the misapplication of knowledge in learning mathematics.

Theme Four: Challenges in Student Writing

The last theme, and perhaps the most telling, to emerge from the data was challenges in student writing. Through this theme of writing, three specific challenges or subthemes emerged: (a) students' perception of writing in math varied, (b) there were limitations in written expression, and (c) there were inconsistencies in math work matching reasoning in writing. Student perception of writing was revealed through pre/post interviews and researcher observations noted in the field notes. Some students seemed confident about verbal statements or body language, yet did not produce writing that demonstrated a depth of understanding. As journal writings were analyzed, it became clear rather early in the study that students struggled to express their mathematical thinking in words. The data indicated a lack of ability to explain their thinking through expository writing as related to math content. through incomplete journal writings and literal step-by-step descriptions. Finally, student writing, although not perfect, showed the researcher that students' math work did not often match their written expression of mathematical thinking and reasoning.

Varied students' perceptions of writing in math. Student perception of journal writing in math was assessed throughout the study. During the first week of the study, pre-interviews were used to provide a base for student perception on writing. During weeks two through seven the researcher observed student behaviors while writing to assess student perception of writing. Then during week eight of the study, the researcher used post-interviews to assess any change in students' perception of writing as related to rational number operations.

During pre-interviews, only one student, Beth, indicated that expressing her thoughts in words was difficult for her. The other seven students were very quick to state they did not feel they had trouble with expressing their thinking into words. When asked if they thought writing should be done in math class, Courtney said, "No because I don't like journal writing because I run out of things to write about." Another student, John, said “I do not have opinion about that,” while the others agreed that writing should be done in math. In the pre-interview, seven students said that they would rather know the why or reason, while only one, Rob, said he would rather just memorize math facts. When asked why, he said, “Because I’ve pretty much done that my whole life.” Student perceptions of writing in math class was positive for the most part at the beginning of the study.

During the implementation of journal writing, in weeks two through seven, the researcher observed various student behaviors during writing time. As evident in the field notes and student journals, confidence, consistency, focus, and writing ability varied among students. Some students wrote with confidence, consistency, and focus throughout the study. For instance, it was noted in the researcher’s field notes that Sue wrote consistently and confidently during most of her journal writings. For example, when she was asked to apply multiplying and dividing fractions, she began to write immediately and stayed focused, which resulted in correct answers and good, accurate explanations.

There were other times that the researcher observed very confident behavior as students wrote that did not result in correct answers. The researcher was hopeful that this meant that they knew material and were confident in their explanation. However, when she examined their journals, only one student got the answer and explanation correct. For instance, Courtney was observed many times writing immediately and staying focused the whole time. In journal three, when she was asked to apply adding and subtracting integers, she wrote confidently and was very focused. However, her explanations were lacking depth, reasoning was unclear, and only one of the two answers was correct. It appeared that student body language could be deceiving for teacher observation. The data indicated several times that even when a student appeared to be confident in their writing, they still might not understand the material.

Other students seemed distracted, disinterested in writing, extremely unfocused, and had trouble getting started on writing. For example, in her field notes, the researcher noted that John was "looking around, not on task the entire time. It took him almost three minutes to even get started but was done in a total of six minutes." There were several times that the researcher had to address students not being prepared with a writing tool. For example, Matthew often did not get started right away because he did not have a pencil and did not ask for one. William seemed to struggle each time to get started, and several times he was not prepared for class with a pencil. On journal six, John was observed by the researcher as having a poor attitude about writing. John was very lethargic and had a no-care attitude, which could have contributed to him being so unsuccessful in connecting his writing and math that day.

Several times during the study, students wrote with their head on their desk and seemed distracted while writing. For instance, Beth wrote with her head down and stopped several times while writing about adding and subtracting fractions. The researcher observed what appeared to be hesitation in beginning to write again after she paused in her writing. In the field notes, the researcher questioned, "Does this help with anxiety or is she not interesting in writing or maybe she is frustrated because she lacks the knowledge to complete the writing?" Other behaviors noted throughout the journal writing process were not focusing, staring into space, not writing, and constantly erasing. William would often rub his head and be very slow to start writing, seeming frustrated and unsure. Several times Matthew was chewing nails and not writing. In the recorded field notes, the researcher questioned, “I wonder again if it’s the writing or do students really not know what they are doing. It may be a little of both.”

During the post-interviews, perceptions on journal writing in mathematics were a little different than during the pre-interview. After journal writing had been implemented, seven of the eight students said they felt better about rational number operations. Beth was the only one that said she felt the same and but did not really know why. Now six out of the eight students said they liked to know the why and thought the journals helped them learn the why, yet they did not consistently explain their thinking in the journal writings. William changed his perspective about learning the why or memorizing when he said, “I would rather memorize now and not have to explain it.” The researcher noted that even though William and Rob said they liked to memorize instead of reason something out; however, their journal writings did not indicate success with even memorizing the math facts.

Another finding related to student perception of writing was that many students in the post-interviews said it was not the journals necessarily but the written and verbal communication (writing in their journals and informal interviews) from the journals that helped them better understand rational number operations. The researcher questioned yet again in her field notes, “Do students like the verbal communication because writing to express their thinking is a struggle for them?” The researcher’s question was answered during the post-interviews, which indicated student perception on expressing their thinking in words had changed through the course of the study. Only one student in the pre-interviews but six of the eight students in the post-interviews said that expressing their thinking in words was a struggle. However, just as several struggled in the interview to express their thinking verbally, most students struggled throughout the journals to make sense of the math and express their thinking in written words.

Limitations in written expression. The data revealed that written expression was limited and indeed a challenge for the eight student participants in the study. This finding impacted the whole study on how journal writing impacts students understanding of rational number operations. The researcher assumed at the onset of the study that seventh graders could write out their thinking effectively. There were a few times when students could explain their mathematical process, but mostly, students struggled to clearly write their thinking.

As journal writing data was read and analyzed, the researcher noticed that six of eight students had a least one journal prompt that was incomplete. These journals were classified as incomplete for various reasons. For example, William had a total of six journal writings and Rob had five that did not completely answer the prompt. When asked to describe how to multiply and divide fractions, William submitted an incomplete journal. He included only on sentence that in part said, “When I’m multiplying and dividing fractions I just do it from left to right.” William did not give any other indication that he knew how to perform these operations with fractions. During an informal interview, William was unable to explain what he meant by “just do it” and responded, “I don’t know.” Rob, when asked to describe how to add and subtract fractions, only wrote about getting a common denominator and did not completely answer the journal prompt. The researcher questioned him during an informal interview and the student could verbalize adding but still struggled to verbally explain how to subtract fractions. Incomplete journals were frequent in the data, but the researcher did not see any patterns in the data that would indicate that an incomplete journal revealed that students did not know the material. The researcher wondered if incomplete journals indicate more about limited written expression instead of math knowledge.

The journal data also revealed students struggled to write clear and complete explanations. The researcher's field notes and student journals showed that student explanations were unclear, literal, or lacked depth. For example, Beth wrote four journals that lacked depth and were unclear. When asked to describe how to multiply and divide integers, Beth gave several math examples, but did not include much written expression to describe these operations. During an informal interview, the researcher indicated in her field notes that, "Beth cannot write explanation in words accurately or verbally explain how to perform these operations." However, she could verbalize the process with guided questions from the interviewer. Matthew had five of his journals that were either unclear or lacked depth in demonstrating understanding. For example, in journal number four, Matthew got the correct answer with multiplying and dividing integers; however, he did not provide any depth in his explanation when stating the rule, "one negative number the answer will be negative" to explain his answers. This rule is true and accurate, but his explanation lacks depth and clarity as to its complete meaning. Katie was also often unclear and seemed to struggle to write a complete and clear explanation. Her explanations often did not include proof or solid reasoning to back up her math performance.

Many times, students were very literal in their written expression. For instance, William and Courtney stated "I did this, I did that" or "you do this, you do that" with no further written detail or explaining. Matthew demonstrated the correct process to multiply and divide fractions, yet his explanation for both math questions were literal, lacking depth of thinking. Theme three demonstrated various ways that limited written expression could have impacted the outcome of this study that focused on the impact of writing in regards to the understanding of rational number operations.

Inconsistencies in math computations matching reasoning in writing. One common thread that was woven through the last few weeks of journal implementation was students did not explain the why or reason behind their mathematics. In both groups, even students that could mathematically give the correct answer did not correctly write out their mathematical reasoning or justify their work. As previously noted, written expression, particularly expository writing, was a challenge for all participants. The assumption was made at the onset of the research that students could explain their thinking in words, but students clearly struggle to write in mathematics. Even when the researcher informally talked to students, many struggled to verbally and generally express the proof or justification for their mathematical thinking.

For instance, six of the eight student participants demonstrated at least once in their journal writings that their reasoning did not match their explanation of mathematical thinking. When Courtney was describing how to multiply and divide integers she had an incorrect explanation but the examples she provided as part of the writing prompt were mathematically correct. In an informal interview, the student and researcher discussed why the examples and written explanation did not match. The student could not tell why she wrote something opposite of her examples, but was clearly able to look at the examples and verbally explain how to perform multiplication and division with integers.

Even though Courtney could verbalize this process, she failed to once again connect the correct reasoning to the answer in journal four when she was asked to apply multiplying and dividing integers. On the first question of journal four, she could get the correct answer, but her reasoning for multiplying matched the operation of addition, not multiplication. On the second question, both the answer and explanation were incorrect. This shows inconsistency in student thinking and performance. Katie provided an example for multiplying and dividing fractions that did not match her written expression. When the researcher met with her during an informal interview, she could verbally make the connection and said, “I do not know why I did not include that in my journal writing.”

Sue, Rob, and Beth all demonstrated a lack of understanding and consistency for multiplying and dividing integers when their work did not match their reasoning. In journal number four, students were asked to apply multiplication and division with integers. Sue and Rob multiplied and divided correctly, but their written reasoning did not match the operations. Both students described using the integer chips using adding reasoning of putting together instead of multiplying and dividing reasoning of groups. In the same journal entry, Beth got the correct answer of negative eight, but in her explanation and reasoning she said, “negative and a positive and it gives me a positive 8.”

When students were asked to apply, justify, and explain in journal 13, not one student gave the reason behind their processes. Although the researcher demonstrates in lessons each day how to write it out while learning students, struggled to do so. They often did not include any reasoning or mathematical proof behind the mathematical actions they performed. For example, Katie and Courtney both had several journals in which their thinking and reasoning justified neither their answer nor math work. Katie correctly multiplied decimals but explained, “Pull down the – [negative] sign if there is one.” In the same journal entry, Courtney divided the decimals to get a correct answer but gave no solid explanation or reasoning for how or why her answer was negative, except, “I knew it would be one negative plus a positive equals a negative.” Neither of these students had the correct reasoning connected to the problems even though their answers were correct mathematically.

To summarize. The journal writing data and informal interview conversations indicated that writing was a struggle for the eight seventh grade student participants. Researcher observations also noted possible frustration in students with the math content, particularly operations with signed numbers and in making sense of the math when expressing it in written form. Teledahl (2016) suggested, “The communicational aspects of writing, such as semantic structure, vocabulary and mathematical symbolism, may in fact be more problematic for students than calculations and standard algorithms” (p. 101).

In the present study, just as in a study conducted by Suhaimi, Shahrill, and Tengah (2016), student journal entries were “not sufficiently explicit, with some parts missing or left unexplained” (p. 14). Many times, student responses were unclear, incomplete, and inconsistent with mathematical thinking, indicating that thinking and writing were not accurately connected to one another and often did not even make sense. McCauley (2004) conducted a study and found that students had difficulty in finding “words to express what they were thinking, both in writing and orally” (p. 75). The researcher of the present study found the same difficulty evident in student journal entries; however, even with these challenges and flaws, the journal entries still “offered insight into the students’ thinking” (Martin, 2015, p. 311).

Interpretation of Results of the Study

The findings of this study showed that journal writing had an impact on student understanding of rational number operations. This impact can be seen through the themes previously discussed, which challenged students to express their mathematical thinking fully through conceptualizing rational number operations. It seemed this was a struggle for most of the students because of a lack of practice and modeling appropriate mathematical language and written expression in the mathematics classroom.

Riccomini, Smith, Hughes, and Fries (2015) claim that “teaching and learning the language of mathematics is vital for the development of mathematical proficiency” (p. 235). The themes and findings from this study seemed to agree with Tan and Garces-Bacsal (2013) when they discussed that inexperience in journal writing in mathematics may be one reason that writing in mathematics was a challenge for students, and therefore, “mathematics teachers should consider implementing journal writing as a regular strategy” (p. 181). The researcher found that these themes revealed a lot about student understanding of rational number operations and could facilitate the direction of future mathematics instruction of rational number operations and future research in the mathematics classroom.

Theme One: Challenges with Mathematical Terminology

Mathematical terminology about rational number operations was shown in the data to impact student thinking and reasoning. When analyzing the data, the researcher concluded that math language added to students’ mathematical understanding. Likewise, the researcher found that when the students did not use math terms, students’ mathematical thinking and understanding was not as clear. In the data analysis, the journals indicated three areas that related to mathematical terminology: (a) terms used, (b) terms not used, and (c) the lack of understanding math terms.

First, the data showed that several students used appropriate mathematical terminology when describing their mathematical thinking. It was clear to the researcher that using the appropriate mathematical terminology helped many students explain their thinking more clearly and helped students stay on topic. In a study conducted by Hackett and Wilson (1995), it was shown that writing opportunities given in the mathematics classroom increased students' usage of appropriate mathematical terms. Through the writing in that study, the students became more aware of ways to use math terms to describe their thinking. In the current study, the researcher noticed that the students who used math terms throughout their journals did so more as the study progressed, similar to those students in the study conducted by Hackett and Wilson.

Secondly, student journals showed that even when students did not use the appropriate mathematical terminology, many could still describe the math concepts in their own words to some degree, but the lack of mathematics terminology created unclear and inconsistent explanations. DiPillo (1994) found that "although many of these responses are inadequate in using correct mathematical terminology, the students were attempting to write the explanation…in their own personalized way" (p. 177). There were many times in this study that Katie, along with others, used common language to attempt to describe her mathematical thinking, but these explanations lacked depth and clarity.

Thirdly, during the study, some students struggled to understand the math terminology used in the journal prompts or terms used by the researcher during the interviews. This lack of knowledge of the mathematical terms created problems for students in staying on topic and in being able to answer the interview questions. For example, it was previously mentioned that Beth struggled numerous times to stay on topic while writing her journals. She would write about integers when the journal prompt asked about fractions.

Another example of students not understanding the math terms is when the interviewer asked about rational number operations. Several students, including John, indicated that they did not understand what the researcher was asking when she used the term “operations.” When asked to describe how to add and subtract integers, students must have understood the math term “integers” or they would not be able to demonstrate their understanding of the concept. Shutt (2003) found that students did not understand what they called “teacher terms.” For this finding he created a strategy called what he called “YOW, for your own words” (p.70). This new strategy allowed students to “claim ownership…which results in increased student participation” (p. 70). This strategy may prove helpful when students are describing their mathematical thinking and understanding; however, the researcher concluded that students must understand and know mathematical terminology to demonstrate, even in their own words, their understanding of that math concept.

These findings demonstrated that some students could use different words to describe the same math concept when using math content vocabulary. However, it was never evident to the researcher, throughout the study whether students chose to use their own words throughout the study because they did not know the appropriate mathematics terminology or if they just wanted to express in their own words. The researcher did not see a clear pattern of how math terms impacted their understanding of rational number operations, but it was shown that the mathematics terminology did at times help students explain their thinking more clearly and on topic. After reviewing the theme of mathematical terminology, the researcher concluded that communication in mathematics is exceptionally important to the learning and thinking process.

The researcher attributed the lack of using math terminology to not enough practice and modeling by teachers to use mathematics terms. Hackett and Wilson (1995) conducted a study where students were given "many opportunities to practice writing using mathematical terminology," which created an awareness of using mathematical terminology in writing (p. 46). It appeared from the data of this study that students need more practice with mathematical terminology to better their mathematical explanations through increased understanding. The researcher wondered how important communication in mathematics is to the learning and thinking process. This theme, challenges with mathematical terminology, can be seen woven throughout the other three themes described in the following pages.

Theme Two: Effects of Misconceptions

Misconceptions were evident throughout the student journal entries and what was gleaned from the interviews conducted. In this study, the researcher knew that "the purpose of writing in the mathematics class is to provide students with opportunities to explain their thinking" and found that student explanations contained obvious misunderstandings in mathematical learning and thinking (Baxter et al., 2002, p. 52). The misconceptions in this study ranged from simple mathematical terminology misconceptions to mistakes in mathematical concepts and procedures. Students' writing and math computations with numbers revealed these misconceptions. The misunderstandings can be categorized into four groups: (a) math terms, (b) integers, (c) decimals, and (d) fractions.

As mentioned, the use of math terminology in students' writing was not a strength for most in the study. During the pre-interviews, the researcher noted that many students had the misconception that rational numbers only included whole numbers. This misconception created many areas of incorrect thinking in journal writings. Only one student of the eight recalled prior knowledge that whole numbers, fractions, and decimals were part of the rational number set. Students even had trouble verbally differentiating between integers, fractions, and decimals. This math term variation was observed numerous times throughout the journal writing.

Integers were shown to be the most obvious and consistent misunderstanding among most of the students. For example, Courtney, among others, demonstrated her misconception of adding and subtracting integers by using concepts of multiplying and dividing. This happened many times throughout the journals. Students consistently connected wrong understanding, procedures, or concepts to operations. One statement that Rob made during the post-interview could be the reason students continue to apply incorrect knowledge to create these misconceptions. When asked if he would rather memorize or know the reason a concept worked he said, "Memorize…because I've pretty much done that my whole life." What the researcher found to be interesting is that even though students like Rob want to memorize the rules, they are not memorizing them correctly connected to the operations. It was shown in the journals that many students had indeed memorized the rule but had faulty thinking or a connection to the wrong operation. For example, Matthew stated a rule for multiplying integers, “one negative number the answer will be negative” and could get the correct answer. However, he was inconsistent in that journal and those that followed in his mathematical explanation. He was also inconsistent with his application of that rule throughout the other journals. These misconceptions in integer operations manifested themselves in all operations with rational numbers.

The misconceptions related to decimal and fraction operations mostly involved many of the same misconceptions from integer operations. Students continued to struggle, not so much with decimal or fraction operations, but with positive and negative decimals. There were a few students that were lacking prior knowledge of how to accurately perform operations with decimals and fractions. For example, a few students, like Matthew, stated that “you have to line up decimals” to multiply decimals but did not count the place value of the product. Instead most student used addition of decimal concepts to place the decimal. Another example was when students were asked to divide decimals. Many students like William demonstrated the misconception that the larger number is always the dividend.

The misconceptions related to fraction operations were more evident in student work than in the written expression of student explanations. The most frequent misconception of fraction operations was the idea of common denominator. This misunderstanding was possibly related to the concept that one must have a common denominator to add and subtract fractions but not to multiply and divide. Over the years, the researcher has seen students getting common denominators to multiply and divide. While this is acceptable and correct mathematical thinking, students have the misconception that the processes are the same, because they are taught to get common denominators for all fractional operations. This poses a problem when they do not clearly understand the reasoning in the processes. Students must know and understand that if one does get a common denominator when multiplying and dividing, one must multiply both numerator and denominator or divide both numerator and denominator. Often, when students try to use these processes for multiplying and dividing fractions, they begin to add and subtract numerators and denominators, which will result in an inaccurate answer. The researcher clearly observed in the journal writings that students possibly had this misconception from being taught to get common denominators for all operations. The researcher, over the years of teaching middle school, has seen many students with this misconception seemingly related to that reason.

The misconceptions of math terms, decimals, and fraction operations were not as frequent as misconceptions with integer operations. The researcher observed that the misconceptions with integer operations impacted students' mathematical understanding and thinking of all rational number operations. The misconceptions that were evident in the journal writings and other data collected were addressed by the researcher throughout the study. During informal interviews, the researcher met with students with the intention of correcting these misconceptions. Many students could verbally correct their own misunderstanding when prompted with questions; however, there were also times the researcher noticed a gap in mathematical knowledge and learning that would need to be addressed in the action plan discussed in chapter five.

Theme Three: Challenges in Applying Strategies and Prior Knowledge

Theme three, challenges in applying strategies and prior knowledge, indicated a lack of ability to accurately apply strategies such as PEMDAS (order of operations) and integer chips, along with prior knowledge of operations with positive and negative numbers, to other rational numbers such as fractions and decimals. Student journals "provided the vehicle wherein the teacher became cognizant of the children's faulty thinking" (DiPillo, 1994, p. 187). Through the analysis of the journal writings, the researcher found that students could demonstrate limited but not full understanding of the PEMDAS or integer chip strategies. However, the most common application that student writings indicated as a struggle was applying prior knowledge of integers (positive and negative whole numbers) to positive and negative fractions and decimals. The researcher found that this inability to apply these strategies and concepts highly impacted students' ability to fully understand operations with fraction and decimals in the rational number set.

Throughout the journal writings several students, including Rob and Sue, used the order of operations strategy of PEMDAS (Parenthesis, Exponents, Multiply, Divide, Add, and Subtract). Most students could begin with the parentheses, but when it came to multiply and divide, then add and subtract, students simply performed operations from left to right. This is an incorrect application of PEMDAS because, although the letters are in order left to right, students must make the correct application of parentheses, exponents, then multiply and divide from left to right, and finally add and subtract from left to right. The reason students do this often, as the researcher observed over the years, was that many teachers teach it that way. Most of the time, the researcher observed that students knew the process by heart but often forgot the part that multiply and divide and add and subtract must be done from left to write. This inaccurate application of the order of operations strategy demonstrated that students did not quite understand the importance of the order of operations, which impacted students' ability to complete journal 13 and 14. These journals presented students with all operations and a mixture of rational numbers. The researcher concluded that students must know and apply the order of operations fully from start to finish to demonstrate a full understanding of order of operations.

The integer chip strategy, which the researcher taught to her class, was also inaccurately applied by many students. Just like the misconceptions of integers, students were using the integer chips to multiply and divide but using the strategy for addition and subtraction. This inaccurate application indicated that students struggled to conceptualize operations with rational numbers. Students should be connecting adding and subtracting as putting together or taking away, while they connect multiplication and division with groups and grouping. When students misapply the integer chips in this way, they clearly do not have a clear understanding of the integer chip strategy; therefore, they are inconsistent in the accuracy and correctness of applying the strategy.

As earlier stated the most frequent application error occurred when students did not apply the concepts of positive and negative numbers to fractions or decimals. The journal writings were divided into integers, fractions, and decimals because those are the type of numbers in the rational number set. Students were asked to describe how to add and subtract and multiply and divide each type of rational number. As the researcher analyzed journals it became very clear that students could complete operations with fractions or decimals but very rarely connected the positive and negative concepts of integers to the fractions and decimals. One reason for this may be because, in the seventh-grade curriculum, integers, fractions, and decimal operations are taught in isolation. The journal writings indicated that students lack an understanding of how rational numbers (integers, fractions, and decimals) are all connected and related to one another. Students seemed to classify these types of numbers as separate when all fall within the rational number system and can be either positive or negative numbers.

Theme Four: Challenges in Student Writing

At the onset of the study, the researcher made some assumptions. One assumption, shown to be incorrect during the study, was that seventh graders could accurately and fully articulate their thinking in written form. The fourth theme, challenges in student writing, showed a change in student perception about writing in math, demonstrated students' inability to communicate their mathematical thinking in written form, and verified that students are unable to support their mathematical thinking with reasoning.

Student perception of writing in math class changed throughout the study. At the beginning of the study, during the pre-interviews, Beth was the only student that said that writing thoughts out on paper was difficult. The researcher observed that the struggle of students to write their thinking in words changed students' perception of writing. Post-interviews revealed that six of the eight students said expressing their thinking in words was difficult for them.

Unlike the study conducted by Walz (2008) where students enjoyed writing to learn and even described it as a benefit to their learning, this study found students did not enjoy writing, but liked the written and verbal feedback from the researcher. Many students in the post-interviews indicated that the verbal (informal interviews) and written feedback (teacher feedback on journal) helped them better understand rational number operations more so than writing themselves. Willoughby (1985) agreed that two-way dialogue among students and teachers is when mathematical learning will be at its best. The researcher concluded that students may like the verbal or teacher written feedback because writing to express their own thinking is a struggle.

Written expression in this study manifested itself in the form of expository writing as described by Bell and Bell (1985). As students were asked to explain their thinking in written form, a learning gap in written expression emerged. It was demonstrated numerous times in the journal writings that it was a struggle for students to write clear and complete explanations. During the study, when this learning gap became obvious in the student journal entries, the researcher met with English teachers to discuss how these students write in other areas. The researcher was told by several seventh-grade English teachers that expository writing (explaining a process) was an area of struggle for most seventh-grade students. This statement was verified in students' expository writings, which not only contained misconceptions, but "were too brief to sufficiently explain the process," lacked depth, and were often difficult to understand (DiPillo, 1994, p. 199).

The journal writings also revealed that students often did not explain or inaccurately explained the reasoning behind their mathematical thinking. Baxter et al. (2002) suggested that writing in math gives students an avenue to explain their mathematical thinking; yet, just as DiPillo (1994) found, many of this study's participants produced partial and limited explanations, often neglecting to include all steps. However, the researcher still found that giving students opportunity to explain their thinking was an excellent way to gain insight on student thinking and reasoning.

Like the Hackett and Wilson (1995) study, the current study revealed that many students who got the correct answer still struggled to correctly explain and reason through how they got the answer. If students' understanding and reasoning does not support their work, the researcher wonders if students understand the operations of rational numbers. At times during the study, students would demonstrate accuracy in their answers; at other times on the same topic, they demonstrated inaccuracy. The researcher thought this unsupported, inaccurate explanation, or no connection to reason, could possibly be one reason why students are inconsistent in their ability to correctly perform rational number operations.

Skemp's (1978) idea of relational understanding notes that one must not only have rules but connect those rules to reason. Many times in the journal writings, the researcher could not adequately determine if students accurately connected the processes or rules of operations with rational numbers to solid mathematical reasoning. Often, students' ability to express their thinking in written form hindered the researcher's observations and limited the interpretation of the data. Through the data analysis, the researcher wondered if student participants tended to lean more toward instrumental mathematics as described by Skemp (1978). In the post-interviews, there were two male students (Rob and William) that said they would rather memorize facts without reason, but even in their journals, they were not consistent in their thinking, reasoning, explanation, or application of procedural rules.

The lack of students' ability to clearly and accurately express their thoughts in words emerged as a theme early in the study. Students did not seem confident or even familiar with writing in mathematics class. Students demonstrated through journal writing and interviews that writing to express their thoughts in written form is a challenge. It seemed that many students did not recognize it as a struggle until they tried to express their thoughts in words, realizing it was difficult, which impacted their thinking and learning of rational number operations.

Conclusion

DiPillo (1994) stated, "Only when students can correctly explain these mathematical concepts in language as well as in numerical examples will a genuine understanding provide a solid foundation upon which mathematical prowess can be built" (p. 191). Fordham et al. (2002) agreed that there is a deeper level of processing when students are explaining mathematical concepts. While writing in mathematics has been shown to be important to student understanding, the data from this study obviously shows that students will need "explicit modeling of disciplinary literacy so that adolescent readers can develop the shared ways of reading and writing within a discipline" (Antoacci, O'Callaghan, & Berkowitz, 2014, p. 4).

The results of this study on how journal writings impact student understanding of rational number operations revealed various challenges in mathematics terminology, misconceptions, applications, and writing. The data supported the idea that students struggled with mathematics concepts, like integer operations, but they also struggled to make sense of their mathematical thinking and reasoning in written form. There are a few things that the researcher can clearly conclude from the data analysis and other things that will require further research.

One way that journal writings seemed to have an impact on students' understanding of rational number operations was the newness of writing in math. Several researchers (Urquhart, 2009; Alvermann, 2012; Lynch, 2003) found that writing and written communication have a place and should be at home in the math classroom. The current research data indicated that this might not be the case for the participants of the study. According to the data, it seemed that students had not experienced much practice with writing in the math content class. The researcher, as classroom teacher, has provided some opportunities for students to write in explaining mathematics thinking and reasoning but not on a consistent basis. Lynch (2003) pointed out that "writing, much as any new skill or concept introduced in mathematics, has to be modeled and practiced" (p. 137). About midway through the study, the researcher observed that student journal writing indicated a lack of modeling by the researcher-teacher.

Lynch (2003) also brought to the researcher's mind the idea that students must learn to write in the content area of math and do not just come knowing how to write in math. Beth, a student in the current study, verbally expressed during the post-interview how writing in math is different than writing in other content areas. The researcher wondered if math teachers often had the mentality that students received "writing instruction in their language arts class and that this learning should carry over to mathematics" (Lynch, 2003, p. 137). The researcher now realizes the importance of "assigning writing activities on a consistent basis...[to] help them see the benefits of learning mathematics through writing" (Hackett & Wilson, 1995, p. 47-48). Many times, students are expected to write across content areas; therefore, the researcher knows it is necessary to offer a variety of opportunities for writing within the mathematics classrooms to assist students' in their writing skills (Antoacci et al., 2014).

Another area the researcher observed in the results that impacted student understanding of rational number operations was memorizing rules versus connecting the reasoning to the rule and process. Skemp (1978) clearly differentiates between these with instrumental and relational mathematics learning. The researcher observed that many students desired to be thinking and reasoning in the relational mathematics but often found themselves in the instrumental mathematics learning. Students would demonstrate math understanding by working out the problems and then writing step by step what they did in the work. Schoenfeld (1992) said, although rules are important in mathematics, there must be a time when "students move beyond the rules to be able to express thinking in the language of mathematics" (p. 335). The researcher concluded that this is true for the eight participants in the study. Students must be taught to move beyond the rules to accurately and correctly express their mathematical thinking.

Another part of the journal writing that the researcher observed as impacting students' understanding of rational number operations were the journal prompts themselves. Linn (1987) found that journal writing nurtured active participants in the learning and increased students' mathematical thinking and communication. In the current study, participants seemed to struggle with completing the open-ended journal prompts such as "describe how to add and subtract integers. Be sure to include all integers and provide examples." Similarly, to the study conducted by Hackett and Wilson (1995), the researcher found that students needed very specific directions and very specific questions as part of the prompts. It seemed that when given such open-ended prompts, students found it difficult to get motivated to fully complete the prompts. The researcher observed that students often answered the prompts about specific math to solve better and more complete than the open-ended prompts.

Antoacci et al. (2014) stated, “the National Commission on Writing stated that writing was the most neglected area of the three Rs” (p. 227). The results of this study supported this statement in the content area of mathematics. The researcher concluded that, while more research on journal writing in mathematics is needed, the data from this study showed that journal writing had an impact on students’ understanding of rational number operations. Student journal entries, interviews, and recorded researcher field notes revealed the themes of challenges with mathematics terminology, effects of misconceptions, challenges in applying strategies and prior knowledge, and challenges in writing. These themes each had an impact on student understanding of rational number operations.

The results of this study will be used to create an action plan for improving students’ writing in the mathematics classroom with the goal of providing learners with explicit instruction on writing in the math content area. As students’ writing in mathematics improves, the researcher anticipates writing to have an even greater impact on students’ understanding of rational number operations.

Chapter Five: Discussion, Implications, and Recommendations

This qualitative research study was conducted to observe the impact of journal writing on students' mathematical understanding of rational number operations. The researcher observed after several weeks of mathematical instruction and practice with rational number operations that many students continued to inaccurately perform operations with rational numbers. These inconsistencies were evident in student work and unit tests that involved rational number operations. The problem of practice that prompted the study was students' inconsistencies and inaccuracies in performing the procedural process of rational number operations.

Research Question

What impact will journal writing have on the understanding of rational number operations among eight seventh-grade math students?

Purpose of the Study

The purpose of this study was to examine the impact of journal writing on the understanding of rational number operations among eight seventh-grade math students.

Overview/Summary of the Study

In chapter four, the researcher thoroughly described and interpreted the data collected during the study such as student journal writings, recorded researcher field notes, and participant interviews. The research question was addressed and related to each theme found in the analysis of the data. This final chapter discusses the major points of the study and what was revealed presents an action plan based on the implications of the findings and suggests areas of future research.

Summary of Major Points

Point one: Mathematical terminology. Mathematics terminology is important to the learning of mathematics and allows students to demonstrate a clear understanding of rational number operations. While students in this study demonstrated some use of mathematical terminology to describe their mathematical thinking and reasoning, it was very limited to certain students. As a group, students were inconsistent in using math terms when explaining their mathematical thinking. Often, students used everyday math words like add, integers, positive, and negative but did not use math terminology at a higher level to describe and explain their thinking or process. There were times when students described in clear, common words the math concept behind their thinking and reasoning. However, students struggled to understand math terms when the researcher asked questions about math concepts. They often connected math terms to the wrong concepts, which created misconceptions in their thinking and learning.

Math terminology also posed a problem when students did not know the meaning of words such as operations and rational numbers. Several times during the interviews, the researcher had to define and clarify math terms to students to gain insight on their understanding of the math concept. Several researchers agreed that students must use and understand mathematics terminology to demonstrate math proficiency and understanding (Tan & Garces-Bacsal, 2013; Hebert & Powell, 2016; Riccomini et al., 2015).

Communication in mathematics using mathematical terminology is essential to learning and thinking and must be modeled for students. Math terminology and understanding are linked; therefore, "teachers should model the use of accurate mathematical terminology" (Tan & Garces-Bacsal, 2013, p. 181). For math terminology to increase understanding, students must learn and use the correct terminology in mathematics through practice. This daily practice with math terminology has been known to better mathematical explanations due to an increase in mathematical understanding.

Point two: Misconceptions affect application. Misconceptions can lead to more misconceptions and inaccurate applications. Throughout the present study, misconceptions were observed in math terminology and procedures with all rational numbers and were discovered in student explanations and computations.

The most frequent misconceptions for students were in integer concepts and procedures. Journal prompts began with integer operations and then moved to fraction and decimal operations. The researcher observed a pattern of misconceptions in integer operations that eventually spread to operations with decimals and fractions. Students demonstrated misconceptions about positive and negative numbers most frequently in written form and interviews. Many students knew an integer concept but had it connected with the wrong operation. This posed a problem when students wrote their explanation of how they solve each problem. Throughout the study, the researcher noted these misconceptions in her field notes and discussed with students during informal interviews. The researcher sought to provide students with feedback that would help them "correct their misunderstandings and overcome their mathematics' difficulties" (Bicer, Caprapro, & Caprapro, 2013, p. 364). There were times that students could identify their misconceptions and verbalize the correct concept; yet, other times they could not. Some misconceptions were corrected by these informal interviews, while others continued to be a challenge for students throughout the study.

It was discovered that misconceptions involving integer operations greatly affected how students performed decimal and fraction operations. Students either did not recognize decimals and fractions as positive and negative, or they continued to demonstrate their misconceptions clearly in their journal entries. While there were a few misconceptions related just to decimal and fraction operations, most could be traced back to operations of positive and negative numbers.

The findings showed that misconceptions also affected how students applied their mathematical knowledge. Students struggled to consistently execute previously learned strategies and prior knowledge when solving problems with rational number operations. Students failed to make connections with positive and negative numbers to all rational number operations in their writing and math computations.

Point three: Written and verbal feedback. Feedback was found to be extremely important to students' thinking during the study. McCauley (2004) stated, "A successful teacher learns from feedback that is given" (p. 519). This statement rang true during the study for the researcher. Written and verbal feedback created an open dialog between the researcher and the participants. Several students commented during the interviews that it was not the journal writing but the feedback that was most helpful to their mathematics learning. When asked if writing the journal entries helped her learn, Beth stated, "Your writing and talking in the interview helped more than the writing itself." It was indicated several times throughout the study that written feedback from the teacher and verbal feedback during interviews helped students identify mistakes and correct them. There were several of the study participants who agreed with Courtney when she said, "When you would explain to me what I was doing wrong…I knew what to do to fix it." The researcher noted that students responded well to the dialogue that was created by the feedback given to students, especially the verbal communication.

The journal writing process in this study focused on students explaining their thinking in written words, but students and the researcher viewed the value of feedback as a great asset and help to student understanding. The feedback provided the researcher with a voice and avenue in the process, verbal or written, to help guide and redirect student thinking. Research shows that feedback is crucial to students' understanding and helps students become independent thinkers and learners (Bell & Bell, 1985; Lynch-Davis, 2011; Willoughby, 1985). Throughout the study, the researcher realized that the purpose of feedback is not to "critique the student work but is to push students' thinking, not imposing necessarily [personal views] on students but to have the student think more deeply about mathematics" (Lynch-Davis, 2011, p. 95).

Point four: Written expression needs practice. Written expression was found to be a challenge for all students in the study. The level of accurate written expression varied among participants, but all participants struggled at times with written expression. English teachers verbally confirmed with the researcher that written expression, especially expository writing, is a challenge for many seventh-grade students. During the study, students struggled to write complete and clear explanations and often simply wrote a literal step by step account of the math work and computations. Their writing failed to clearly communicate their thinking and reasoning behind the strategy or math computation used to solve the problem.

Many factors were revealed in the data that contributed to the writing challenge for the participants. One contributing factor was student perception. Kenney, Shoffner, and Norris (2014) stated, “Mathematics and writing are two topics that are not typically associated with one another, especially from students’ perspectives” (p. 28). This was true for many of the participants in the study. Students in the study did not perceive writing to be a part mathematic instruction and learning, which contributes to the challenge of expressing their thoughts in words. Several students noted during interviews that writing in math was somewhat different than writing in other content areas. For instance, when asked in the post-interview if expressing her math thinking and learning in words was a struggle, Beth responded, “Writing for math is different.” Many of the participants at the end of the study admitted that expressing their thoughts and ideas in words was a struggle and were quick to point out that writing in math is different than writing in other subjects.

The lack of practice is another contributing factor to the challenge of written expression. Martin and Polly (2016) noted that the role of teachers is significant in showing and reviewing writing so that students are familiarized with writing in the math classroom. It is important to model for students how writing looks in the content area of mathematics. When expectations are set and students rise to the challenge presented in expressing their math thinking and reasoning in words, thinking and learning can increase. Bostiga, Cantin, Faontana, and Casa (2016) found that student skills improved immensely with time and “they [students] became better at communicating their reasoning and explaining their thinking” (p. 553). Not only is teacher modeling extremely important to increase written expression in mathematics, but students also must be given ample opportunities to practice writing in math on a consistent basis. Teacher modeling along with student practice can improve not only math thinking and learning but their written expression of math ideas and concepts.

To summarize. It was revealed through the present study that writing is important to learning mathematics. The researcher set out to discover how journal writing impacted students' understanding of rational number operations. The four major points summarize the findings of the study. It was evident that journal writing did impact students' understanding of rational number operations. However, the research exposed many factors that hindered writing from having a maximized impact on students' mathematical understanding and thinking of rational number operations. These factors discussed above in the four major points of the study were used to develop an action plan for classroom instruction.

Action Plan: Implications of the Findings of the Study

. The researcher began the research process with the goal of improving classroom instruction with the ultimate result of increasing student understanding, thinking, reasoning, and learning in the area of rational number operations. The following action plan is based on the results of the study and the implications noted.

Action step one: Focus on math terminology. Although the study indicated that some students could explain in their own words, math terminology is important to the learning and performing of mathematics. As students began to get used to writing in math class, some could "develop more precise use of mathematical vocabulary and enriched conceptual understanding" (Tan & Garces-Bacsal, 2013, p. 175). Riccomini et al. (2015) stated that "teaching and learning the language of mathematics is vital for the development of mathematical proficiency" (p. 235). The researcher plans to put an emphasis on math terminology that relates to each math concept taught. Students will be encouraged and expected to use this terminology when writing about their mathematical learning and thinking.

Action step two: Identify misconceptions and redirect student thinking. Misconceptions affected how students could accurately perform the mathematical operations and the application of mathematical concepts to solve problems during the study. Clearly, misconceptions must be identified and redirected to help students further their learning and thinking in a positive direction. Identifying misconceptions is the first step in addressing and changing student thinking.

The researcher plans to not only intentionally and periodically identify student misconceptions, but also guide students to self-identify misconceptions through written feedback and dialogue. Lynch-Davis (2011) clearly pointed out that journal writing should be used to challenge and change student thinking to deeper mathematical concepts. Once misconceptions are identified, the researcher plans to reteach concepts to redirect and correct student thinking. For students to be able to move forward in their learning of mathematics, misconceptions need to be corrected fully and promptly.

Action step three: Verbal and written feedback periodically. The participants in the study verbally stated that feedback (both written and verbal) was important in the journal writing process. According to student interviews, most participants thought the verbal feedback given through informal interviews helped redirect and push their thinking forward more than the written feedback on the journal writings. However, the researcher noted that feedback in general was a positive outcome of this study and will intentionally implement both verbal and written feedback periodically in her classroom.

Written feedback will be given on student work, journals, and graded assignments. Verbal feedback will be given during student-teacher conferences at least once every few weeks or as needed to address student misunderstandings. The researcher realizes that some students may need to have more feedback than others. The amount of verbal and written feedback will depend on individual student learning, but the researcher plans to conference with every student periodically.

Action step four: Model and practice writing in math. Written expression was shown throughout the study to be a challenge for all eight participants. For students to increase their ability to write clearly and completely, the researcher will model for students weekly what writing looks like in mathematics. Martin and Polly (2016) stated that modeling "increased familiarity with writing to support problem solving and thinking" and fostered "growth in students' ability to communicate in a coherent, clear, and detailed manner" (p. 72).

The researcher plans to create familiarity with writing in mathematics, highlighting math terminology by implementing weekly writing based on math concepts being learned in the math classroom. The researcher will include modeling as a part of each writing exercise to demonstrate how to write clearly and explain fully using math terminology. Students will then be asked to practice which creates an avenue for the researcher to provided written and verbal feedback to students. The researcher intends to create a mathematical learning environment where writing is so intertwined in mathematics instruction that it becomes “a normal part of [her] classroom instead of something that is thrown in at random times” (Kenney et al., 2014, p. 40).

To summarize. This qualitative research study was conducted using the action researcher model described by Mertler (2014). The goal and purpose of action research is to collect data that is used to foster positive change in the researcher in the mathematics classroom. The researcher created an action plan that will implement journal writing periodically into mathematics instruction and learning. This journal writing time will emphasize the use of mathematics terminology, identify misconceptions, provide both written and verbal feedback, and allow opportunities for students to grow in their written expression and mathematical thinking.

Suggestions for Future Research

The present study was limited by grade level, a small sample, time constraints and a focus only on rational number operations. Future research is needed to discover ways teachers can increase students’ ability to write in math so that journal writing will have the maximum impact on students’ mathematical learning and thinking. On the following pages, the researcher makes four suggestions for future research that may be considered.

Research Suggestion One: Larger Participant Size and More Diverse

One major limitation of the present study was the small and non-diverse participant size. The participant group included only eight students, four males and four females. There was a very small amount of diversity represented among the participants, but future research should consider using a larger more diverse group of participants.

Research Suggestion Two: Grade-Level and Math Concept

In this study, the participants were all seventh-grade math students and journal writing was focused only on operations with rational numbers. By replicating the present study with a different grade level and math concept, one can gain a better understanding of how journal writing impacts math understanding and learning. By identifying how journal writing impacts other concepts and grade-levels, math educators can see the value of using journal writing daily in the classroom.

Research Suggestion Three: More Frequent Writing, Longer Study

The present study occurred over an eight-week period. Future studies could be conducted using the same methods of data collection just over a whole semester (18 weeks) or even a whole academic school year (36 weeks). This longer time frame would help researchers examine if consistent use of journal writing impacts students learning to a greater degree.

Research Suggestion Four: Open-Ended Journal Writing and Dialogue

Teacher-designed, structured journals were used in this study. Future studies could focus on using an open-ended journal writing format to observe the impact of writing on student understanding. With open-ended journals in mathematics, there could still be teacher-student dialogue which would allow researchers to examine the benefit of verbal and written feedback in a different format. Students would be able to freely express their thoughts about their math thinking and learning. The teacher-student dialogue would allow teachers to extend and stretch student thinking into deeper mathematical thinking and learning.

Research Suggestion Five: A Mixed Methods Research Design

The present research found that writing has a positive impact on student understanding of rational numbers in several different areas. A mixed methods study on journal writings can be conducted to observe the impact of journal writing on academic math achievement measured with test scores. This mixed method study could focus on student journal writings, pre-posttest scores, and researcher observations.

Conclusion

This study focused on journal writing in the mathematics classroom. The research question sought to determine the impact of journal writing on students' understanding of rational number operations. The participants included eight seventh-grade students with varying math abilities. There were four male and four female participants all enrolled in a math enrichment class taught by the researcher that met every other day. During the study, students were asked to write about their math thinking using 15 teacher-created, structured writing prompts. These prompts focused on the four operations of rational numbers: addition, subtraction, multiplication, and division.

The data analysis revealed four major themes: (a) challenges with mathematics terminology, (b) the effects of misconceptions, (c) challenges in applying strategies and prior knowledge, and (d) limited written expression. There were also several subthemes. These themes were apparent in student writing, interviews, and recorded researcher field notes and revealed many notions about students' thinking and mathematical understanding of rational number operations.

The present study revealed that writing had an impact on students' mathematical understanding and learning to some degree; however, the researcher feels that further research studies are needed to continue to examine writing in mathematics and its potential benefits to students' mathematical understanding and learning. Along with further research studies, the researcher believes that there needs to be an increase in teacher modeling and student practice in writing in the math classroom. An action plan was created based on the results and implications to increase and improve writing in the mathematics classroom to maximize the impact of journal writing on mathematical thinking and learning.

While this study focused on journal writing and students understanding of rational number operations the researcher found a significant non-math theme emerge: building relationships with students through dialogue. The one statement that caused the researcher to reflect on relationship building with the participants was made by a student in the post interviews in the study. The researcher asked Courtney if the journal writings helped her understand rational number operations, to which she responded, "yes because when I did it you would explain to me what I was doing wrong." After further discussion with Courtney and other students the researcher realized how significant the written and verbal feedback was to the students. This led the way to understanding that it was not about the writing or even the math content but it was about building relationships through dialogue. Freire (1972) claimed that true learning and education cannot happen without communication through dialogue, to which Bakhtin (1984) added "Life by its very nature is dialogic" (p. 293). Kirylo (2016) describes this dialogue and communication as teachers building relationships with the children they teach, not the curriculum.

As the researcher observed students throughout the study and met with students for interviews several things were observed about student's perspective on learning. As the study progressed the researcher observed the student participants gaining confidence and becoming more comfortable with talking about mathematics. Many times as the researcher had dialogue with students, especially towards the end of the study, she noticed that students were more willing to take risks in answering and trying to think deeper about the math they were learning. This observation is linked back to building relationships with the student participants during the study. Building these relationships that will foster trust and risk-taking must be intentional. Thomas Hoerr (2013) said, "failure is something we will all face and fostering grit prepares us for it" (p. 40). Miller (2015) suggests teachers can foster trust and risk-taking among students by redefining failure in a positive way. Teachers must encourage students to embrace failure as an opportunity to learn and create a classroom "culture that gives them [students] the freedom to do so" (p. 5).

The feedback provided to students during the study, whether verbal and written, seemed to lessen student's math anxiety which may be one cause of improved confidence in math learning. The time that the researcher took to invest in these eight student participants fostered trust and transparency among the teacher-researcher and student participants. The researcher knows that the relationships that were built along the way did not immediately create perfect thinkers or perfect reasoning among the student participants. Yet, the process of building relationships creates trust, confidence, and a warm classroom environment, qualitative concepts that ought to be emphasized more in education.

As the researcher begins to implement her action plan with an emphasis building these essential relationships with students there will be challenges: (a) time management, (b) class size, and (d) students' writing weaknesses. Developing relationships with students through dialogue and seeking to implement journal writing, as discovered in this study, is very time consuming and can become a very daunting task. There are only so many hours in the school day and time is limited. The researcher knows that she is responsible for teaching the state math standards and is accountable for student learning. However, the researcher has also seen a very small glimpse of the impact relationship building can have on students' learning. Time management must be kept in perspective as the researcher develops relationships with students through her action plan.

This task of relationship building through the researcher's action plan implementation also becomes a challenge due to large class sizes. The more students in a class the more difficult it becomes to invest in individual students to build these very important relationships through the action plan. This study only used eight student participants which was manageable for the researcher. Needless to say, the power and structure of most public schools create a challenge for building relationships with students due to class size. It is projected that next year the average class size at the researcher's school will be 25 students. The researcher must keep this in mind as well when implementing the action plan and allow for monitoring and adjusting the action plan for what works best for the students, all the while keeping relationship building as the central theme.

Students' written expression was seen as a huge challenge for students during the implementation of journal writing in this study. This challenge was a struggle for students but also created a great avenue for the researcher to build relationships through these weaknesses. Many of the students stated that feedback from the researcher, not their individual writing, helped them most; therefore, the researcher will focus her action plan on dialogue among teacher and students. This dialogue can be written or verbal allowing students the opportunity to capitalize on their strengths instead of struggling in their weaknesses. In the study, many students were able to better verbalize their mathematical thinking and understanding through dialogue than in written form.

In conclusion, the researcher believes that it was the dialogue (verbal or written) that fostered and established relationships with the students which in turn built trust, confidence, and decreased math anxiety in learning. If educators focus on building relationships through dialogue then students could use the mode of dialogue they prefer, written or verbal, to demonstrate understanding of mathematical concepts and learning.

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Appendix A

Parental Consent Form

8/20/2016

Dear Parents/Guardians:

I am a student in a graduate program at the University of South Carolina seeking a doctoral degree in Curriculum and Instruction. I will be observing and collecting data from my math students this fall as part of a research study that is partial fulfillment of the degree program. My research is designed to improve classroom teaching practices with the goal to observe how journal writing impacts mathematical understanding over time. Throughout the study students will not be asked to do anything outside of the normal class assignments. Students will take a pretest, write daily journals about mathematical concepts, and then take a posttest during two different math units. These journals will not in any way hinder your child's learning but have the potential to enhance learning.

All identifying information will remain confidential and be changed when reporting results in the research write-up. Additionally, there are no risks involved in the participation of this study. The results of this study will be reported in my dissertation write-up and could be reported in professional settings or other educational literature.

I need your consent and permission to use your child's journal data and assessments scores in my research study. If your child's work is not used, you are in no way hindering your child's learning progress. Your consent to use your child's work is completely voluntary. Please complete the bottom of this form, sign and date and return it to me by September 2, 2016. Thank you for your time and consideration in this matter.

Sincerely,
Amanda Smoak, Doctoral Candidate

- -

➢ By signing below, I give my permission for Mrs. Smoak to use my child's work as part of this study.

Parent/Guardian's name: __________________________ Child's name: _____________

Parent/Guardian's signature: ____

Appendix B

Semi-Structured Formal Interview Guide

Student Gender ____________________________ Student Name _____________

Today I'm going to ask you a few questions about how you feel about learning math. Specifically, we will focus on rational number operations (add, subtract, multiply, divide numbers lJohn integers, fractions, and decimals)

1. How do you feel about learning about rational number operations? Why?
2. What makes rational number operations difficult to learn? What makes them easy to learn?
3. In general, when it comes to learning mathematics would you rather memorize math procedures and facts or learn why the math procedure works?
4. Do you lJohn to know why you are learning the math concept? Why?
5. Do other people affect how you feel about learning math? If so, who?
6. What do you know about rational number operations? Tell me everything you remember learning.
7. Do you think journal writing should be done in math class? Why or why not?
8. Is writing, expressing your thinking in words, a struggle for you? Why?

Appendix C

Journal Prompts

Journal #1
Describe how you add and subtract integers. Be sure to include all integers, positive and negative. Give examples.

Journal #2
Describe how you multiply & divide integers. Be sure to include all integers, positive and negative. Give examples.

Journal #3
Solve 3 + -4. Explain in words how you got the answer.
Solve -2 – (-1). Explain in words how you got the answer.

Journal #4

Solve $-4 \times (2)$. Explain in words how you got the answer.

Solve $10 \div -2$. Explain in words how you got the answer.

Journal #5
Describe how you add and subtract fractions. Be sure to include all fractions, positive and negative. Give examples.

Journal #6
Describe how you multiply & divide fractions. Be sure to include all fractions, positive and negative. Give examples.

Journal #7
Solve $\frac{2}{3} + -\frac{3}{5}$. Explain in words how you got the answer.
Solve $-2\frac{1}{2} - (-\frac{4}{5})$. Explain in words how you got the answer.

Journal #8

Solve $-\frac{1}{3} \times (2\frac{1}{5})$. Explain in words how you got the answer.

Solve $\frac{3}{5} \div -\frac{1}{2}$. Explain in words how you got your answer.

Journal #9
Describe how you add and subtract decimals. Be sure to include all decimals, positive and negative. Give examples.

Journal #10
Describe how you multiply and divide decimals. Be sure to include all decimals, positive and negative. Give examples.

Journal #11
Solve 0.25 + -2.36. Explain in words how you got the answer.

Solve -1.45 – (-2.58). Explain in words how you got the answer.

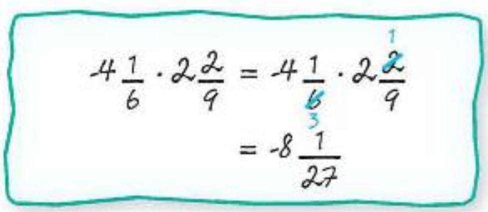
Journal #12
Solve -2.3 $\times$ (2.2). Explain in words how you got the answer.
Solve 5.1 $\div$ -0.3. Explain in words how you got the answer.

Journal #13
Solve 9 + (-6) $\div$ (-21 – 5) $\times$ -2. Justify each step to explain how you got your answer.

Journal #14
Solve $(-\frac{1}{2}+\frac{3}{5}) \times (-1.5 + 2.3)$. Explain in words how you got your answer.

Journal #15
Find the Error below & explain how you are supposed to multiply mixed numbers.

Find the Error Kelly is finding $-4\frac{1}{6} \cdot 2\frac{2}{9}$. Find her mistake and correct it.



Appendix D

Researcher Field Notes

Date: __________ Time: _________	Student Behaviors Observed *list any student behaviors that occur that may affect journal writing*	Time to complete prompt *list the average time taken to complete prompt*	Observer's Comments (OC) *Use the column for any "preliminary interpretations of what has been observed" (as cited in Mertler, 2014, p. 128)