MATHEMATICALLY GIFTED STUDENTS’ ATTITUDES TOWARD WRITING IN THE MATH CLASSROOM: A CASE STUDY

A dissertation submitted to the Kent State University College of Education, Health, and Human Services in partial fulfillment of the requirements for the degree of Doctor of Philosophy

by

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Using a constructivist paradigm, this qualitative case study examined mathematically gifted students’ attitudes toward various types of writing in the math classroom and how this writing impacted student learning. Eight fifth grade mathematically gifted students from a rural elementary mathematics classroom were immersed in various transactional/expressive and poetic writing projects throughout the year. Writing included journals, a Math Pledge, Math Nursery Rhyme Book, and a final Journal Project.

The purpose of this study was to investigate and describe mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in a classroom utilizing writing in mathematics and its impact on their learning. The theoretical framework for the study consisted of components from sociocultural theory and social constructivism. Interviews, document analysis, and a focus group were conducted and analyzed to determine student attitudes towards writing in the math classroom and how writing in mathematics impacted their learning. To learn about the students’ attitudes, a focus group was conducted initially. In order to gain further insight, students, their parent(s), and the teacher were asked to keep a journal. Finally, documents were collected and interviews were conducted with students, their parent(s), and both the
current and former school principals. The results of the analysis showed that the mathematically gifted students generally did not mind writing in math or enjoyed it as they all displayed neutral to positive attitudes, though they preferred poetic writing. Furthermore, analysis of the data revealed transactional/expressive and poetic writing in mathematics positively impacted student learning and benefited the teacher as well.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Rationale for Study</td>
<td>3</td>
</tr>
<tr>
<td>Purpose Statement</td>
<td>7</td>
</tr>
<tr>
<td>Research Questions</td>
<td>8</td>
</tr>
<tr>
<td>Theoretical Framework</td>
<td>8</td>
</tr>
<tr>
<td>Sociocultural Theory</td>
<td>9</td>
</tr>
<tr>
<td>Social Constructivism</td>
<td>10</td>
</tr>
<tr>
<td>Definitions of Terms</td>
<td>12</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>13</td>
</tr>
<tr>
<td>Summary</td>
<td>15</td>
</tr>
<tr>
<td>II. REVIEW OF THE LITERATURE</td>
<td>17</td>
</tr>
<tr>
<td>Introduction</td>
<td>17</td>
</tr>
<tr>
<td>Types of Writing in Mathematics</td>
<td>21</td>
</tr>
<tr>
<td>Benefits of Utilizing Writing in the Math Classroom</td>
<td>25</td>
</tr>
<tr>
<td>Student Attitudes Toward Writing in Mathematics</td>
<td>31</td>
</tr>
<tr>
<td>Evolution of Writing in Mathematics</td>
<td>38</td>
</tr>
<tr>
<td>The 1970s: Getting Our Feet Wet</td>
<td>40</td>
</tr>
<tr>
<td>The 1980s: Creative Exploring and Problem-Solving</td>
<td>47</td>
</tr>
<tr>
<td>The 1990s: Winds of Change</td>
<td>57</td>
</tr>
<tr>
<td>The 21st Century: Who is the Mathematically Literate Citizen?</td>
<td>71</td>
</tr>
<tr>
<td>Conclusion</td>
<td>77</td>
</tr>
<tr>
<td>III. METHODOLOGY</td>
<td>82</td>
</tr>
<tr>
<td>Introduction</td>
<td>82</td>
</tr>
<tr>
<td>Situating Myself as a Researcher</td>
<td>83</td>
</tr>
<tr>
<td>Researcher as Instrument</td>
<td>86</td>
</tr>
<tr>
<td>Research Design and Methodology</td>
<td>87</td>
</tr>
<tr>
<td>Methods</td>
<td>89</td>
</tr>
<tr>
<td>Setting</td>
<td>89</td>
</tr>
<tr>
<td>Participants</td>
<td>89</td>
</tr>
<tr>
<td>Data Collection</td>
<td>92</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Justin’s observations about math</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Jonathan’s understanding of the benefits of writing in mathematics</td>
<td>29</td>
</tr>
<tr>
<td>3.</td>
<td>Hierarchical Tree Diagram</td>
<td>110</td>
</tr>
<tr>
<td>4.</td>
<td>Collin’s picture of a math student</td>
<td>115</td>
</tr>
</tbody>
</table>
**LIST OF TABLES**

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Benefits of Writing in Mathematics</td>
<td>30</td>
</tr>
<tr>
<td>2. Summary of Students’ Responses</td>
<td>32</td>
</tr>
<tr>
<td>3. Theme Analysis Table</td>
<td>109</td>
</tr>
<tr>
<td>4. Student/Parent Attitudes Toward Writing in Mathematics</td>
<td>191</td>
</tr>
<tr>
<td>5. Journal Summary Table</td>
<td>200</td>
</tr>
<tr>
<td>6. Writing Fluency Table</td>
<td>241</td>
</tr>
<tr>
<td>7. Benefits of Writing in Mathematics (From This Study)</td>
<td>257</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION

Traditionally mathematics has been taught as a set of computations, not fostering mathematical reasoning (Hiebert, 1999). When a second grade teacher asked her students to describe writing in mathematics, Figure 1 shows how one of her students responded (P. E. Whitin & Whitin, 1997, p. 108). As evidenced in the picture above, not only did that child think obtaining the correct answer was the goal of math but that the teacher played the dominant role in making sure he or she was correct. It is suggestive that the teacher had all the right answers, and not the students who constructed and justified the answers themselves. Hiebert (1999) explicated, “Compared with the curricula in other countries, the U.S. curriculum provides few opportunities for students to solve problems and to engage in mathematical reasoning, communicating, conjecturing, justifying, and proving” (p. 11).

Figure 1. Justin’s observations about math. From “Ice numbers and beyond: Language lessons for the mathematics classroom,” by P. E. Whitin and D. J. Whitin, 1997, Language Arts, 74(2), p. 108. Copyright 1997 by the National Council of Teachers of English. Used with permission.
Within the last 20 years, writing in mathematics has been brought increasingly into the spotlight of mathematics education. In fact, I find it challenging to discuss teaching without using the word *communication* as it is a major tool utilized by educators. What was once dominated by oral communication now has to share the stage with written communication. Connolly (1989) expounded:

Within the classroom, written language is more useful than oral, too, if *all* students are to think, not just a dominant few; if all are to rehearse their own understanding in their own terms; if all are to be heard: only by themselves at first, perhaps, but it is by ourselves that we mainly practice our personal performance of social understanding, not in front of teachers. (p. 10)

Reform efforts in mathematics education by the National Council of Teachers of Mathematics (NCTM) prioritized communication in mathematics at all levels (1989, 2000). Beginning with the *Curriculum and Evaluation Standards for School Mathematics*, NCTM (1989) presented five general goals for all students, one of which was to communicate mathematically. More specifically, they said writing was a tool that had been underutilized and that middle school students (grades 5–8) should have multiple occasions to use writing in order to not only communicate their ideas but also to explain and defend those ideas.

Eleven years later, NCTM published *Principles and Standards for School Mathematics* (2000) which built upon the *Standards* (1989). Communication was viewed as a crucial part of mathematics. “Students’ repertoire of tools and ways of communicating, as well as the mathematical reasoning that supports their
Communication, should become increasingly sophisticated. Support for students is vital” (NCTM, 2000, p. 60).

Communication was one of the 10 standards laid out in that document. The communication standard stated the following: Instructional programs from prekindergarten through grade 12 should enable all students to:

* organize and consolidate their mathematical thinking through communication;
* communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
* analyze and evaluate the mathematical thinking and strategies of others;
* use the language of mathematics to express mathematical ideas precisely.

(NCTM, 2000, p. 60)

Writing in mathematics was nonexistent up until the 1970s. Mathematics’ educators and students did not see it as having a place in the math classroom. “Few things stand so far apart in students’ minds as mathematics and writing, and traditionally the amount of writing required in mathematics courses has been minimal” (Borasi & Rose, 1989, p. 347). So when those standards came out and math educators were asked to incorporate writing into their classrooms, we saw a reform that asked for systemic change.

**Rationale for Study**

Writing in the math classroom gained recognition in the 1980s with the large number of writing workshops being conducted and articles being published from a number of authors (Connolly, 1989; Johnson, 1983; Keith, 1988; D. L. Miller & England,
1989: Shaw, 1983; Watson, 1980). The articles focused on the different types of writing being implemented such as journals (Watson, 1980), a biography of a mathematician (Johnson, 1983), daily logs (Shaw, 1983), and exploratory writing (Keith, 1988). D. L. Miller and England (1989) made the point that teachers did not have the opportunity to talk to every student daily but there was the possibility to have every student write daily. The work of Connolly and Vilardi (1989) also opened us up to a plethora of ideas contributed by various authors in their book *Writing to Learn Mathematics and Science*. In that volume the contributing authors shared writing activities that could be utilized at various levels throughout the mathematics curriculum.

Rose (1989) discussed how writing was viewed as more of a recursive practice in which the process was considered to be just as important as the product. In 1975, James Britton, a name well known when it came to writing in mathematics, and his team of researchers conducted a study in Britain. In their study which is further discussed in chapter 2, Britton, Burgess, Martin, McLeod, and Rosen (1975) classified writing into three categories: transactional, expressive, and poetic. Transactional writing focuses on the final product as its purpose is to inform, advise, persuade, or instruct. As shown in chapter 2, that appeared to be the most popular type of writing teachers utilized when they had students write in mathematics. Expressive writing is more exploratory and personal from which either a finished product may be constructed or it may stand alone (Rose, 1989). Journal writing is commonly associated with expressive writing. Poetic writing encourages imagination and may come in the form of poems, drama, plays, and stories. Poetic writing comes from ideas inside of us that we feel strongly enough about
that we can not wait to get them out. Creative writing is often synonymous with poetic writing (Fulwiler, 1986).

The problem was that the distinction between transactional and expressive was not always clear as it depends on the intention of the writer. Expressive writing could be transactional as it develops into something that becomes public and is no longer private, like moving from a first draft to the final draft. The journals utilized in this study were characterized as transactional/expressive as they contained characteristics of both types of writing.

Research found there could be many positive effects to both students and teachers when writing in the math classroom was utilized (Aspinwall & Aspinwall, 2003; Dusterhoff, 1995; Elliott, 1996; Gordon & Macinnis, 1993; Johnson, 1983; Krussel, 1998; Mayer & Hillman, 1996; Montague, 1973; Pugalee, 1997; Watson, 1980). Some benefits noted for students were that writing clarified their thoughts (Gordon & Macinnis, 1993), challenged and allowed them to experience a sense of accomplishment (Montague, 1973), and realize they could be creative in mathematics (Krussel, 1998). Cited as benefits to teachers were writing built student/teacher relations (Gordon & Macinnis, 1993), provided insight to student development in both the affective and cognitive domains (Aspinwall & Aspinwall, 2003), and guided teacher planning (Elliott, 1996). This area is explored in much greater depth in the literature review in chapter 2.

Affect plays a major role in the learning of mathematics, and research on affect needs to be more prevalent (McLeod, 1992). Current reform efforts support the role of the affect as it was reflected in their goals. Of the Standards’ (NCTM, 1989) five goals,
two of them included statements about students valuing mathematics and becoming confident in their mathematical abilities. “Attention to affect is of primary importance in any curriculum or course change since self-esteem, self-confidence, and attitudes toward a subject all play a vital role in the learning process” (Grossman, Smith, & Miller, 1993, p. 6).

A distinction needs to be made between beliefs, emotions, and attitudes as all three were used to describe affective responses in mathematics. Beliefs are developed over a long period of time and are fundamental in the development of attitudes and emotional responses to math (McLeod, 1992). For example, a belief students may have about mathematics is that it involves memorization and following certain rules. This may in turn influence their feelings when they encounter nonroutine activities such as writing in mathematics. “Feelings are discussed in the literature as attitudes, although that term does not seem adequate to describe some of the more intense emotional reactions that occur in mathematics classrooms” (McLeod, 1992, p. 576). We must realize that student emotions may be the source of later attitudes that form (McLeod, 1992), in this case towards writing in mathematics.

The study of gifted students’ attitudes toward writing in mathematics has been limited and lacking. What had been shown was that as students got older their attitudes became less positive toward mathematics (Gentry, Rizza, & Gable, 2001; Howley, Pendarvis, & Gholson, 2005). Studies that involved all students (not just gifted students) showed students generally had positive attitudes toward writing in mathematics (Borasi & Rose, 1989; Ciochine & Polivka, 1997; Johanning, 2000).
Purpose Statement

Many students and mathematics’ educators expressed concern about using writing in the math classroom; they believed writing should be reserved for language arts (Ciochine & Polivka, 1997; Watson, 1980; Williams & Wynne, 2000; Zinsser, 1988). Some educators still questioned when they were even supposed to implement writing in the math classroom while dealing with the pressure of trying to get through the curriculum (Quinn & Wilson, 1997). In addition, math educators who used writing in the classroom faced another battle when it came to mathematically gifted students. Those students did not feel the need to write as they oftentimes went through the process mentally (Zupancic & Ishii, 2002).

The purpose of this study was to investigate and describe mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in a classroom utilizing writing in mathematics and its impact on their learning. Students from a small rural school district in northeast Ohio were immersed in various transactional/expressive and poetic writing projects throughout the year. Interviews, document analysis, and a focus group were conducted to determine those attitudes. My goal is to inform teacher practice as understanding those attitudes and using writing in the mathematics classroom has many benefits for both students and teachers as illustrated in chapter 2. As a preview, it exposes informational gaps students may have (Mayher, Lester, & Pradl, 1983) which possessing such information would help guide teacher decisions, and also help develop a teacher’s ability to ask better questions (Fosnot, 1989).
Research Questions

Using a constructivist paradigm, this study examined mathematically gifted students’ attitudes toward transactional/expressive and poetic writing through a case study approach. More specifically, the research questions were: What are mathematically gifted students’ attitudes towards transactional/expressive and poetic writing in mathematics? How do transactional/expressive and poetic writing in mathematics impact student learning? This approach was chosen as it involves in-depth data collection using multiple sources of information. Case study was also chosen for its characteristic of providing a detailed description of the case with themes (Creswell, 2007). To learn about the students’ attitudes, a focus group was conducted initially. In order to gain further insight students, their parent(s), and the teacher were asked to keep a journal. Finally, documents were collected and interviews were conducted with students, their parent(s), and both the current and former school principals. Students provided valuable first-hand, descriptive, and rich information from a variety of sources gathered in this case study.

Theoretical Framework

The framework for the study consisted of components from both sociocultural theory and social constructivism. Both view the learner as an active, rather than passive participant in the learning process. Sociocultural theory and social constructivism also look at learning as a social experience in which individuals learn from those around them. In the sociocultural theory, learning is a social experience as one learns from a more capable other. Social constructivism includes others who may be on the same level but they learn from being engaged with one another in common experiences.
**Sociocultural Theory**

In mathematics, attention to writing has been disregarded in favor of procedural performance. However, Vygotsky acknowledged the importance of writing in the learning process. Writing is a vehicle for students to reflect on their thinking. That vehicle could lead to the development of higher-order thinking skills. This closely paralleled Vygotsky’s (1978) *zone of proximal development* (ZPD). In the zone of proximal development a child can achieve a goal with the support and guidance of a “more knowledgeable other” (MKO) as it ranges from what is known to what can be known. What the child can do with the help of an MKO is referred to as the “level of potential development” (Vygotsky, 1978). The full development within the ZPD depends upon social interaction. The more the child takes advantage of the MKO’s assistance, the broader the zone of proximal development.

A major tenet of Vygotsky (1978) was that development could not be distinct from social contexts or language, either in oral or written form. Vygotsky believed the development of these higher thought processes starts in the ZPD. When students are faced with tasks that go beyond their own capabilities, someone else (teacher or other adult) who is more knowledgeable can assist them in this process. At the center of this process is a social interaction that happens at two different planes. On the first plane which Vygotsky called “interpsychological,” students work with other students collaboratively or participate in teacher facilitated situations. These social interactions then lead students to the second plane, “intrapsychological,” in which they think, reason, or problem solve independently (Vygotsky, 1978). In Vygotsky’s sociocultural theory,
language then serves to mediate human activity on both planes; it takes the form of social speech and inner speech (Wertsch, 1991).

Writing, more specifically writing in mathematics, involves a process that advances learning. Writing requires students to use higher order thought processes such as analysis, synthesis, and evaluation. It is in the interpsychological plane that students develop their thinking through social contexts; for example, the classroom. They can use those social interactions with peers and the teacher to reflect upon and refine their thoughts as they move into the intrapsychological plane which may occur through journal writing. It can be through this writing that their independent thinking is further developed. “Written speech is monologous; it is a conversation with a blank sheet of paper” (Vygotsky, 1986, p. 181). It is the conversation with the self (the inner speech occurring) that grants students the chance to showcase their thoughts and knowledge through their writing. In this study students moved from whole class interactions (interpsychological) to individual practices (intrapsychological) through both their transactional/expressive writing (journals) and poetic writing (Math Nursery Rhyme books and 5th Grade Important Math book).

**Social Constructivism**

Constructivism is a learning theory that describes knowledge and the process of constructing knowledge. This construction of knowledge is active, not a passive process. Social constructivism breaks away from the traditional views and favors social interaction, contradictory to individuals acting on their own. Social constructivists believe that the world cannot be known with any certainty; there are no absolute truths
but rather a belief that multiple realities exist. They assume a stance of “fallibilist” epistemologies, understanding that knowledge is “lived and socially accepted” (Ernest, 1996, p. 343).

In social constructivism knowledge comes from conversations with others. Social constructivism concerns both an individual construction and a social interaction; it is the language that helps the learner build his or her knowledge through conversations with others (Ernest, 1996). An individual uses this language from conversations to continually examine his or her beliefs and then chooses to accept or reject this knowledge gained through the conversations with others (Ernest, 1996). Then, as new knowledge is accepted he or she is reconstructing his or her knowledge. Vygotsky supported this notion of knowledge coming from social interaction through his zone of proximal development.

In application, such a classroom would provide students a “contextually meaningful experience through which they can search for patterns; raise questions; and model, interpret, and defend their strategies and ideas” (Fosnot, 2005, p. ix). In this study students communicated their ideas through multiple representations. One example of that was students supported their learning by illustrating their own books. They modeled after various other math literature books in the classroom. It was their interpretation of what had been learned and how they chose to communicate it to others while still being able to defend those choices.

While proposing their case for the constructivist classroom, Brooks and Brooks (1999) explicated, “In order to understand, students must search for meaning. In order to
search for meaning, students must have the opportunity to form and ask questions” (p. 54). The student created books helped establish a community of learners which assisted in each others’ learning and meaning construction. The fifth grade mathematically gifted students in the classroom were presented the opportunity to formulate and ask questions through their journals. Students were being asked to communicate mathematically in active and creative ways. Their journals were being used both as a tool to support their thinking and as a reflective tool.

**Definitions of Terms**

The following operational definitions were used for terms in this study:

**Attitudes**: “affective responses that involve positive or negative feelings of moderate intensity and reasonable stability” (McLeod, 1992, p. 581); a personal preference for or dislike of writing in mathematics. (Note: Though “attitudes” may encompass many things, for this study, McLeod’s definition was utilized.)

**Mathematically gifted students**: students who were identified by the state of Ohio procedures for identifying children who are gifted in mathematics; that is, a score of 95 or above on the mathematics section of the Iowa Test of Basic Skills.

**Transactional writing**: a type of writing that informs, advises, persuades, or instructs people (Britton et al., 1975).

**Expressive writing**: a type of writing that is personal and exploratory in nature and is intended to make one’s thinking explicit (Rose, 1989).

**Transactional/expressive writing**: a type of writing that slides on the continuum between expressive and transactional; it may contain characteristics of both.
**Poetic writing**: a type of writing that is a verbal construct, an “object” made out of language. The words themselves, and all they refer to, are selected to make an arrangement, a formal pattern (Britton et al., 1975, p. 90). This type of writing is synonymous with “creative writing” (Fulwiler, 1986).

**Significance of the Study**

This study was essential for many reasons. It could be of value to researchers and practitioners interested in studying and improving instruction. Moreover, it could improve teaching by impacting future curricular decision-making. Once teachers come to understand what their students know, they can make decisions about whether they need to remediate or continue building upon student knowledge (Borasi & Rose, 1989). It could also advance learning and provide all students a means to share their voice which does not always happen on a day-to-day basis. Furthermore, mathematically gifted students’ attitudes toward different types of writing in mathematics had not been looked at to any great extent. Teachers could learn about these students’ conceptual thought processes as well as provide them an outlet to express themselves. “The extant literature, though descriptive of gifted children’s attitudes toward mathematics, does not reveal much about the wider context that shapes the practices of mathematics learning and teaching for mathematically talented students” (Howley et al., 2005, p. 130).

Additionally, the study helped fulfill the communication standard set forth by NCTM (1989, 1991) which explicated students should have multiple occasions to use writing as a tool to communicate. Journals allowed students to communicate, explain, and justify their ideas. Journals became sort of a historical artifact for students to track
their thoughts and allowed them to reflect upon their learning. Through the “choice” journal entries, students made connections between mathematics and their daily lives.

Affect has traditionally been studied through quantitative methods that utilize questionnaires (McLeod, 1992). This study added to the body of research on mathematically gifted students’ attitudes toward writing in mathematics while making a methodological contribution from a qualitative standpoint. McLeod posited,

Current efforts at curriculum reform place special emphasis on solving nonroutine problems, on applying mathematics in new situations, and on communication regarding mathematical problems. The novelty (as well as the difficulty) of such changes in the curriculum will cause more intense affective reactions for many students and teachers; research that investigates these more emotional responses is particularly important if the reform movement is to succeed. (p. 591)

Affect has a role in learning and its role is supported by reform efforts in their goals. This reform movement still continues. It began with the Standards (NCTM, 1989) and continued to be built upon in the Principles and Standards for School Mathematics (NCTM, 2000). It will continue to be echoed in the new Common Core State Standards (2010) most recently adopted, though are not scheduled to be implemented until 2014.

This study helped mathematics educators learn what mathematically gifted students’ attitudes are toward transactional/expressive and poetic writing in the math classroom. More importantly, it helped educators see the benefits of implementing writing into their classroom. By educating mathematics educators of the value and place writing has in the math classroom, it is hoped that it would create a domino effect. That
effect would be an increase in the number of mathematics educators utilizing writing in their math classrooms and creating positive student attitudes towards it as well.

Summary

In this chapter, the rationale of the study has been laid out; the purpose statement has been presented; the research questions have been stated; theoretical framework was expounded; terms were defined; and the significance was elucidated. In order to help the reader navigate the study, what follows is an outline of the remaining chapters:

In chapter 2, I provide a comprehensive review of the literature in the areas of types of writing in mathematics, benefits of utilizing writing in the math classroom, student attitudes (including gifted students) toward writing in the math classroom, and the evolution of writing in mathematics. Then, in chapter 3, I describe the methodology employed for this case study in which eight mathematically gifted students from a rural elementary school participated, bound by time and setting. Chapter 4 includes profiles of the teacher and each of those eight students. The profiles include background information on the students and their parent who participated, academic performance and attendance, information about some of their beliefs when it came to mathematics and writing in mathematics as well as various writing samples that exhibited both transactional/expressive and poetic student writing. In chapter 5, I discuss the findings of the study based on data collected from interviews, document analysis, and a focus group. The chapter is arranged by research questions along with the themes which emerged from the data. Finally, in chapter 6, discussions and implications of the findings are related to the literature and recommendations for future implementation of writing in the math
classroom are provided. Additionally, recommendations for future research are made, and I conclude with some final thoughts.
CHAPTER II

REVIEW OF THE LITERATURE

Introduction

How can your present work impact the future without an understanding of the past? William Pinar (2007) used the terms “verticality” and “horizontality” to describe the historical look at a discipline as well as its present circumstances (pp. xiii-xiv).

“Acknowledging the discipline-specific historical context in which one’s topic becomes intelligible is one marker of disciplinariness” (Pinar, 2007, p. xi). Therefore it is my intention that you will discover both the verticality and horizontality of writing in mathematics as you turn the pages that trace the time from the late 1950s to the present day.

Nel Noddings (1993) explicated, “I want to suggest that classrooms, including mathematics classrooms, should be politicized; that is, students should be involved in planning, challenging, negotiating, and evaluating the work that they do in learning mathematics” (p. 150). Writing in mathematics is one way to make this happen as it allows students to have a voice when it comes to their education. Although, we know that hasn’t always been the case.

The changes that we do see in education are coming from the minority, not the majority as they are still following the dominant paradigm introduced by traditionalists such as Ralph Tyler. His rationale “reflects the dominant scientific mode of thinking in the twentieth century, which claims objectivity and impartiality and separates itself from
value determination” (Walker & Soltis, 2004, p. 58). His objectives and evaluation one can say mirror the state indicators and high-stakes testing.

During the first half of the 20th century there was a battle between progressive educators and such traditionalists. The effect on elementary school practices and curriculum theory are still visible today, especially in light of our mandated state tests. Looking at progressive educators, “(John) Dewey has been described as the first educational thinker to provide for the teacher-essential elements for a successful learning experience” (Marsh, 2005, p. 23). Dewey, who was considered one of the most influential of all American philosophers, took 91 pages in *Experience and Education* to not only showcase the differences between “Traditional and Progressive” education but more importantly discuss the need for a philosophy of experience. He opined education must be based on the life-experiences of individuals. The road he asked educators to take would not come without its challenges.

Dewey (1938), the pragmatist he was, strongly believed in the “unity of theory and practice” (p. 7). I read this and automatically thought about the myriad of changes that take place in education without this unity. The decisions that drive these current changes rest solely upon good intentions for the most part. Until educative decisions can truly be made for the benefit of the students and not for political reasons, I am not sure how much “Deweian” change will ever come to fruition. His description of progressive education included things like student focused, freedom of choice, learning from experience and acquiring knowledge for direct application which are in stark contrast to how one would describe traditional education. “‘Learning by doing’ and ‘learning from
experience’ became the slogans that progressive educators took away from Dewey” (Walker & Soltis, 2004, p. 17).

I believe students have to be able to make connections between their learning experiences and see how they can apply what they are learning in their daily lives. When they are isolated they become what he called a “mis-educative” experience (Dewey, 1938, p. 25). I do not believe they can have these types of experiences without being “engaged” in learning. If learning is not meaningful and relevant, I do not believe it can occur in its truest sense. Curriculum then is like a roadmap for instruction. It marks the beginning point, all the stops along the way, and the final destination. The curriculum tells what knowledge and skills each student should acquire. However, it is up to the teacher to determine the mode of travel and the length of stay at each point. I believe teachers can add or detract from the curriculum by consciously or unconsciously imposing their values and beliefs on lessons and/or the environment. Unfortunately being in the predominant standardized management paradigm, standardized requirements (curriculum) force school systems into a strangle hold. The creativity of teachers who are forced to implement it may be squelched because teachers are forced to get students to “pass the test” rather than truly integrate the learning of subject matters in creative ways, which gives the learning material more meaning in the students’ everyday lives. In the standardized management paradigm, Henderson and Gornik (2007) noted, “Administrators manage teachers through the creation and maintenance of an accountability system geared to students’ learning achievement as measured by carefully selected standardized tests” (p. 8).
Brooks and Brooks (1999) stated, “In order to understand, students must search for meaning. In order to search for meaning, students must have the opportunity to form and ask questions” (p. 54). Writing in mathematics is one way to afford students the opportunity to formulate and ask questions. Knowing that we construct our understandings from experience, the more we can get students to become active participants in the classroom, the richer experiences we can provide them. Moreover, believing that students and teachers construct knowledge together, writing in mathematics has become more of a central focus in my own teaching. “From a Vygotskian perspective, the teacher’s role is mediating the child’s learning activity as they share knowledge and meaning through social interaction” (Dixon-Krauss, 1996, p. 18). Understanding that regurgitating information is not what makes learning meaningful and relevant to students, nor does it sustain over time, it is important to understand both when writing came into play in the teaching of mathematics as well as why. hooks (1994) referred to this regurgitation as she described Paulo Freire’s work on the “banking system of education,” and explained it as “the assumption that memorizing information and regurgitating it represented gaining knowledge that could be deposited, stored and used at a later date” (p. 5). Freire (1985) went on to say, “The more students work at storing the deposits entrusted to them, the less they develop the critical consciousness which would result from their intervention in the world as transformers of that world” (p. 60).

“Mathematical competence is vital to every individual’s meaningful and productive life” (National Council of Teachers of Mathematics [NCTM], 1980, p. 17).
How could one become mathematically competent if he or she only has the ability to deposit, store, and retrieve information? For many years mathematics was taught as computation, not facilitating reasoning or the development of logic. Fosnot (1989) described it by stating:

The discipline to which the greatest disservice occurs in the schools is perhaps mathematics . . . the result is that many teachers do not understand the concepts they are expected to teach and thus rely on workbook pages, computation sheets, and drill as common instructional practices for the safety they provide. (p. 71)

Historically, writing had not always had a place in mathematics but as we will see it has gained much support over the years and in turn has a definite place in the mathematics classroom today.

**Types of Writing in Mathematics**

“Surely mathematics was a world of numbers. Could it also be penetrated with words?

*Could a person actually write sentences that would lead him through a mathematical problem and suggest further questions—different from the ones the teacher might raise?*

(Zinsser, 1988, p. 149)

Writing is important in all school subject areas but is rarely used in traditional mathematics classes. Writing in mathematics, as is discussed later, can be used in a variety of ways. The most important feature of writing is that it is reflective; it forces a person to think before doing, in contrast to orally communicating ideas. This reflection allows students to develop a deeper understanding of concepts (Johanning, 2000).

“Writing about a problem and including writing as an integral part of the thinking process
helps students to slow their thinking for time to clarify thoughts, identify concepts, and refocus possible questions and solutions” (Barone & Taylor, 2006, p. 80). When students write, they supply themselves physical evidence of their thoughts which allows the opportunity for self-checking. Putting their thoughts on paper promotes metacognition. It forces students to think about their thinking which adds to their understanding. It is a recursive process between thinking, writing, and reflecting.

Britton et al. (1975) conducted what has become a well-documented study in Britain. They looked at “the relationship between writing and learning . . . [the] team collected 2,000 pieces of writing from British school children aged 11-18 and classified each according to the function it served: transactional, poetic or expressive” (Fulwiler, 1986, p. 23). The findings showed the majority of school writing is transactional (writing that informs, persuades, or instructs) as it accounted for 63%, poetic (creative writing) took up 18%, and expressive (diaries, journals, etc.) minimally took up only 5.5% (Fulwiler, 1986).

Fried and Amit (2003) posited, “writing is seen to come between communication, which is fundamentally public, and reflection, which belongs to a private domain” (p. 104). Beginning with transactional writing, it would be considered public. Transactional writing is used to communicate one’s understanding to another person as an active part of the learning process. It is writing meant to be read by someone else. Some examples of this may include summaries, definitions, explanations, math autobiographies, and exit slips. You might ask your students to explain how to add and subtract fractions with unlike denominators.
Expressive writing, on the other hand, is writing that would be considered private. “First drafts, diaries, journals and letters to very close friends are places where such writing can be found” (Fulwiler, Gorman, & Gorman, 1986, p. 54). Students usually reflect upon a prompt or some activity in which they engaged. This type of writing allows them to refine their thinking and reflect upon their thoughts. It provides a means for students to think through problems. Britton et al. (1975) believed expressive writing was “the kind of writing best adapted to exploration and discovery . . . language that externalizes our first stages in tackling a problem or coming to grips with an experience” (p. 197). However, the results showed this type of writing was not equally valued or encouraged in the classroom. Expressive writing, also know as “informal writing,” is believed by Barone and Taylor (2006) to have two goals:

1. Students’ clarification and extension of thinking about a content area (in this case mathematics) or topic.
2. Students’ and teacher’s understanding of misconceptions or incomplete knowledge of the content area or topic to serve as a basis for further instruction.

It is possible that transactional and expressive writing are interchangeable as the distinction between them is subtle. The difference lies in the communicative purpose. Transactional is more explanatory while expressive is more reflective. Expressive writing can be thought of in two ways. It can be thought to be done in order to evolve into transactional writing or stand alone to document “present feelings as well as thoughts about a problem, issue, or text” (Rose, 1989, p. 16). Expressive writing (journals) could
be read by the teacher or a peer, which would not necessarily categorize it as transactional. Expressive writing is more like a first draft whereas transactional writing can be thought of as the final draft. Expressive writing is more personal and not meant for others to read; the writer writes for himself rather than to communicate understanding as transactional writing would. Some examples may include diaries, journals, and freewriting (thinking out loud on paper) where the writer is free from grammatical constraints.

Expressive writing could become transactional “during the writing or rewriting of the piece, as the writer thinks about the problem, figures it out, and explains it to someone else” (King, 1982, p. 44). Therefore, expressive writing can lead to a transactional piece of writing (Fried & Amit, 2003). My students were asked to communicate mathematically in active and creative ways; a tool that supported their own thinking and as a reflective tool. Student journals therefore served both purposes, private and public. They served as a place for reflection to occur as well as refinement of those reflections as they transformed to transactional writing. “When we write expressively in a journal, we imprint ideas, information, and experiences deeply within us” (Romano, 2000, p. 138).

The third type of writing that was classified by Britton et al. (1975) was poetic. Poetic writing, like transactional, is considered to be public, yet it is writing that is done for the writer and not the reader (Fried & Amit, 2003). Poetic writing encourages imagination and may come in the form of poems, drama, plays, and stories. Poetic
writing comes from ideas inside of us that we feel strongly enough about that we can not wait to get them out.

Poetic writing, often synonymous with creative writing, is for “readers to experience the writing, to be observers, to emotionally and intellectually give themselves over to the creation” (Romano, 2000, p. 137). A group of sixth grade gifted students used this type of writing, based on the book *A Gebra Named Al* (Isdel, 1993), to communicate their mathematical understandings (Ironically, the author was just around their age when she began writing it!). One example problem the students were asked to respond to was: “*Explain your selection of five kinds of animals that might live on Multiplication or Division Land*” (Pinchback, 2001, p. 41, italics in original). Here is an excerpt from one of the students (Pinchback, 2001, p. 42):

> Composite Cows: graze on composite plain who are put together with black and white spots. Each cow is born with a composite number of spots. As they grow elderly, their spots divide and are factors of their first number. When they get to a prime number of spots it is time for them to die. They are not USDA Prime Beef.

Students and teachers must accept that creativity has a place in mathematics. Krussel (1998) asserted, “creative writing should be as important a component in mathematics as it is in language” (p. 439).

**Benefits of Utilizing Writing in the Math Classroom**

> “*Is this child taking a risk, sharing a surprise, describing a new strategy, building on the ideas of others, or suggesting an extension?*” (P. Whitin & Whitin, 2000, p. 69)
Using writing as a tool for learning has numerous benefits for both teachers and students. (Though I discuss many of them here, others can be found in Table 1 at the end of this section as well as sprinkled throughout the “Evolution of Writing in Mathematics” section.) In general, writing in mathematics can expose information gaps students may have which can be of immense value to the teacher (Mayher et al., 1983). More specifically, Bell and Bell (1985) cited two benefits of using expository (transactional) writing. Writing can provide communication dialogue between students and teachers, and it also offers teachers an opportunity to provide individual feedback to students in order to clear up any misconceptions.

Though writing may provide windows for teachers to get to know their students, it has to be looked at as purposeful by the student; then, and only then can the dialogue be meaningful. Borasi and Rose (1989) discussed how using journals can guide future curriculum making decisions. Once teachers read student journals and learn what students understand versus what they are still struggling with, they can plan to remediate or see students are ready to build upon their new knowledge. The dialogue going on in the journals can also build the classroom atmosphere at a different level. After implementing journal writing into a college math course, one student insightfully commented:

I feel writing in my journal has helped in learning just because it shows you care enough about teaching and your students to listen to their comments and give suggestions and encouragement. I think many times students won’t talk or speak up and say how they feel because of the ‘classroom atmosphere.’ But writing
helps me say what I want to without feeling intimidated. (Borasi & Rose, 1989, pp. 361-362)

When it comes to writing in mathematics, numerous benefits have been stated for students as well. In reference to writing being done on a daily basis in college math classes, Birken (1989) explicated, “Since writing requires the ability to communicate (even if only to oneself) a process or idea, most students comment that they have a deeper understanding, further clarity, and better retention of concepts after writing” (p. 41).

Believing students needed to be active agents of their own learning, Debra Johanning (2000) developed a writing program for two seventh grade gifted classes and one advanced eighth grade class. That writing program opened channels of communication that may not normally have been present. The act of students putting their thoughts onto paper introduced an added element in the learning process that was typically not there. Students themselves noted three benefits. Writing helped them “find their mistakes, helped them remember the problem better, and helped them understand the problem better” (Johanning, 2000, p. 154).

Writing in mathematics can rejuvenate students who become bored. It provides an opportunity for higher level math students to showcase their creativity. In addition, it can be an individualized tool used in trying to make sense of a topic a gifted student may be stumped by for the first time (Birken, 1989). For others, it can be a way to demonstrate their mathematical reasoning. To that end, writing is an active rather than passive process students can engage in as a meaning-making tool (Mayher et al., 1983).
Although Barone and Taylor (2006) identified the following list as “purposes” for writing, I contend that many can also be considered benefits as they lead to meaning-making and ultimately learning.

* To learn
* To clarify relationships
* To inform
* To explain simple to complex issues
* To describe
* To problem solve
* To convince
* To problem find
* To entertain
* To make a request
* To get better at writing
* To connect new information to old ideas
* To think about and revise ideas
* To remember
* To generalize
* To reflect
* To analyze
* To demonstrate knowledge and understanding. (pp. 2-4)

Another benefit of writing in mathematics is that students are involved in active learning and critical reflection. The National Writing Project and Carl Nagin (2006) opined, “writing is a complex activity; more than just a skill or talent, it is a means of inquiry and expression for learning in all grades and disciplines” (p. 3). By reflecting on what they have written, writing helps students find their mistakes. “Because when I work it out at the top, just using the numbers, I think I have it, and then when I write it out, I think about it more, and I catch my mistakes when I write it” (Johanning, 2000, p. 154).

Writing is a way for students to make their thinking visible. Once they can begin to see their thoughts on paper, they can begin to see its usefulness. After spending the
majority of his time in fourth grade writing in mathematics, Jonathan sketched his understanding of its benefits (see Figure 2; P. Whitin & Whitin, 2000, p. 4).

Figure 2. Jonathan’s understanding of the benefits of writing in mathematics. From *Math is language too: Talking and writing in the mathematics classroom* (p. 4), by P. Whitin & D. J. Whitin, 2000, Urbana, IL: National Council of Teachers of English. Copyright 2000 by the National Council of Teachers of English. Reprinted with permission.

Writing was also viewed by another fourth grade student as a tool for making mathematical discoveries. She stated, “It [writing in mathematics] teaches me how to learn. When I write I get lots of ideas of what else I want to say” (P. Whitin & Whitin, 2000, p. 3).
## Table 1

**Benefits of Writing in Mathematics**

<table>
<thead>
<tr>
<th>Benefits to Students</th>
<th>Benefits to Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing in mathematics can:</td>
<td>Writing in mathematics can:</td>
</tr>
</tbody>
</table>

*Challenge and allow them to experience a sense of accomplishment (Montague, 1973)

*Provide a means to give individual feedback to students (Bell & Bell, 1985)

*Get students excited; feel voices are being heard; feel teachers care (Watson, 1980)

*Build student/teacher relations (Gordon & Macinnis, 1993)

*Foster creativity; aid in problem-solving (Johnson, 1983)

*Be used to assess student understanding (Barone & Taylor, 2006; Dusterhoff, 1995; Pugalee, 1997)

*Provide a forum to vent frustrations one may be experiencing (Bell & Bell, 1985)

*Guide teacher planning (Dusterhoff, 1995; Elliott, 1996)

*Build procedural and conceptual understanding (Borasi & Rose, 1989)

*Provide insight to student development in both the affective and cognitive domains (Aspinwall & Aspinwall, 2003)

*Clarify student thinking (Dusterhoff, 1995; Gordon & Macinnis, 1993)

*Serve as informal assessment as it provides a window into students’ thinking (Barone & Taylor, 2006)

*Help identify areas of difficulty (Mayer & Hillman, 1996)

*Help allow students to realize they can be creative in mathematics (Krussel, 1998)

*Help students keep track of their thoughts (Albert, 2000)


Student Attitudes Toward Writing in Mathematics

“Many students hate to write because they have never had much success with it. Most of the feedback they’ve ever received has been negative. We do not characteristically praise good work, but we regularly condemn poor work.” (Marwine, 1989, p. 62)

Affect plays a major role in the learning of mathematics, and research on affect needs to be more prevalent (McLeod, 1992). Current reform efforts support the role of the affect as it is reflected in their goals. Of the Standards’ (NCTM, 1989) five goals, two of them included statements about students valuing mathematics and becoming confident in their mathematical abilities. “Attention to affect is of primary importance in any curriculum or course change since self-esteem, self-confidence, and attitudes toward a subject all play a vital role in the learning process” (Grossman et al., 1993, p. 6).

While asking students to be active participants in a higher-order thinking, writing in mathematics classroom, we have come to understand that their “affective responses are going to be much more intense than if they are merely expected to achieve satisfactory levels of performance in low-level computational skills” (McLeod, 1992, p. 575). According to McLeod attitudes develop in two ways. One is that they result from repetitious emotional reactions. For example, if every time a student did a word problem involving expressions he or she had a negative experience, then that response became more stable over time. Attitudes also develop from existing attitudes. The student who had a negative attitude towards word problems involving expressions may attach that same attitude towards word problems he or she encountered with equations or inequalities.
Asking students to write in mathematics is a new experience for a large number of students. In fact, it is also new for a large number of teachers as it was not part of their prior mathematical learning or teaching practice. By the time students leave elementary school, many do not view writing as an integral part of learning mathematics (Liedtke & Sales, 2008). That observation led Liedtke and Sales to conduct a study with a group of seventh grade students to see if implementing writing in mathematics would change their attitude toward its value. The results which indicated a positive growth in all statements are presented in Table 2 (Liedtke & Sales, 2008, p. 336).

Table 2

Summary of Students’ Responses

<table>
<thead>
<tr>
<th>Statements</th>
<th>Time of Year</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beginning</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>1. Writing can be an important part of learning mathematics.</td>
<td>16</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>2. Sharing ideas in mathematics can involve writing.</td>
<td>10</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>3. I enjoy writing about mathematics.</td>
<td>1</td>
<td>30</td>
<td>9</td>
</tr>
<tr>
<td>4. Reading the writing of others can show me different ways of thinking about mathematics.</td>
<td>13</td>
<td>18</td>
<td>24</td>
</tr>
</tbody>
</table>


Many mathematically gifted students began exhibiting characteristics during their preschool years (Rotigel & Fello, 2005). “At an early age, some gifted students note relationships between products and prices in the grocery store, the passage of time,
changes in weather temperatures, and measurements of distances” (p. 5). A common characteristic displayed by mathematically gifted school age children is that they are able to come up with the correct answers quickly and accurately (Rotigel & Fello, 2005).

Challenging tasks need to be designed that are authentic, develop metacognition, and increase motivation (Diezmann & Watters, 2005). Teachers are sometimes at a loss when it comes to discovering ways to challenge those students whose ability does not match their grade level placement. Although, the Principles and Standards for School Mathematics (NCTM, 2000) stated that those students need to be provided occasions to achieve their mathematical capabilities. One means of supporting those students in their learning is through differentiation. Reed (2005) discussed three types: extension and application, investigating an open-ended question, and self-selection of problems. Those are especially helpful if you are working with mathematically gifted children in a heterogeneously grouped math class. Instruction may be differentiated by content, process, or product (Pierce & Adams, 2005).

Tretter (2005) discussed using math journals with gifted high school students as one component of the Governor’s School in North Carolina where he taught. He felt it was important he provided those students a forum for their voices to be heard. At the end of the six-week program, one of his students commented that “the thinking is more important than the product” (p. 133). That is interesting as gifted students usually come up with the solution quickly and then find themselves bored. Furthermore, when asked what would be the most important idea(s) the readers should get from reading their journals, Tretter noted, “Many students discussed the exposure to really thinking about
underlying mathematics and connections between seemingly difficult applications as part of the most important and enjoyable aspect of this course” (p. 135).

Joan Countryman was worried about her gifted students when she started using writing in mathematics because they were so confident they did not need to write it down or thought they could be more productive with their time. That is a feeling that many educators have whether they are working with the gifted population or not. Although, time passed and eventually her students said, “This is really useful. I’m learning mathematics better because I’m writing this stuff” (Zinsser, 1988, p. 154).

Moving to the middle school population, a number of studies were conducted at that level. Beginning with a mixed methods design, Albert (2000) used a classroom approach that paralleled nicely to Vygotsky’s ideas on the interpsychological and intrapsychological planes (discussed in chapter 1). In his study of seventh graders, the pedagogical practices utilized by the teacher started on the interpsychological plane as students were participants in whole class discussions and then collaborative groups. They then moved into the intrapsychological plane as they were asked to engage in some transactional writing to explain their struggles and procedures to solve various problems. Those students in the experimental group displayed improved or positive attitudes toward writing in mathematics as compared to those in the control group.

Students expressed how they were able to use their writing as a record of their thoughts that they could go back and reread. They felt doing this would be beneficial in the future if they forget something (Albert, 2000). Students also realized that basic skills were not necessary for conceptual understanding and preferred to focus their energies on
the latter through writing. It was evident that the collaborative discussions and writing activities changed their attitudes towards writing in math in a positive way (Albert, 2000).

Johanning (2000) also looked at middle school students in a study involving a year long writing and collaborative group program in which students responded to problem-solving prompts. The middle school students were comprised of both gifted seventh graders and advanced eighth graders. Most displayed positive attitudes towards writing because they recognized the benefits. Though a particular student did not display such a positive attitude, he was able to see the benefits.

I don’t like writing it out because it takes a long time. But it helps also when you are going to do a problem in class and you go, “Oh, I remember that, we did a problem about it” because you remember how to do it. (Johanning, 2000, p. 154)

A few of the studies looked not only at transactional writing but also expressive and creative. Looking at students 11-13 years old, Jurdak and Zein (1998) found students had positive attitudes toward journal writing which included transactional and expressive types of writing prompts. In fact, 92.3% of the students reported in a questionnaire that they would like to continue journal writing in mathematics (Jurdak & Zein, 1998). A year earlier, Ciochine and Polivka (1997) also conducted a study with middle age students to find they enjoyed the various types of transactional (Problem of the Week), as well as creative (mysteries and number autobiographies) writing. That came to the teachers surprise as she admitted being hesitant to try writing in math at first because she
thought her students would resist the idea when they actually welcomed it (Ciochine & Polivka, 1997).

It was stated that as students got older their attitudes toward mathematics became less positive (Howley et al., 2005). In addition, Aspinwall and Aspinwall (2003) declared that students entering fifth grade already had established beliefs about mathematics. In looking at the attitudinal changes of gifted boys and girls towards mathematics over a two-year period, Terwilliger and Titus (1995) found a “decidedly negative change in attitudes toward mathematical concepts” (p. 34).

Looking specifically at gifted rural students, Gentry et al. (2001) discovered students at the elementary level found their classes to be less interesting and challenging but more enjoyable as compared to those from urban and suburban districts (Gentry et al., 2001). At the middle school level, rural students not only felt their classes were less challenging but also less enjoyable. “When considering the potential of gifted students together with their perceptions of how challenging, interesting, and enjoyable school is, it becomes clear that the cognitive and affective needs of rural gifted students are at risk of not being met” (Gentry et al., 2001, p. 125).

Similar to those findings, Howley et al. (2005) also found as students got older their attitudes toward math become less positive. They looked at mathematically gifted rural children in grades two through eight. Their view of the subject, though not stated, may have been a contributing factor. “Far from seeing mathematics as a way of expressing ideas or as a method for characterizing relationships and patterns, these gifted
children instead saw mathematics principally as a set of procedures with numbers—as calculations and algorithms” (Howley et al., 2005, p. 138).

While it was just mentioned above that as students got older their attitudes toward mathematics became less positive, and studies were discussed which supported that notion, keep in mind that none of those involved writing in mathematics. Let us now turn to one that did and I begin by introducing you to the professor, Richard Lesnak.

*When the Robert Morris College writing-across-the-curriculum program was proposed in 1984, I volunteered to be a participant in the initial implementation—a somewhat doubting, skeptical participant. At the time I had taught mathematics for 25 years with what I consider to be a great deal of success. In fact, I had serious doubts as to whether writing-to-learn strategies could improve the learning process in my math classes. At that time I was only cautiously optimistic that my students’ attitudes toward mathematics might also be changed in the process. I am no longer a skeptic. I have no doubt that writing-to-learn activities can be a valuable tool not only in improving academic achievement but in eliminating the negative attitudes of many of our students with respect to mathematics in general, and beginning or remedial algebra in particular.* (Lesnak, 1989, p. 147, italics in original)

In short, his students wrote procedures to problems and then referred to them while engaged in problem-solving. Prior to their first exam he asked students to write the procedures for the various types of problems that would appear on the test on a “ticket” which was their ticket to take the exam. He then categorized them as those which were
written correctly (Group A) and then the others (Group B). Upon grading the exams, all
students who had tickets in Group A scored between 80-100%. Those with tickets in
Group B all scored less that 80%. Results were presented to the students for verification.
As the semester progressed, students in the experimental group became more
“enthusiastic” and “confident” (Lesnak, 1989). The final assignment for the
experimental group which was to evaluate the writing activities they had engaged in
showed 100% positive responses1.

Evolution of Writing in Mathematics

“How do I know what I think until I see what I say?” (E. M. Forster, 1927, p. 152)

Fawcett et al. (1959) opined:

Growth in understanding of a fundamental idea and of its extensions is a
continuous process that is facilitated by properly chosen classroom techniques . . .
some of our most desirable objectives, while requiring an understanding of
mathematical ideas by both teachers and pupils, will be achieved best by teachers
who consciously adopt classroom procedures which develop mathematical
thinking habits and techniques. (p. v)

Although they were not talking about this in the context of writing in mathematics, I
think their statements were a precursor for what was to come. Taking a brief look back,
World War II (WWII) had a deep impact on people’s ideas about the necessity for math
as the young men and women were not able to comprehend or perform the needed math
for things such as how “to operate weapons systems, maintain supplies, navigate ships

1 To read the complete study, please see Lesnak, R. (1989). Writing to learn: An experiment in remedial
algebra which appeared in P. Connolly and T. Vilardi, Writing to learn mathematics and science, 147-156.
and airplanes, and do other relatively simple tasks needed in the war effort” (Willoughby, 2000, p. 3). It was in 1957 that things really began to take off as that was the year the Soviets launched the first Sputnik satellite, the National Defense Act was passed, and the National Science Foundation (NSF) provided monies for improving math and science education. Although the inception of “new math” occurred in 1951, it really did not take off until those funds were made readily available from NSF after Sputnik. So the 1960s were filled with considerable excitement in math curriculum and instruction. However, the “new math” era was widely criticized by the public as they viewed it as too abstract and not having real world connections.

This is not to suggest that the public is about to turn its back on ‘new math’ innovations . . . but it is to say that the day of blind public acceptance and automatic deference to our mathematical ministrations is probably behind us. (Mueller, 1966, p. 622)

Society became concerned with this and gazed at what was happening with a much more watchful eye. Ironically, a year later, there did not seem to be much forward moving in regards to the “new math” era. Davis (1967) reported, “Despite newspaper reports, publishers’ claims, cartoons, and even songs to the contrary, the ‘new mathematics revolution’ has not taken place” (p. 1). He went on and said, “one sure fact that stands out is that the real revolution, if it does begin, will not be finished in a day, or a week, or a year” (p. 1). There was a parallel to the problems going on in the field of curriculum as well. The field had become irrelevant as a number of curriculum projects had failed. In addition, it was Joseph Schwab (1969) who declared the field as being “moribund” (p. 1).
The 1970s: Getting Our Feet Wet

“Writing as an analytical tool is often used in literature and social science courses, but students are almost never given an opportunity to do meaningful writing in mathematics classes.” (Johnson, 1983, p. 117)

Moving into the 1970s, the concern focused on problems brought to light almost exclusively by test scores. Schools responded in a variety of ways but “a clear-cut and carefully reasoned sense of direction that looks toward the future has been lacking” (Hill et al., 1980, p. i). That was also the time known as the reconceptualization era in which Janet Miller (2005) defined as “understanding curriculum as intersections of the political, historical, the autobiographical” (p. 19). It was a change from the development of curriculum to understanding it. It was a time of transformation both in the field of curriculum and the classroom.

It was in 1972-73 that the National Assessment of Educational Progress (NAEP) conducted its first assessment in mathematics. That was a major event in the history of mathematics. The purpose of the assessment was to gather information on the “levels of understanding of selected mathematical concepts and the levels of performance on selected mathematical skills” for 9-, 13-, and 17-year-olds as well as adults between the ages of 26-35 (Carpenter, Coburn, Reys, & Wilson, 1975, p. 453). Less than one-fourth of the problems were multiple-choice and therefore the rest were open-ended type questions. NAEP used a “measure by objectives approach . . . having two dimensions: the content of mathematics and the abilities of mathematics” (Carpenter et al., 1975, p. 455). In describing the abilities of mathematics, Carpenter et al. used the following:
I. Recall and/or recognition of definitions, facts and symbols

II. Performing mathematical manipulations

III. Understanding mathematical concepts and processes

IV. Solving mathematical problems—social, technical, and academic

V. Using mathematics and mathematical reasoning to analyze problem situations, define problems, formulate hypotheses, make decisions, and verify results. (p. 455)

It is the last one which campaigned toward writing in mathematics. So what were the results? Carpenter et al. (1975) reported the following:

The implications for needed improvement in mathematics programs are abundant in these data. As a whole, these age groups need to develop problem-solving skills. Even such fundamental habits as checking the correctness or reasonableness of a result, or making an estimate seem to be lacking. (p. 470)

It was the recognition of the need for problem-solving skills that played a major part of the next decade. I believe as a result of that assessment, though not stated, two conflicting trends that emerged in the early 1970s were a “back-to-the basics” movement in response to the “new math,” and on a smaller scale new modern programs that were being created and tested by some commercial publishers also known as “Open education” (Walker & Soltis, 2004). As cited in Willoughby (2000):

These innovative programs could be considered precursors to the NCTM Standards in that they were based on very different principles from those
of the back-to-the-basics movement and demonstrated that all children could learn a remarkable amount of mathematics, including higher-order thinking skills, if appropriate instructional activities were used. (Dilworth & Warren, 1980, p. 5)

Both movements were “closely allied in the minds of reformers who saw open exploration as the most effective way to foster intellectual growth in younger children” (Walker & Soltis, 2004, p. 79).

Paradoxically, it was in the 1970s that I found the first article where students were writing in mathematics. In Let Your Students Write, Montague (1973) discussed how students in grades 10-12 authored a book on matrix algebra as a “result of a teaching-learning experiment in an NSF Summer Institute in Mathematics for High School Teachers” (p. 548). She met with those 14 students for 15 one-hour sessions throughout the summer to accomplish that. After they agreed on their overall outline and intended audience, they decided the book would include not only theory but application as well. That constructivist approach allowed students to be fully emerged in the process as active participants. Fosnot (2005) stated:

Teachers who base their practice on constructivism reject the notions that meaning can be passed on to learners . . . a constructivist view . . . gives learners the opportunity for concrete, contextually meaningful experience through which they can search for patterns; raise questions; and model, interpret, and defend their strategies and ideas. (p. ix)

Montague acted as facilitator, not authoritarian as students had open dialogue and voices were heard. From that, they created a 63-page book!
Montague categorized the benefits of engaging in such a project into two separate categories, one for students and one for teachers. The benefits for students included: being challenged to learn in new ways, taking ownership of their learning, being able to discuss and listen to multiple perspectives. “I witnessed the emergence of humility out of bravado and self-confidence out of self-effacement” (Montague, 1973, p. 549). Also listed as benefits to students were a sense of pride and accomplishment as well as appreciating the difficulty in finding the words to convey ideas to their readers. Montague stated, “An appreciation of the communication process is not developed in our classes to the extent that it should be” (p. 549). The realization of the importance of writing in mathematics started to become apparent. Speaking of the benefits to teachers, she noted a feeling of freedom from the day-to-day strangle hold of traditional teaching, deepened subject-matter understanding and coming to know your students better through such iterative dialogues. “The individual personalities of the students are quickly revealed to the teachers in these sessions. As teachers, we do not know our students as they are known by their peers” (Montague, 1973, p. 550).

In 1975 James Britton, a name well known when it came to writing in mathematics, and his team of researchers conducted a study in Britain. They looked at “the relationship between writing and learning . . . (and his) team collected 2,000 pieces of writing from British school children aged 11-18 and classified each according to the function it served: transactional, poetic or expressive” (Fulwiler, 1986, p. 23). The findings showed the majority of school writing was transactional (writing that informs, persuades, or instructs) as it accounted for 63%, poetic (creative writing) took up 18%,
and expressive (diaries, journals, etc.) minimally took up only 5.5% (Fulwiler, 1986). Fulwiler contended, “The complete neglect of expressive writing across the curriculum is a clue to the value of writing in schools. According to Britton’s classification, expressive is the most personal writing, the closest to ‘inner speech’ and the thinking process itself” (p. 24). So, from that study a few things became obvious. First, it did not appear that we were allowing students to express themselves through writing. Secondly, we were not tapping into the creativity of students. Therefore, how meaningful could school be to students who could not express their own thoughts or allow their creativity to flourish? Were we just striving for robotic, carbon copies?

Traveling back to the U.S. in the mid to late 1970s, modern math asserted that students make relationships and connections between ideas as contrasted to the traditional more “back-to-the-basics” ways of learning. So, as we began to ask students to write in mathematics, we came to find they had no idea how, and that should not have come as a surprise. “Most students will not have encountered such tasks before, and thus frustration is likely to occur” (Geeslin, 1977, p. 114). We would not expect someone who has never run a marathon before to go out and cross the finish line without sufficient training and practice. Likewise, writing in mathematics was not something that was going to develop overnight but would take time provided students were continuously asked to write. As with anything else, we get better with practice.

This was evident in a study conducted by Geeslin (1977) in which students (who were average to above average in ability and socioeconomic status) were asked to write sentences or paragraphs about relationships between pairs of probability concepts. They
performed poorly at all levels (sixth grade, eighth grade, and high school). Geeslin stated:

The remarkable thing is that most of the students can repeat on a test a definition such as “An event is a set of outcomes.” Yet when asked to explain how these two concepts are related or to write a sentence containing both words, students almost never write the definition or any mathematically correct statement. (p. 112)

This raised a serious issue in math education: “[the] inability to express a complete mathematical idea, much less a correct one” (Geeslin, 1977, p. 113). Therefore, students may have had misconceptions which were not necessarily caught by standardized tests in which students showed they got the correct answer, even if they had no idea why it was the correct answer. In my personal experience, I still saw this happening 30 years later! Getting my students to write in their own words (as they just want to copy mine or from the book) has opened my eyes (and theirs) to their true level of understanding. This has important implications as it guides my planning as I come to know what is learned versus what has been ingested.

[Teachers] also need experience investigating children’s understanding. Such investigations serve two purposes. First, when teachers discover the misconceptions children have of the material they have ‘covered,’ their scheme of “I covered it, they should know it” is contradicted . . . Second, during the process of investigating children’s understanding, teachers also develop the ability to question better. (Fosnot, 1989, p. 89)
Another way I typically investigate student understanding is through oral discussions. Eisner (2009) noted, “The practice of conversation is almost a lost art” (p. 329). I feel having oral discussions with students first may help them get clarity on their ideas before they are asked to get them down on paper. Although engaging in mathematical discussions are important, Geeslin (1977) felt that written explanations had advantages as presented:

1. All students can participate simultaneously.
2. Teachers can consider written examinations more carefully than verbal ones.
3. Writing tends to encourage the student to be more precise than verbal expression.
4. Both teacher and students can review the work together and discuss specific problems.
5. It may improve technical skills which seem to be declining.
6. Writing tasks also provide an opportunity for cooperative activities between mathematics and English classes. (p. 114)

I still believe students can benefit from both. We need to allow for whatever means helps our students. My bigger question was now that those advantages had been highlighted for us, why was it four years after the first article (Montague, 1973) appeared we were still seeing a lack of writing occurring in the classroom? Why was it that 30 years later I still felt like at the start of the year when we began writing in math it was the first time they had been asked to do it? Had we not learned anything? Did it have to be explicitly stated in our curriculum for teachers to implement it? Eisner (2002) also expressed
discontent with the standardized management way of doing things as he felt it neglected the artistry of teaching.

**The 1980s: Creative Exploring and Problem-Solving**

> “Writing is originating and creating a unique verbal construct that is graphically recorded.” (Emig, 1977, p. 123)

How did society want its children to be educated in mathematics in the 1980s? Did it wish to have children with the ability to regurgitate or who had developed an ability to think? If it was the latter then Choat (1980) claimed,

> A teacher will secure her intended outcomes through a mathematical education which awakens in children an interest in the relevance of mathematics to life; a desire to use their ability to ask questions, interpret their actions, and communicate their experiences. (p. 71)

To anchor onto that notion, Fosnot (1989) reported, “Of utmost importance to good teaching is the ability to probe the understanding of the learner; to be aware of developmental issues: in a sense, to be skilled in the art of ‘getting inside the student’s head’” (pp. 2-3). What better way to do that than through their written words? This went back to the whole concept of constructivism. Fosnot described constructivist teaching as “a model that emphasizes that learners need to be actively involved, to reflect on their learning and make inferences, and to experience cognitive conflict” (p. 3). It is that “cognitive conflict” that is still being sought after today. We want to disrupt others’ thinking so as to expand their views and perspectives. We want to push students’ thinking forward and have them mentally wrestle with ideas. Our vision as educators is
to expand the teaching practices and curriculum of the traditional mathematics classroom.

In the field of curriculum however that was a time when it was described as “disjunctive, contradictory and unsettling” as there was a new generation of curriculum scholars who entered the field (Marshall, Sears, Allen, Roberts, & Schubert, 2007, p. 165). It was the decade of the theory-practice debate. Schubert (1992) noted one of the single best “contributions scholars can make is to acknowledge and facilitate such inquiry by teachers . . . one of the greatest contributions teachers can make is to tell scholars more about the ways they theorize in the concreteness of their educational settings” (p. 243).

We know the curriculum of American schools has always been dynamic, as is our society. In the “back-to-the-basics” era of the 1970s and 1980s, educational professionals pushed for an expanded vision for mathematics. That vision was described by An Agenda for Action which was published by NCTM in 1980 and A Nation at Risk in 1983 by the National Commission on Excellence in Education. NCTM (an organization of professional math educators) felt it had an obligation to put forth its informed point of view on the direction math education should take in the 1980s. Their recommendations presented both “realism and responsibility . . . realistic in their attention to hard data” (NCTM, 1980, p. i). Those primarily came from a series of studies funded by the National Science Foundation and from mathematics assessments conducted by NAEP as discussed earlier. NCTM felt an obligation not only to the profession but also the public.

2 The National Commission on Excellence in Education was created by Secretary of Education T. H. Bell. They were to examine the current quality of education and construct a report for the Nation. “The Commission was created as a result of the Secretary’s concern about ‘the widespread public perception that something is seriously remiss in our educational system’ (http://www.ed.gov/pubs/NatAtRisk/intro.html). The call was for commitment to high quality schools. Recommendations were made in the following areas: content, expectations, time, and teaching.
They conducted a thorough survey to obtain the opinions of many sectors of society. The project was called Priorities in School Mathematics (PRISM). In order to build upon those recommendations they felt the need to acquire the public’s opinion since the recommendations were geared toward the direction educational programs should take in the next decade. In that “agenda for action” the recommendations were as follows (NCTM, 1980, p. 1):

The National Council of Teachers of Mathematics recommended that-

1. problem-solving be the focus of school mathematics in the 1980’s;
2. basic skills in mathematics be defined to encompass more than computational facility;
3. mathematics programs take full advantage of the power of calculators and computers at all grade levels;
4. stringent standards of both effectiveness and efficiency be applied to the teaching of mathematics;
5. the success of mathematics programs and student learning be evaluated by a wider range of measures than conventional testing;
6. more mathematics study be required for all students and a flexible curriculum with a greater range of options be designed to accommodate the diverse needs of the student population;
7. mathematics teachers demand of themselves and their colleagues a high level of professionalism;
8. public support for mathematics instruction be raised to a level commensurate with the importance of mathematical understanding to individuals and society.

That was a monumental document for mathematics education as it laid the foundation for the future. The entire rest of the short, 29-page book then took each of the above recommendations and laid out subcategories and main points for each. Under recommendation #1, a focus on problem-solving which became a theme in the 1980s, they stated, “Performance in problem solving will measure the effectiveness of our personal and national possession of mathematical competence” (NCTM, 1980, p. 2). As pointed out later, the articles from this decade not only focused on problem-solving but also student thought processes, creativity, and technology, ironically not mentioning standardized tests. Realizing that No Child Left Behind (NCLB) had not been put into place yet, it was still very surreal to read about curriculum and instruction with no mention of high-stakes testing . . . a joy, I must say!

In order to develop such a mathematically competent student, there was a belief that teaching needed to involve more than just the basics. Under recommendation #2 NCTM (1980) opined a person who could not “analyze real-life situations to the point of recognizing what computations must be made to solve real-life problems has not entered the mainstream of functional citizenship . . . where the criterion is the productive applicability of the learned technique to real-life problems” (p. 6). So again we went back to the level of understanding desired versus the regurgitation of formulas and

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3 In 2001, No Child Left Behind (NCLB) was unveiled by President George W. Bush and is still very much an integral piece of education today. The emphasis was on increased accountability in schools across the U.S.
concepts. There was a realization as well that the skills from one era would not necessarily be adequate in another, especially as society continued to change and advances with technology were made. “Teachers should provide ample opportunities for students to learn communication skills in mathematics. They should systematically guide students to read mathematics and to talk about it with clarity” (NCTM, 1980, p. 8).

Talking about something intelligently and with clarity would require understanding. Teachers in this decade learned plenty about student understanding or the lack thereof once they got their students writing, as we will come to see.

Under recommendation #4, there was a realization that a restructuring of class time needed to transpire if the focus was going to be on problem-solving. “Priority in classroom time should be devoted to involving students in meaningful problem-solving activities. Explanations, practice, and directive teaching are important but should not diminish the time necessary to achieve this priority” (NCTM, 1980, p. 11). Currently, with NCLB this does not take precedence often enough anymore. There was also insight into the changes that needed to take place with regards to assessment. We would not be able to just give the same old multiple choice or computational type problems. NCTM (1980) asserted, “The evaluation of problem-solving performance will demand new approaches to measuring . . . will demand innovative techniques” (p. 13).

NCTM was not the only group at the time with recommendations for the new vision to come to fruition. Janet Emig (1977) of Rutgers argued for writing across the curriculum as well. She stated, “a unique form of feedback, as well as reinforcement, exists with writing because information from the process is immediately and visibly
available as that portion of the product already written” (p. 125). This would help those who were visual learners as well. In the absence of writing, how could we ask them to broaden or develop their ideas without seeing them? Fulwiler (1986) also argued that students need to have faith and patience when starting out and they will come to see where it can take them. “I begin writing with a more or less clear direction in mind—in my head—and always discover that the act of writing takes me places I never imagined. . . I’ve learned to trust the process” (Fulwiler, 1986, pp. 22-23). He felt teachers needed to teach their students to trust the process too. That goes back to the study Geeslin (1977) did which was discussed previously. His complaint was that students could not articulate a complete mathematical idea. Again, this needs to be expected in the beginning. As educators who are really just starting to implement this in their classrooms, I feel they need to set realistic expectations. They need to encourage the students and note progress rather than complain and voice what they cannot do.

Another big trend that appeared to be happening was the number of writing workshops taking place and more interesting was the number of math teachers in attendance. In every article I read from this decade, there was some mention of the teacher(s) becoming interested after attending a state writing project. I found this intriguing as nowadays when my fellow colleagues get math related conference material they stick it in my mailbox. What if that is what the math teachers from this decade did when they received information for these writing workshops? One reason for all those workshops popping up may have been related to what was found in a language arts journal from that time. Evans (1984) noted, “Since the seventies, there has been an
increased awareness of the need to improve the writing skills of American students” (p. 828). So I am sure there was a big push from administration for teachers to attend.

The tone of the 1980s seemed to be nicely summed up when Johnson (1983) wrote, “Writing is a device that can greatly aid in the problem-solving process and stimulate creative thought by the student. Teachers of mathematics need to see that students make use of this little-used but valuable tool in their classes” (p. 119). One way teachers did this was through journal writing. After she attended her state writing project and began implementing writing into her high school math class, Watson immediately noticed a new found level of excitement in her students. They felt their voices were heard and their teacher actually cared as she took the time to read and comment on each and every journal. In addition, both she and her students noticed an increase in their math grades. So what began on a trial basis from having attended a writing project was continued as she saw the benefits and decided she would find the time to implement it. She utilized open-ended prompts such as “This is how to . . . , The problem I am having with . . . , My feelings about . . . ” as well as gave students the option to write about whatever they chose at times (Watson, 1980, p. 519).

Other ways teachers were incorporating writing into mathematics besides journals were: essay questions on tests, rewriting story problems and/or writing their own story problems, rewriting a passage or page in a math textbook they found unclear, and writing a biography of a mathematician (Johnson, 1983). “Writing such a paper (biography of a mathematician) also gives a historical perspective to mathematics and helps students see how progress in other disciplines is linked with progress in mathematics” (p. 118). All of
the above mentioned ways were believed to help students retain information and not just memorize a process or formula for a test.

As clearly shown, teachers got more innovative in their approaches to incorporating writing into the classroom. The mid 1980s represented an exploratory time when they not only had their students write but sought creativity too. Students created games and wrote the directions, wrote problems for students in younger grades, as well as kept daily logs. “The log should include some comments about the lessons learned, but a log may also include the writer’s feelings about the class, comical situations that occurred during the day, or moments of frustration and misunderstandings” (Shaw, 1983, p. 17).

So whereas Britton’s findings showed only 5.5% of school writing was expressive in 1975, we saw a major shift in this decade where that number would have been much higher. In addition, we have heard teachers identify their level of accountability whereas before there was a ring of complaint. “If we, as mathematics teachers, complain that on an objective test we can’t get students to express themselves clearly . . . then we have an obligation to become teachers of writing as well as teachers of mathematics” (Shaw, 1983, p. 16).

Another example of the mid 1980s being an exploratory time was when teachers began doing research studies in their own classrooms. In 1984, Evans, a fifth grade teacher, read about a high school biology teacher using writing in his classroom as a way of learning content and wanted to test if the same would hold true for her math class. She used three types of writing in her study. The first was “how to do” something which was something they wrote for a third party, not another peer or herself. That was done
because kids often presumed their peers or the teacher already knew the material and therefore an explanation seemed unnecessary. The second type of writing was definitions. She had them write their own because she found they remembered their own more easily than ones from a textbook because they made sense. In addition, they were something they could take ownership for since they created them. The last type of writing was referred to as troubleshooting. That involved students’ ability to explain their own errors. Here is a sample from one of her students (Angela): “I missed this problem because I put forty-two down on seven times seven instead of forty-nine” (Evans, 1984, p. 833). Evans felt if she got her students to “‘own’ knowledge rather than just ‘rent’ it, we could cut down on the amount of time we spend reviewing work from the previous year. That would enable us to spend more time on new topics” (p. 835). It went to show that not only were teachers exploring with different things in their classrooms but were also making conjectures and reflecting on what was happening too.

Hitting the late 1980s I started to notice teacher confidence levels (when it came to implementing writing into the classroom) on the rise as they used writing more continuously rather than on a sporadic basis. I also witnessed more sophisticated types of writing being used. Keith (1988) utilized exploratory writing with her students. “Students explore their knowledge about a topic by writing what they know about it in their own language. Then to refine their ideas further, they share reactions with other students and the teacher” (p. 714). I also got the feeling that teachers were much more concerned about mathematical content and probing for understanding than correct grammar and spelling. “My objective is to get closer to how students think, and
continually correcting spelling and grammar tends to drive students into using a smaller vocabulary and taking fewer risks” (Keith, 1988, p. 719).

So while there was not so much action in the 1970s, the 1980s appeared to have brought hope with a focus on problem-solving and the exploratory routes educators took to implement writing in the mathematics classroom. However, in 1988, the Educational Testing System released a document titled *The Mathematics Report Card: Are We Measuring Up?* The conclusions showed we were not. We still seemed to be lacking in the area of reasoning skills. Following that NCTM (1989) presented five general goals for all students:

1. that they learn to value mathematics
2. that they become confident in their ability to do mathematics
3. that they become mathematical problem solvers
4. that they learn to communicate mathematically
5. that they learn to reason mathematically. (p. 5)

More specifically, they went on and said:

For grades K-4: “Writing is a communication skill that has been used too infrequently in mathematics” (p. 28).

For grades 5-8: “Middle school students should have many opportunities to use language to communicate their mathematical ideas . . . Opportunities to explain, conjecture, and defend one’s ideas orally and in writing can stimulate deeper understandings of concepts and principles” (pp. 78-79).
With all that was happening, I think we could agree the 1980s were a time of making strides but NCTM’s *Standards* were a precursor to what was to come in the 1990s. In fact, Bell and Bell (1985) even threw out a challenge to teachers. Because writing in mathematics involves critical thinking and can become a “mode of learning,” it must become part of the daily routine in the mathematics classroom (p. 213). That notion was supported by Miller and England (1989) who claimed:

> In mathematics classes, one cannot always know what and how students were thinking as they worked a problem just by looking at their solutions. It is not possible to talk to every student every day. It is possible for every student to write every day. (p. 308)

**The 1990s: Winds of Change**

*These winds of change come from four different directions. The winds from the north and south represent the ideas of the educational theorists and the challenges of the school practitioners, while the winds from the east and west represent the concerns of parents and the perspectives of the child. From the theorists come data on teaching and the human brain; from the practitioners comes frustration with an already overcrowded curriculum; from the parents comes concern for student preparation and readiness for issues outside the classroom; and from the children comes a feeling that learning is too fractured and fragmented to apply to real-life situations.* (Fogarty & Stoehr, 1995, p. x)

The ship had clearly set sail but in what direction did the wind take it in the 1990s? There was obviously a big push from NCTM for writing in the classroom as
being central to the current vision for mathematics.\textsuperscript{4} This decade became known as the writing to learn era. “Since researchers have recognized writing as a heuristic, a large number of mathematics educators are now involved in a ‘writing-to-learn-mathematics’ movement” (Grossman et al., 1993, p. 3). Buzz words such as “transition” and “revitalize” came up repeatedly throughout this decade. And although we left the 1980s feeling better about where writing in mathematics was headed, many stakeholders began to panic when they thought about the 21\textsuperscript{st} century and therefore rallied for curricular reform. The concept of “hybridity” also popped up in regards to political and cultural tensions. Marshall et al. (2007) noted, “hybridity helped create the conditions for what we refer to as the ‘perfect storm,’ the convergence of events and beliefs that would envelope education” (p. 203).

The national goal was for the United States to take the gold in mathematics education. To do that, the National Research Council (1989) laid out a number of transitions which included:\textsuperscript{5}

1. The focus of school mathematics is shifting from a dualistic mission-minimal mathematics for the majority, advanced mathematics for a few- to a singular focus on a significant common core of mathematics for all students.

2. The teaching of mathematics is shifting from an authoritarian model based on “transmission of knowledge” to a student-centered practice featuring “stimulation of learning.”


\textsuperscript{5} For the full list of transitions, see \textit{Everybody counts: A report to the nation on the future of mathematics education} from the National Research Council, 1989, pp. 81-84.
3. Public attitudes about mathematics are shifting from indifference and hostility to recognition of the important role that mathematics plays in today’s society.

5. The teaching of mathematics is shifting from emphasis on tools for future courses to greater emphasis on topics that are relevant to students’ present and future needs.

7. The public perception of mathematics is shifting from that of a fixed body of arbitrary rules to a vigorous active science of patterns. (pp. 81-84)

In order to revitalize mathematics education, a plethora of stakeholders need influenced: teachers, parents, local businesses, the community, school boards, colleges/universities, textbook publishers, state legislators, and so forth. We were looking at a total systemic change in order to make the U.S. more competitive globally, increase expectations, challenge students, raise student achievement, and provide high-quality equitable schools. According to Walker and Soltis (2004), there are four stances teachers can take with regards to reforms: embrace it, resist it, adapt it to your own purposes, or ignore it. In regards to teachers, we were gaining support from some, while peaking curiosity from others and skepticism from many. Speaking to the use of writing in the mathematics curriculum, Kenney (1992) noted, “Over thirty talks on the topic were given at a contributed paper session [1988] of the Mathematical Association of America (MAA) . . . a session so well-attended that, at times, there was standing room only in the meeting room” (p. 17). One of the reasons, however, many were skeptical was not knowing how
to implement writing into their courses. I believe this gap in the literature may have led to the number of books and articles being published in this decade.

Starting out in higher education, many professors continued to claim they received ill-prepared students and therefore created “memory-based courses” (Gopen & Smith, 1990). However, the professors at Duke University yearned for more and expected more of their students.

We began with (1) a mathematics professor interested in investigating the possibilities and (2) a new methodology for analyzing and teaching writing, compact enough to be imported into the mathematics classroom and effective enough to make it worth the import . . . These weekly lab reports typically include data, tabulations, graphs, and 1-3 pages of expository writing. (Gopen & Smith, 1990, p. 3)

They started incorporating expository (transactional) writing into their courses as they not only wanted to improve students’ math abilities but their writing too. It was hard for students to transition from using numbers and believing in absolute truths to realizing there could be multiple interpretations once words came into play. They were being asked to think rather than let the numbers or formulas be their thoughts. Where was this type of prose present in textbooks? The answer was quite simple, it wasn’t! Too much emphasis had been put on one’s ability to compute rather than conceptualize.

The weekly lab reports students were asked to submit expected the following: Should describe the process by which you studied [whatever topic]: the decisions you made and why you made them, mistakes you made and how you corrected
them, observations you made and what you learned from them. It should also state your conclusions and the evidence supporting those conclusions. (Gopen & Smith, 1990, p. 6)

The professors found that students had difficulty with the sophisticated level of writing mathematically and knowing what to say. The methodology employed at Duke which helped with that was known as “reader expectation” (Gopen & Smith, 1990) which basically asked if the reader walked away with the same interpretation the student tried communicating to them? From engaging in such an experimental course, something that became clear was “thought and expression of thought are so inextricably intertwined for students that improving one will improve the other” (Gopen & Smith, 1990, p. 18). Engaging in such projects allowed students to see the value of writing. Their logic became clearer and more focused. The more they wrote, the more their own confidence of their math knowledge and ability was built. They came to understand the importance of being able to communicate their knowledge effectively. It was the ability to communicate that was highly emphasized by NCTM.

Mary Lindquist, president of NCTM (1992-1994), had a conversation with Portia Elliott, the editor of the 1996 Yearbook. During that conversation Portia asked Lindquist why communication was “imperative for change?” Lindquist responded:

First and foremost, Portia, if we want to fulfill the societal goals of a mathematically literate workforce, lifelong learning, opportunities for all, and an informed electorate, then we will all need to communicate mathematically. These goals are so fundamental to the work of the Council [NCTM] that learning to
communicate mathematically is one of the five overarching goals for students.

(Lindquist & Elliott, 1996, p. 1)

With a strong focus on communication, we saw writing in mathematics was becoming an iterative process between student and teacher. Gordon and Macinnis (1993) used “dialogue journals” which are different from regular journals as they added a personal dimension to learning. Dialogue journals house conversations occurring between the student and teacher in the form of writing (Atwell, 1984). There was also a change in the classroom environment that occurred. Gordon and Macinnis (1993) noted, “we as teachers began to understand what was happening in the classroom by ‘listening’ and observing in a more focused way. As a result of this watching and listening, teachers and students became a community of learners” (p. 37). In addition, they noticed a shift in the students’ attitudes toward writing. Their use of dialogue journals became a way to empower students and give them a sense of ownership for their learning. “They saw the journal as a place to take risks, to make mistakes, to sort out and to be open about problems they had in understanding mathematics” (p. 41). In addition to sharing raw emotions, it also held the teacher more accountable. “We learned that students wanted to be heard . . . that their requests must be considered and must result in instructional change or, at the very least, an explanation of why an instructional modification was not possible” (p. 40).

Problem writing was another example of the more iterative process that happened in mathematics classrooms. “A student-centered problem-writing approach to school mathematics exploits students’ natural dispositions to wonder and ask questions”
(Winograd & Higgins, 1994-1995, p. 311). One way that was carried out was through the use of a “mathematician’s circle.” A student presented his or her written problem to the class to try and solve. “After understandings are reached regarding students’ solutions, the problem writer asks peers ‘What did you like about my problem?’ and ‘How can I change the problem?’” (p. 312). Bruce, an elementary student wrote a problem about one of his favorite hobbies, biking, which was also a hot topic at school as the principal biked across the U.S. the previous summer.

If I biked across Kanses and Colorado I would go about 600 the next summer I would try to go about 700 then I would try to up it to 900 If I did that amount of rideing every 3 summers how long would it take to get a total of what it would be to go both way across the united states. Look at the map of the united states to see how far it is. (p. 313)

As you could see from his problem, he was applying math to real-life situations, ones that were of interest to him as the other kids did too. Those personal, self-created problems would resonate more with students than just calculating answers from a textbook. Winograd and Higgins noted, “Elementary students often approach school mathematics problems impulsively, attending to surface features . . . When students write and solve their own problems, it becomes more difficult to rely on just the surface features of the problem” (p. 316).

Whether students are writing their own problems or not, they need to be actively engaged. Countryman (1992) asserted:
We want students to learn to interpret unfamiliar texts, to construct convincing arguments, to understand complex systems, to develop new approaches to problems, and to negotiate the resolution of those problems in groups, to pose questions and to evaluate alternative responses to those questions. (p. 12)

In posing those lofty ideals, she claimed students need to be “agents of their own learning” (p. 14). A well cited author when it comes to writing in mathematics, she provided many examples in her book of how to accomplish that. Some strategies she has utilized are: autobiographies, math problems, formal papers, freewriting, learning logs, journals, and essays. Countryman really advocated for the use of math autobiographies at the start of the year. She believed they could really set the tone for the year. They force the teacher to reflect on his or her practice as well as provides him or her with valuable student information that would guide and inform teacher decisions. Moreover, she felt the teacher should write too. Countryman (1992) argued, “You should write with them, and share some of your writing, so that students see that you are serious enough about the usefulness of the experience to do it yourself” (p. 39).

The mid 1990s focused more on making meaningful connections and developing metacognitive skills. That was a major platform of Dewey’s as he “always championed teaching students to think for themselves” (Flinders & Thornton, 2009, p. 13). “As the curriculum becomes more tightly packed with each new mandate and trend, it’s important that our students be able to connect the pieces into meaningful wholes that can be applied to their future lives and learning” (Dusterhoff, 1995, p. 48). Dusterhoff felt writing could

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achieve that. However, the question still remained “when” by many. Just as well-written pieces should have a beginning, middle, and end, teachers can think of “when” to write in math the same way. Elliott (1996) suggested:

During the first few minutes, students can respond or reply to a review question or warm-up by answering . . . in the middle of class . . . can become an excellent tool for evaluating conceptual understanding . . . can summarize the day’s lesson or write about new concepts they have learned in the often-neglected last few minutes of a class. (p. 92)

Powell (1997) discussed the use of a multiple-entry log. “We see that writing forces students to reflect on mathematical experiences and that as students examine their written reflections, writing leads them to reflect on their ideas critically” (p. 22). I too saw that happening in the classroom as my students were journaling. They had to think back on their experiences and try to make sense of them before they could communicate their thoughts to others or just articulate a coherent thought. In addition, those multiple-entry logs required students to choose something that interested them; they then reflected on that by expressing their own thoughts and finally at a later time went back and reflected again. That process could aid in developing one’s metacognitive skills. Metacognition involves “self-regulation, students’ monitoring and orchestration of their own cognitive skills” (Campione, Brown, & Connell, 1989, p. 94).

Another use of writing was a learning log. It was and still is an underutilized powerful tool for teaching mathematics. I recently spoke with a mathematics consultant and former teacher who is still very active in the math community. She described her
purpose of learning logs as getting students to think about their thinking. She had them write down not only their own thoughts but also ideas of others. She used them daily with students and discussed how they continued to refer to them in the following years. Elliott (1996) provided a sample of what one student wrote in his log:

What I don’t understand about sections 3-1 to 3-3: Sections 3-1 to 3-3. Not a joke. What I do understand: Standard Form: $Ax + By = C$, Pt. Slope: $y - y_1 = m(x - x_1)$, Slope Int.: $y = mx + b$, Formula for Slope: $\frac{y_2 - y_1}{x_2 - x_1}$

Okay, so I know these equations, but I have no earthly idea where and when to use them. That’s my main problem. (p. 92)

Some other more unique ways she incorporated writing into her class were having the students evaluate her teaching as well as predict and respond to their test scores.

A pattern was definitely emerging after having read numerous articles. The various types of writing provided insights to teachers, influenced their instructional decisions, and allowed them to identify any misconceptions students had as well as provided more individualized assistance. There was also a realization that writing could be used for both informal and formal assessments. Lambdin (1993) stated that NCTM recommended “having students write essays about their understanding of mathematical ideas” (p. 7). Interestingly put, she listed five quotations of assessment techniques from the 1940s to 1980s from the Standards and all advocated informal assessments. So why had they not been implemented in the past? Teachers did not blame themselves but society for that. “As long as society—embodied, in particular, by standardized
tests—focused attention on lower-level mathematical skills, these skills continue to be the priorities of classroom teachers and the objects of their classroom assessment techniques” (p. 11). Moreover, Walker and Soltis (2004) elucidated, “Standardized, multiple-choice tests were introduced as part of educational reforms in the 1920’s, and they still govern much of what is taught” (p. 80). That notion was supported by Countryman (1992) who expounded, “It is important to keep in mind that what is tested is what will be taught, however, and many mathematics educators believe that real change in the mathematics classroom will come only when the tests are revised” (p. 80). We will see if the new assessments that are aligned with the Common Core State Standards which are scheduled to be implemented in the 2014-2015 school year bring about such a change. Moreover, Countryman made me think about the pressures placed upon teachers in various districts in order to get students to pass the current high-stakes tests still in place. Maxine Greene (1988) noted, “We do not know how many educators see present demands and prescriptions as obstacles to their own development, or how many find it difficult to breathe” (p. 14).

To parallel with that, there was a study conducted with second, seventh, and eleventh grade teachers from various schools that attempted to encapsulate all socioeconomic groups. The study dealt with teacher attitudes towards writing as well as the use of writing in math. The results showed a dichotomy between beliefs and practice. The majority of teachers felt writing in math was extremely beneficial to student understanding and as a form of assessment. However, the data revealed that “teachers at all grade levels used each type of writing activity less than once every two weeks, except
in the case of writing to explain solutions to problems” (Quinn & Wilson, 1997, p. 16), which was the predominant type when writing was used. They also noted that explaining solutions (transactional writing) ranked at the top as teachers saw it as being the most important type of writing with writing word problems right behind. That made sense as those are the more traditional forms of writing. The reasons Quinn and Wilson cited were poor writing skills, the class time it would take, and the time on the teacher’s part to grade students’ writing. Another reason may have been lack of teacher preparation. “Most teacher education programs do not furnish prospective teachers with extensive experience with mathematical discourse, nor do most graduate-degree programs for teachers” (Silver & Smith, 1996, p. 26).

Teachers also used different types of writing as formal assessments; it was how we assessed in most other areas, so why not math? One type of writing teachers used as a formal evaluation was portfolios. Those were typically ongoing throughout the year and afforded students the power to choose what to include in them and the opportunity to engage in peer reviews. Mayer and Hillman (1996) contended, “Through their writing, students are often able to pinpoint their difficulties. They tend to ask more precise questions in class rather than saying ‘I don’t get it’” (p. 430).

Talking about assessment, Burns (1995) believed writing could serve three purposes:

1. Reading students’ papers helps teachers evaluate how well the instructional program is supporting learning goals.
2. Students’ writing is also important for learning about individuals’ understanding and skills.

3. Writing provides an excellent vehicle for communicating with parents about what their children are learning and the progress they’re making. (pp. 29-30)

Moreover, talking about Marilyn Burns, I would be remiss if I did not spend some time talking about her as we are speaking of a well-known and respected name amongst practitioners. Her book, *Writing in Math Class: A Resource for Grades 2-8*, provided numerous examples of students’ work at various grade levels, strategies and methods she has employed over the years, and how she specifically went about implementing various types of creative and expository as well as general writing assignments. She incorporated her own personal narratives throughout as well. In addition, she always linked her practice back to recommendations that were made in the *Standards*. I find it to be a great book for teachers so they could see how to implement the recommendations being set forth, and must admit it has been on my shelf and used quite often in my classroom.

As with many new experiences, the process of incorporating writing into math teaching may involve growing pains, both for teachers and for students. My skill and comfort with making writing an integral part of math instruction have evolved over years of experience in which I’ve made many mistakes and discoveries. From trial and error, I’ve learned a great deal about how to encourage children to write, and my teaching techniques have improved. (Burns, 1995, p. 125)

She concluded her book with tips and suggestions to help students write in mathematics along with ideas for how to use students’ writing as a part of classroom instruction.
Moreover, the final section addressed questions most often asked by teachers which she compiled over the last 10 years from doing professional development with teachers, conference presentations, and from 60 teachers who have implemented writing into their math class.

At the end of the 20th century, it was reported that teaching math had not really changed for the past 100 years (Hiebert, 1999). Despite years of advocating against scientific curriculum making, mainstream curriculum texts still utilized the scientific approach. I believe this was due to political pressures. Eisner (2009) stated:

Driven by discontent with the performance of our schools, we are, once again, in the midst of educational reform, as we were in 1983 with A Nation at Risk, in 1987 with America 2000, a few years later with Goals 2000. Each of these reform efforts was intended to rationalize the practice and performance of our schools. Each was designed to work out and install a system of measurable goals and evaluation practices that would ensure that our nation would be first in science and mathematics by the year 2000, that all our children would come to school ready to learn. (p. 327)

So how did it appear things were moving in the right direction when it came to writing in mathematics? I think this was due in part to what has been highlighted in the literature. However, those appeared to be notable exceptions. Had we truly not made any progress? I did not believe that to be true. What I did believe was that progress was being made by a minority and not the majority as people were resistant to change. Hiebert (1999) noted:
Students learn what they have an opportunity to learn. In most classrooms, students have more opportunities to learn simple calculation procedures, terms, and definitions than to learn more complex procedures and why they work or to engage in mathematical processes other than calculation and memorization. (p. 8)

Did we step out of our comfort zone in the 21st century and buy into the benefits of implementing writing into mathematics? Did educators feel they had the support they needed to do this? Did standardized tests change to bring about such changes in the math classroom? Hiebert contended:

It is difficult to change the way we teach . . . change doesn’t happen automatically; it requires learning. And learning for teachers, just as for students, requires an opportunity to learn . . . Because most classroom teachers in the United States do not yet have learning opportunities of this kind, it is not surprising that promising alternatives are not widely implemented. (p. 10)

The 21st Century: Who is the Mathematically Literate Citizen?

“Futurists believe that students in the twenty-first century will need greatly enhanced communication skills, including speaking, listening, and writing, and higher-order thinking skills that will allow them to be critical and creative.”

(Fogarty & Stoehr, 1995, p. 2)

In this new century basic skills are no longer a valued competence sought after by employers as those can be handled by technology (Willoughby, 2000; Zinsser, 1988). In a conversation with William Zinsser, Countryman (1988) stated, “all the algebra we [math teachers] used to spend weeks teaching—factoring and quadratic equations—is
available today on a little piece of software that a school can buy for less than fifty dollars” (Zinsser, 1988, pp. 161-162). In addition, this century brought with it the ideal of a “mathematically literate” (NCTM, 1989, p. 5) citizen. Kersaint (2007) contended, “mathematics literacy can be characterized as the use of oral or written language to make sense of mathematics and to communicate, solve problems, and engage in discussions and decision making” (p. 89). To promote this in the classroom students should be encouraged to think and reason, communicate, and use various representations as well as make mathematical connections with what they are learning (Kersaint, 2007). This notion was supported by Kembitzky (2009) who stated, “Literacy and writing need to find a place in the mathematics classroom to promote student success. This might seem a daunting task to what is already a complicated situation” (p. 45).

One way to develop this mathematically literate citizen is to build discourse communities in the classroom. To do so students need to be encouraged to “explain, build and go beyond.” Sherin, Mendez, and Louis (2000) stated,

The explain strategy involves giving a reason for a particular idea or stating how you arrived at a specific result. Build refers to building on other students’ ideas. Go beyond involves generalizing from a particular example to a broader mathematical issue. (p. 189)

Although that was initially intended to be used for oral discourse, I believe it could be applied to written discourse as well. In fact, with the technological advancements occurring, it can go well beyond the classroom. Students can engage in blogs on the web or exchange ideas with others through email. In doing so, it could allow students to go
back and read each others’ posts, help review for assessments, and be used as a resource tool. “Thus, as we seek to improve students’ learning and help teachers make sustained changes in their practices, the development of discourse communities should become a central goal for mathematics education reform in the twenty-first century” (Sherin et al., 2000, p. 188). To that end, D. J. Whitin and Whitin (2000) claimed, “These goals are even more urgent now because of our increasingly pluralistic classrooms in which students bring a wide range of cultural and linguistic experiences” (p. 213).7

With that being said, we looked to the Principles and Standards for School Mathematics (NCTM, 2000) which built upon the Standards put out by NCTM in 1989 to lead the way. Communication was still being viewed as a crucial part of mathematics. “Students’ repertoire of tools and ways of communicating, as well as the mathematical reasoning that supports their communication, should become increasingly sophisticated. Support for students is vital” (NCTM, 2000, p. 60). Communication was one of the 10 standards laid out in the document. The communication standard stated the following (NCTM, 2000, p. 60):

Instructional programs from prekindergarten through grade 12 should enable all students to –

*organize and consolidate their mathematical thinking through communication;
*communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
*analyze and evaluate the mathematical thinking and strategies of others;

7Not only are we seeing more diverse classrooms but we are also seeing changes at other levels. NCLB (2001) highlighted increased accountability and is still very central to education today.
*use the language of mathematics to express mathematical ideas precisely.

More specifically, NCTM (2000) noted what was expected at various grade levels:

In grades 3-5, students can work on sequencing ideas and adding details, and their writing should become more elaborate . . . middle grades, they should become more explicit about basing their writing on a sense of audience and purpose . . . by the end of the high school years, students should be able to write well-constructed mathematical arguments using formal vocabulary. (p. 62).

So even though communication had its own standard, teachers still noticed a lack of conceptual understanding in their students. “This project was motivated by our observations of students’ lack of conceptual understanding of mathematics concepts. Even students receiving good grades demonstrate a lack of conceptual understanding” (Zupancic & Ishii, 2002, p. 35). In response to those observations, they developed a format called ODEAR (Organize, define, explore, answer, and reflect) to help their eighth grade students throughout the year. Zupancic and Ishii found that “using the strategy and having students write their ideas and solutions led to more classroom discussion, and helped get more students involved . . . especially noticeable with the low-achieving students” (p. 38). So were we seeing classrooms that were beginning to build discourse communities?

In a study done with fifth grade students in 2003, however, six prompts were given and the results were not as favorable. Only in two of the prompts did the students rate high in conceptual understanding (What is addition? What is subtraction?); three prompts had the highest rating in procedural understanding (What is math? What is
multiplication? What is division?); and one in limited understanding (What is a fraction?; Aspinwall & Aspinwall, 2003). So, the problem still seemed to be that the communication standard was not being taken seriously by the majority but a small minority, the same problem we saw in the 1990s. Paradoxically, some textbook companies such as the Connected Mathematics Project (CMP) and Investigations which were reform-based math programs started to appear. “Among other things, CMP emphasizes using student discourse, articulating understanding in writing, and making connections to previously acquired knowledge and real-life experiences” (Sjoberg, Slavit, & Coon, 2004, p. 491).

Some teachers even seemed to recycle back to the 1980s and implemented more creative (poetic) types of writing in their classrooms (Rubenstein & Thompson, 2002, p. 109):

Strategy is to have students write journal entries, stories, cartoons, bumper stickers, skits, raps, songs or poetry . . . for example, consider two verses for the distributive property:

3 times the quantity
2 plus 5
is 3 times 2
plus 3 times 5.

It doesn’t matter
what numbers you use,
just follow the pattern
with whatever you choose.

Whatever kind of writing teachers were using, my thoughts were they still had their students writing which was more than many others could say. The research has been done, the benefits have been written. It was time for educators to take the risk and reap the rewards. Appel et al. (2002) explicated:

Writing is another way for students to discover, organize, summarize, and communicate knowledge. Writing makes thinking processes concrete and increases retention of concepts. The act of writing gives a student access to his or her own thinking processes, enabling the construction of new understandings that are meaningful and applicable. (p. 88)

Writing is what is going to develop the mathematically literate student.

Most recently, the new Common Core State Standards were adopted by the State Board of Education in June, 2010. Ohio and 43 other states have now formally adopted these standards. The adoption was part one of a three phase adoption process which is scheduled to conclude in June of the 2014-2015 school year. It is in these new standards that mathematical understanding and procedural skills are being weighed as equally important. “One hallmark of mathematical understanding is the ability to justify, in a way appropriate to the student’s mathematical maturity, why a particular mathematical statement is true or where a mathematical rule comes from” (p. 4). The new “Standards for Mathematical Practice” seem to encapsulate the old NCTM process standards of

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8 All information from this section was retrieved from [http://www.corestandards.org/the-standards](http://www.corestandards.org/the-standards) on August 9, 2010.

9 For a complete list of all states that have adopted the Common Core State Standards, please visit [http://www.corestandards.org/in-the-states](http://www.corestandards.org/in-the-states). This information was retrieved on August 2, 2011.
problem solving, reasoning and proof, communication, representation, and connections. These eight standards include:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning. (pp. 6-8)

They each go on to nudge various aspects of communication. For example, under standard number six, it is further expounded: “Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. In the elementary grades, students give carefully formulated explanations to each other” (p. 7).

Conclusion

“A conclusion is the place where you got tired of thinking.”

-Martin H. Fischer (Willingham, 1997, p. 191)

“In the United States and in virtually every Western democracy, there is a national clash as to what students should learn and how they should learn it” (Canestrari & Marlowe, 2004, p. ix). Going back to the 1970s, “Getting Our Feet Wet” was the theme and we saw transformations both in the classroom and the field of curriculum. Due to
NAEP’s assessment at the beginning of the decade, and the not so favorable findings, we began to take steps forward. We saw the first article published that discussed students writing in mathematics. It was also brought to light that writing in math was not valued in schools. Moving to the 1980s: “Creative Exploring and Problem-Solving,” there was a vision to expand the teaching practices and curriculum of the traditional classroom. Both the *Agenda for Action* and *Nation at Risk* were published and NCTM surveyed the public to get their perception. From that, problem-solving became a focus as well as the need to develop mathematical competence in students which involved affording opportunities for communication in mathematics. That was also the time we witnessed a large number of writing workshops had occurred. Journal writing became a popular choice but teachers also explored with more creative forms of writing and began doing research studies in their own classrooms as well. Then, the *Standards* (NCTM, 1989) came out in the late 1980s which left lasting impressions.

Moving into the 1990s the theme was “Winds of Change.” There was the “writing-to-learn-mathematics” movement that focused on students making meaningful connections and developing their metacognitive skills. In addition, there was panic from many stakeholders for 21st century skills and the need for curriculum reform in order to make the United States more competitive globally, raise student achievement, and provide high-quality equitable schools. There were a large number of books/articles being published during that time as teachers’ concern was still on ‘how’ to implement writing into the classroom. A number of positive changes continued to take place. Teachers and students were becoming a community of learners and students’ attitudes
toward writing were changing as they experienced a sense of empowerment. A number of other types of writing were being utilized by teachers as well.

Finally, moving into the 21st century: “Who is the Mathematically Literate Citizen?” we see that basic skills are no longer valued. The ideal is that of a mathematically literate citizen along with a push for building discourse communities in the classrooms. Communication is viewed as a crucial part of mathematics as well as mathematical reasoning. Principles and Standards for School Mathematics (NCTM, 2000) which built upon the Standards put out by NCTM in 1989 had communication as one of the 10 standards. However, the problem at hand is that communication is still only being taken seriously by a minority and not the majority. Maybe with the recent adoption of the Common Core State Standards (2010) that continue to focus on communication, more will see a need to learn how to implement that standard as the new assessments coming in 2014 will be reflective of a more balanced emphasis between mathematical understandings and procedural skills.

Many positivists still try to mold students into learning mathematics through rigid rules and formulas in the predominant standardized management way of teaching. Klein (2005) contended, “The curriculum students experience in the classroom has been seriously out of balance for many years. This phenomenon is a significant result of the student’s role being severely diminished as the drive for high standards becomes more dominant” (p. 52). Consequently when a student does not conform to that because he or she has their own ideas and ways of getting the solution, utilizing the more constructivist approach, we lead them to believe math is not for them or they are not any good at it. A
child’s intuitive way of thinking needs to be welcomed and encouraged by educators, not squelched. To support this, Greene (1988) purported, “children who have been provoked to reach beyond themselves, to wonder, to imagine, to pose their own questions are the ones most likely to learn to learn” (p. 14).

“We live in a time of extraordinary and accelerating change. New knowledge, tools, and ways of doing and communicating mathematics continue to emerge and evolve” (NCTM, 2000, p. 4). Educators struggled and continue to struggle almost 40 years later with questions of “how” and “when” to use writing in their mathematics classrooms even after numerous books and articles have been published to aid them in this process. Eisner (2002) noted, “complexity is difficult to sell politically. Simple solutions are more appealing” (p. 6). However, no matter what type of writing was being utilized, they all could inform instructional decisions. Journals were the predominant choice and a nice entry into writing in mathematics as they could be viewed as a non-threatening dialogue tool between teacher and student.

My vision for writing in the mathematics classroom involves the inclusion of student voice and students being active participants in their learning. We need to continue to push students’ thinking forward and allow for creativity. Students need to be pressed to mentally wrestle with ideas. It’s not so much the type of writing they are doing that matters, but that we begin to change because “without thinking teachers, we do not have thinking schools. Without thinking schools, we do not have thinking students or future citizens who can think” (Page, 2004, p. 219). We need to invite change and welcome it. Mewborn and Cross (2007) claimed,
Beliefs that have been held for a long time are more resistant to change. Thus, teachers need sustained and consistent support if they are going to undertake a serious examination of their beliefs about mathematics and learning and the classroom practices that result from these beliefs. (p. 267)

In the end, the problem was not that teachers were not incorporating writing into their math class and reaping the benefits; the problem was that it was still the minority and not the majority. “Children who think critically push for meaning regularly in their daily lives. They take risks in their discussions, reading, and writing” (Akhavan, 2004, p. 20). To that end, Amos (2007) opined, “Are your students thinking, talking, clarifying, and validating ideas and a variety of solutions? If not, begin to invite risk taking” (p. 73).

Are you a mathematically literate citizen???
CHAPTER III

METHODOLOGY

Introduction

College students reported losing interest in mathematics around third grade (Rose, 1989). While conducting a parent workshop, Rose shared comments from a mother who observed “while her first grader loved math, her fourth grader was losing interest” (p. 234). Entering fifth grade, students already had established beliefs about mathematics (Aspinwall & Aspinwall, 2003). As discussed in chapter 2, research was conducted on attitudes toward writing in mathematics; however, it was limited and focused mainly on middle school through college level students. There was a gap in the literature on attitudes towards writing in mathematics, especially at the elementary level. Therefore, this study looked to add to that body of research and discover what gifted students’ attitudes were towards various types of writing in the math classroom.

The purpose of this study was to investigate and describe mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in a classroom that utilized writing in mathematics, and how it impacted their learning. I was interested in specifically drawing out students’ voices as well as their experiences to better understand those attitudes. Such findings could influence future curricular decision-making by mathematics teachers in the elementary classroom. At the very least teachers, along with students’ parents, could become more aware of the attitudes these elementary students had toward transactional/expressive and poetic writing.
The method used to explore the problem was a qualitative case study approach. I utilized a focus group, interviews, documents, and audio/visual materials. As the teacher and researcher for the study, I was both the facilitator for the focus group and the interviewer for the individual interviews with parents and the principals. In this chapter, I describe the research design including sample, data collection, analytic process, and an explanation of trustworthiness and validity. First, however, I discuss where my study was situated paradigmatically, and explain my relationship to the study and how that shaped who I was as a researcher.

**Situating Myself as a Researcher**

Born into the stage of “blurred genres” (1970-1986) which Denzin and Lincoln (1994) characterized as the third stage in the history of qualitative research, it was a time when the great paradigm war was raging between quantitative and qualitative researchers (p. 9). However, it was also a time that “qualitative work began to develop more stature as a legitimate form of educational research” (Hatch, 2002, p. 4). It was during that period that various paradigms came to the forefront and various qualitative journals moved into position. “The naturalistic, postpositivist, and constructionist paradigms gained power in this period, especially in education in the works of Harry Wolcott, Egon Guba, Yvonna Lincoln, Robert Stake, and Elliot Eisner” (Denzin & Lincoln, 1994, p. 9).

While all of that was evolving, I was in school where the positivist view dominated. Positivists believe an objective reality exists and that hypotheses can be empirically verified. In this paradigm the researcher and those being researched act independent of one another (Hatch, 2002). That view was ingrained in my own schooling
and prevalent throughout my own teacher training; yet, I personally came to realize that may not be the way I think, believe, or see things. When I sat and thought about my own ontological, epistemological, and methodological beliefs, I self-identified as a social constructivist.

Social constructivism concerns both an individual construction and a social interaction; it is the language that helps the learner build his or her knowledge through conversations with others (Ernest, 1996). An individual uses this language from conversations to continually examine his or her beliefs and then chooses to accept or reject this knowledge gained through the conversations with others (Ernest, 1996). As knowledge is gained and accepted, the learner is rebuilding his or her knowledge.

It is in this paradigm that one believes multiple realities exist. These multiple realities are “unique because they are constructed by individuals who experience the world from their own vantage points” (Hatch, 2002, p. 15). We each bring our own lens, preconceptions, and assumptions which are socially constructed by previous experiences.

A constructivist believes these realities may change as one becomes more informed and sophisticated (Guba & Lincoln, 1994). Applied to my teaching and the learning that went on in my fifth grade classroom, I recognized the prior knowledge my students brought with them. That prior knowledge was going to shape newly constructed knowledge, and would change as they continued to move through the educational system. Their knowledge would become more in-depth and sophisticated as they grew to be more informed. Together, we looked at things as not just having one way of getting there, not
one absolute truth. That was due to the fact that interpretations came into play and each of us had our own interpretations for the way we saw things.

I believe whenever individual perspectives are looked at that multiple realities are going to exist. Stake (1995) asserted, “Thick description, experiential understanding, and multiple realities are expected in qualitative case studies” (p. 43). In addition, “inquiry is value-bound” (Lincoln & Guba, 1985, p. 37, Table 1.1). Lincoln and Guba (2000) discussed how values could “feed into the inquiry process: choice of the problem, choice of theoretical framework, choice of major data-gathering and data-analytic methods, choice of context, treatment of values already resident within the context, and choice of format(s) for presenting findings” (p. 169).

The second core part of the constructivist paradigm is the epistemological belief that “the investigator and the object of investigation are assumed to be interactively linked so that the ‘findings’ are literally created as the investigation proceeds” (Guba & Lincoln, 1994, p. 111). In other words, it is an iterative process between the researcher and participants; a mutual engagement in the co-construction of knowledge. The knower is not distinct from the known (Lincoln & Guba, 1985) as in the positivist paradigm. Traveling back to the classroom to apply this belief, the teacher would not just impart his or her knowledge on the student but rather construct it together. Constructivists want participants to be active in the process of developing questions and channeling findings to a larger population (Lincoln & Guba, 2000). Continuing to look back at my own form of inquiry, knowledge was co-constructed through the use of interviews and the gathering of stories from the students.
The third core part of the constructivist paradigm is the methodological belief that is both hermeneutical and dialectical (Lincoln & Guba, 2000, p. 3, Table 6.1). In other words, the researcher and participant listen to and interpret what the other is saying to arrive at some sort of shared meaning. This goes back to knowledge being co-constructed by both the researcher and participant. This hermeneutic-dialectic approach is the best way to construct meaning as it is interpretive and promotes persuasion of arguments in order to construct meaning (Guba & Lincoln, 1989). This form of knowledge produced by going back and forth and refining helped create credibility as well (Lincoln & Guba, 1985). For my inquiry, that process took place with member checks during the interviews and reconstruction of stories told by students and their lived experiences in relation to their math perceptions.

**Researcher as Instrument**

I am an educational, classroom-based researcher who works out of a constructivist framework and views reality as being multiple and socially constructed by those involved and influenced by culture. I am a mathematics educator who knows students do not learn by being passive receptors of knowledge that is imparted on them only to be regurgitated out at a later date, described by Freire (1985) as the “banking system of education.” I believe students learn from actively engaging and participating in meaningful and relevant activities.

Writing in mathematics has not always had a place in my classroom as I, like many other practitioners, felt writing was reserved for language arts class. The only writing my students did was transactional as they had to be able to explain their answers
on the high-stakes state tests. Teaching in a field dominated by positivist views, writing in mathematics was not a high priority of mine.

Coming to see that students were able to pass tests by computing the correct answer but did not necessarily know why they did the performed steps or how to apply the same concepts elsewhere concerned me. To that end, I began encouraging students to use mathematical words in their everyday vocabulary. I started reading the literature and saw how other educators were using writing in mathematics in a variety of ways to foster student conceptual understanding. I began asking my students to write in math and found they had no prior experience with writing in mathematics. My students questioned why we were going to be writing in math as did my colleagues. One responded, “What do you mean writing in math?” Currently, writing very much has a place in my classroom and has for the past two years.

Research Design and Methodology

The purpose of this study was to understand mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in mathematics for a group of fifth grade students at Baylor Elementary (pseudonym). In this study, attitudes were defined as “positive or negative feelings of moderate intensity and reasonable stability” (McLeod, 1992, p. 581); a personal preference for or dislike of writing in mathematics. Therefore my research questions were: What are mathematically gifted students’ attitudes towards transactional/expressive and poetic writing in mathematics? How do transactional/expressive and poetic writing in mathematics impact student learning? To investigate those questions I used a case study approach.
Yin (1989) opined, “The first and most important condition for differentiating among the various research strategies is to identify the type of research questions being asked” (p. 19). Though how and why questions are common to the case study approach, Yin (1984) acknowledged that what questions could pertain to case studies as well. This approach was well-suited for many reasons which I describe. Creswell (2007) discussed how, in choosing an approach, a researcher should start with the outcome. Moreover, he listed four other factors to consider: the audience, background, scholarly literature, and personal approach. In answering those questions I felt as though this was the best fit. In the literature the majority of the studies focused on the following as discussed in chapter 2: how writing could be an effective tool in math class, how to implement various types of writing into your math class, and the benefits to teachers as it could guide future planning, assess student learning, and aid in developing metacognitive skills. Therefore I hoped to fill the gap in the literature where there was a lack of studies on mathematically gifted students’ attitudes toward transactional/expression and poetic writing in the mathematics classroom.

As stated previously, interviews were conducted with the students, and various other sources of information including documents, focus groups, and audio/visual materials were gathered as well. A case study requires “extensive material from multiple sources of information to provide an in-depth picture of the case” (Creswell, 2007, p. 96). In the constructivist paradigm this study assumed an emergent design and was context dependent (Creswell, 2007). In addition, Creswell defined a case study as one in which “the investigator explores a bounded system or multiple bounded systems over time,
through detailed, in-depth data collection involving multiple sources of information, and reports a case description and case-based themes” (p. 73).

Methods

Setting

This case study, bound by time (one academic school year) and setting (Baylor Elementary, fifth grade gifted students) occurred at a small rural district in northeast Ohio. The population at Baylor Elementary was approximately 590 students of which 95% were Caucasian, 3.3% were Multi-Racial, and 30% were economically disadvantaged according to the 2009-2010 school year report card (Ohio Department of Education, 2011). The site was chosen based on the fact that I wanted to represent a rural school district which seemed to be underrepresented in the literature as well as that particular school because of close proximity and therefore was more feasible to myself, the researcher.

Participants

Participant selection took place from April to August, prior to the academic school year of the study. Participants in the study included eight 5th grade students, Baylor’s current and former principals, the mathematics teacher, and parent(s) of the children. The eight participants included one female and seven male fifth grade students. All students were identified as mathematically gifted by the state of Ohio procedures for identifying children who are gifted in mathematics; that is, a score of 95 or above on the mathematics section of the Iowa Test of Basic Skills.
My case study utilized purposeful sampling, which according to Patton (1990) was selected for “information-rich cases for in-depth study” (p. 182). The purposive sampling was based on the criteria that students had to be identified as mathematically gifted (criterion sampling). Since the number of students who were identified was small, I included all eight of them.

To solicit participants, access must first be granted by the gatekeeper which in my case was the principal. Stake (1995) asserted, “In requests to district, school, and teachers, the nature of the case study, the sponsor, the activity intended, the primary issues, the time span, and burden to the parties should be made known” (p. 57). In order to do that I acquired access early on by allowing enough time to make initial contacts and set up meetings. “Convincing individuals to participate in the study, building trust and credibility at the field site, and getting people from a site to respond are all important access challenges” (Creswell, 2007, pp. 138-139). My process proceeded in several steps:

1. To begin, I contacted the principal and requested a meeting in the spring prior to the academic school year I began the study.

2. At that meeting to obtain initial access, I discussed the nature of my study, what I planned to do in my classroom, the duration of the study, and who would be involved. Following that, I contacted both the gifted teacher and the fourth grade math teacher.

3. Then I set up a meeting involving myself and those two teachers. Again, I explained to them the nature of my study and asked for their participation in the selection process. The reason I requested both the fourth grade teacher and the gifted teacher was
to seek information from the fourth grade teacher who currently had the students who
would be in fifth grade the following year. I requested information in regards to the
achievement levels of those fourth graders she had in order to see if there were students
who fit the criteria of my sampling. Having the gifted teacher there as well confirmed
their achievement level and identification based on test scores she had for them.

4. Next, I gathered parental contact information for those potential students from
the main office at the elementary school.

5. Using that information I contacted all eight parents at the end of summer,
introduced myself, described the study, and stated why their child was chosen to
participate. I let them know their names would be kept confidential as pseudonyms
would be used, and asked if they would be willing to attend an informational meeting
with their child to answer any questions they had and seek access and willingness from
them and their child to participate.

6. At the start of the school year, I met with the new building principal and again I
discussed the nature of my study, what I planned to do in my classroom, the duration of
the study, and who would be involved.

Once human subjects’ approval was obtained and participants attended one of the
informational meetings and agreed to participate, they were asked to sign consent forms
with the knowledge that they would be allowed to discontinue participation at any time.
The consent forms (see Appendices A, B, and C) included participation consent and
consent to audio-record the interview and focus group. It was further explained that there
was no risk to them beyond the risks associated with everyday life. Finally, they were
again informed that their anonymity and that of the data collected would be protected as pseudonyms would be used. Parents were provided a copy of the signed consent forms for their records as well as directions for their journals (see Appendix D). Both the current and former principals were also provided with copies of their signed consent forms at the time of their interview. During the informational meetings, I also met with the eight students separately (see Appendix E) to discuss the study while their parents were reading over the consent forms.

**Data Collection**

I conducted a pilot study a year prior with five girls and four boys from my fifth grade classroom. Interviews were conducted and journal samples and documents (creative writing—student authored books) were collected and read to see if they would serve as appropriate artifacts for this study. Testing out those interview questions aided in refining my interview protocol for this study. Yin (2003) recommended the use of a pilot test and discussed how a pilot could be chosen on the basis of convenience, access, and geographic proximity.

Data collection for this study took place during one academic school year (September to May). A number of reasons were behind why I chose to start with a focus group with the eight students. First, I believe in beginning with a focus group students might be more comfortable as well as their parents rather than jumping into one-on-one interviews. Focus groups are advantageous; participants may offer more information than would have been provided in an individual interview (Stewart & Shamdasani, 1990). Second, the focus group is still an interview, not simply a discussion (Patton, 1987). As
Patton asserted, “Participants get to hear each other’s responses and to make additional comments beyond their own original responses as they hear what other people have to say” (p. 135). Again, this could help stimulate conversation and responses as hearing what someone else says may trigger an experience or story of their own. In addition, Fontana and Frey (1994) discussed that the purpose of a focus group is exploratory. Utilizing this data collection method allowed me to listen for common experiences and/or contradictions that were then followed up during the individual interviews.

The focus group took place at the end of September in an empty classroom after school to avoid distractions. It lasted approximately an hour, was audio-recorded, and later transcribed. Desks were arranged in a circle to provide equal opportunity to see everyone and make the setting feel more comfortable. Light snacks and a drink were provided to students who may have been hungry after being in school all day or used to having a snack right after school. The students were reminded that they could stop at any time.

I served as the moderator of the group and facilitated the conversation. I brought an assistant who helped with the fieldnotes. As Patton (1987) opined, “It can be difficult to take notes during a focus group interview while also facilitating the discussion, so many groups are conducted by pairs of interviewers with one person focusing on taking notes and the other focusing on facilitation” (p. 136). The assistant was a third grade mathematics and language arts teacher with more than 10 years of experience. We each introduced ourselves to the students, again provided a brief explanation of our purpose as well as used pseudonyms in our writing to assure confidentiality. In addition, we asked students to keep each others’ responses confidential and to be respectful of one another too. Students chose
their pseudonyms before we started. We then asked the students to draw what they thought a math student looked like which got them to feel at ease. Some discussion prompts included: Tell me something you like about math; Tell me something you dislike about math; What is the first word you think of when I say “writing in math class”? and Why do you think that came to mind? Questions (see Appendix F) were limited as Krueger and Casey (2000) recommended 6–8 when conducting focus groups with children. In facilitating the group, I used wait time and nodding to encourage students to continue speaking or probed to clarify and get students to elaborate more on what they said. Understanding that children communicate in various ways, they were given the option at times to draw a picture or tell a story (Krueger & Casey, 2000). At the end of the focus group I thanked the students for participating and discussed the journaling I had asked them to do. In addition, I asked if there was anything else they wanted to add or if they had any questions.

In addition to this focus group, individual follow-up interviews with the same students, their parent(s), and the current and former principals were conducted based on data gathered from the first interview.

*Student interviews were supposed to occur in November and January. Due to the challenge of securing an outside interviewer, the second round of interviews occurred mid-February and then the last three in early March as those students were absent when the interviewer came in February.
Parent interviews occurred in September and January with the exception of one of the parents. Haley’s first interview occurred the first of October as she was sick and had to reschedule.

Principal interviews occurred in December. Due to the dual role of teacher/researcher and perceived power relations between students and their teacher, an outside person conducted the individual student interviews. This outside interviewer was obtained through the instructor of an advanced qualitative research class in order to reach a doctoral student enrolled in the course.

All interviews were audio-recorded and later transcribed. At the start of each interview, I (or the outside interviewer) briefly chatted with the participant to make them feel at ease, indicated our role as researcher (not acting as the teacher at the time) or interviewer, and repeated the purpose of the research as well as thanked them for their participation. We also reminded them that their confidentiality was assured and they could withdraw from the process at any time. Student interviews lasted anywhere between 8–25 minutes and occurred in an unoccupied classroom free from distractions. For the parent interviews, I initially made contact with them by phone and again briefly reminded them of the nature of the study and then set up the actual interview. Parent interviews lasted anywhere between 18–57 minutes as some parents had lots to share whereas others did not elaborate much even after being probed further. For the principal interviews, I made face-to-face contact with each of them and followed in the same manner as the parents. The principal interviews lasted between 27–41 minutes.
All interviews were conducted using Rubin and Rubin’s “Responsive Interview” model in which the “researcher and the interviewee develop a relationship within a conversational partnership that influences the interviewing process” (2005, p. 79). One of the principle uses of case study, as Stake (1995) asserted, is “to obtain the descriptions and interpretations of others” (p. 64). Hence, the interview drives the existence of multiple realities. In addition Yin (2003) stated, “The interviews will appear to be guided conversations rather than structured queries . . . are of an open-ended nature, in which you can ask key respondents about the facts of a matter as well as their opinions about events” (pp. 89-90). Therefore, this model was chosen because it is all about conversations, relationships, and constructing meanings through conversations, all of which I set out to accomplish. In addition, I wanted to elicit specific concrete examples and experiences which this model represents as well.

Using interviews after the focus group allowed students to feel more at ease as rapport had been established and students had some time to build student/teacher relationships in the classroom. Responsive interviews “are more focused, more in-depth, and more detailed than ordinary conversations, and also less balanced, because one person does most of the questioning and the other does most of the answering” (Rubin & Rubin, 2005, p. 108). The interviews all focused on student attitudes toward transactional/expressive and poetic writing in the math classroom. The semi-structured interviews were guided by the following discussion prompts (see Appendices G, H, and I) for the various participants:
Students: What was your experience in writing the Math Pledges? How would you describe your experience of writing in math to a student at another school? Describe your attitude when you are asked to write in math class?

Parents: What do you think of when I say “writing in math class”? Describe your attitude towards writing in math class. What do you think your child’s attitude towards writing in math class is? What experiences do you have with writing in mathematics?

Principal: What attitudes towards writing in math do you think students in your building have? Describe your attitude towards writing in math. Has it always been positive (negative)?

To clarify meaning and indicate understanding, follow-up questions and probes were also used. Student questions also reflected information that was gained through the initial focus group. At the conclusion of their participation in the study (focus group and individual interviews), each participant was given a book and thank you note as compensation for their time.

In regards to the times chosen for the interviews, I thought it would behoove me to start with the parent individual interviews at the beginning of the year to build trust and rapport as I would be dealing with their child over a prolonged period of time. That provided an opportunity to discuss the journaling I asked them to do as well. Then the second interview with them at the end of the first semester allowed me to ask questions that pertained to what they wrote in their journals as well as statements they made in the first interview. In regards to the principal interviews, there was really no rhyme or reason
for the time chosen except that it allowed me time to transcribe the focus group and first parent interviews. So that would be considered researcher feasibility.

Documents were collected as secondary data. Stake (1995) suggested, “Quite often, documents serve as substitutes for records of activity that the researcher could not observe directly” (p. 68). Those mainly consisted of journals from the students, their parents, and the teacher, but also included student poetic (creative) writing samples. According to Yin (2003), the strengths of documents are that they are “stable, unobtrusive, exact and have broad coverage” (p. 86) as well as their most important use being “to corroborate and augment evidence from other sources” (p. 87).

In regards to the student journals, they began at the start of the school year and I continued to collect them until their winter break; although, a final journal project was collected at the end of the year which allowed for students to express their thoughts on the journals they kept (see Appendix J) as well as how it impacted their learning. Journals were a regular part of their math class; it did not require them to complete additional work. Students were aware that journals would be collected in October and December which was specifically chosen to allow myself time to read through them before each of their interviews. The final journal projects were collected in May.

Creswell (2007) asked, “What instructions should be given to individuals prior to writing their journals?” (p. 141). Students were given some flexibility with their journals as I realized they also had homework, studying, and possibly sports/family commitments that would come first. I only asked them to make two journal entries a week. Some entries were topic specific to look at examples of their transactional (expository) writing
and some were “choice” (transactional/expressive). In a “choice” journal, students could write about any topic they chose as long as there was a mathematical connection (baking a cake at home with a parent). Both types of entries were pilot tested and students were pleased with the variety as some preferred “choice” while others favored having a specific topic provided to them. An example of a topic was: Explain the difference between an expression and an equation and provide examples (see Appendix K for sample prompts).

In regards to the journals their parents wrote, I also realized they may have had family commitments, children’s activities to attend, and home and/or work related tasks that would come first. So that it was not a burden, they were only asked to keep their journal for the first semester, though I put out a final call at the end of the year to see if there were any additional insights or experiences they had to offer from the second semester. Therefore, I asked them to make at least one entry every two weeks but surely let them know they could do it more often. As cues to complete those, I sent out email reminders bi-weekly. I also understood that not everyone may be comfortable with journaling so I tried appealing to all and what they were most comfortable doing. They had the option to write their entries, email them to me, or even record them on a tape recorder that I would have provided if they chosen that option. All parents chose to email their entries. I gave them many options while I still would have gathered the information I was looking for, and that was observations of their child’s experiences with writing in mathematics. I sought any comments their child may have made during math homework that included writing, experiences they discussed relating to writing in math class,
attitudes and behaviors when it came to completing math assignments at home that involved writing, or anything else the parent deemed would have highlighted the same sort of information. It was good to be able to compare those to the students’ journals which provided a means for some triangulation to occur as well. Their journals were collected bi-weekly and guided their second round interview questions.

Yin (2003) stated the three principles of data collection are as such: “using multiple, not just single, sources of evidence; creating a case study database; and maintaining a chain of evidence” (p. 85). I have just focused on the first of these and discuss the latter two in subsequent sections. In hopes to communicate the depth and multiple forms of data, I created both a data collection matrix that summarizes my information by source, type, and frequency (see Appendix L) as well as a data collection timeline to better understand the scope of the study (see Appendix M). This will allow one to infer the study’s complexity.

**Data Management**

In order to store and retrieve all of the raw data from interview transcriptions, documents, and emails, I needed to have a systematic plan rather than become overwhelmed by it all. That plan also allowed others to trace my steps in order to arrive at similar perspectives, thus making my data transparent. Stake (1995) set out an idea for using a matrix to keep track of tasks needing accomplished which also illustrates the progress of a study. He stated some use a “matrix of tasks to accomplish, modifiable so that tasks can be added and deleted. Some keep track of time spent on different tasks, issues, and data sources so that the distribution is not badly skewed” (p. 55). Therefore, I utilized my data collection matrix for data management as well. In spacing the data sources
out, I allowed myself an appropriate amount of time for each versus putting all of my time into just the interviews per se. I also used it as a dual checklist and placed a check on the left when that data source was obtained, and once the data had been transcribed and/or had an analytic memo written I placed a check on the right. In addition, I fell back on another of Yin’s (2003) three principles of data collection which was to create a case study database. In doing so he talked about four components: case study notes, case study documents, tabular materials, and narratives. It is the first two to which I paid attention in managing my own data. For my case study notes, I had transcriptions of both my interviews and focus group. Those transcriptions were placed as hard copies in file folders which also served as back-ups to the audio-recordings which made them available for later access. They were also available as files on my computer.

My documents were student, parent, and teacher journals, as well as student poetic writing samples. Yin (2003) asserted, “In those instances when the documents have been relevant to specific interviews, one additional cross-reference is to have the interview notes cite the document” (p. 103). Therefore, I put those documents in the same file folder with the specific interviews for easy retrieval. However, I placed each student’s transcriptions with his or her parent’s transcriptions. In addition, each child’s folder included their journal entries and those of their parents’ along with their work samples. The principals’ transcriptions had their own folder. Each of the eight students had their own file which was housed in a locked file cabinet in my office. Each student file contained the following:

- Copy of the transcript from the focus group
- Their individual interviews
- Their parent interviews
- Their journals and final journal projects
- Their parent journals
- Their poetic work samples
- Their report cards and test results

That folder then became the starting point for the within-case analysis.

Data Analysis

Beginning with the focus group transcript, I addressed each of the questions Stevens (1996, p. 172) posited when analyzing focus group data as follows:

How closely did the group adhere to the issues presented for discussion? / Why, how, and when were related issues brought up?

All students were very respectful not to talk over someone else. I felt they were honest for the most part but at times I also felt they just agreed with what the first person said. For example, when they were asked to tell me something they liked about math, Bobbie responded first by saying the review games we played the day before a test. Five others then patterned after his answer and gave the same response.

I typically initiated all questions though students were free to have done so as well. A final question was asked by Bobbie at the end – What’s writing in math supposed to help you do? I asked for others to respond first and then I responded.

Overall, everyone stayed on topic or additional related questions were posed to draw out further information.
What statements seemed to evoke conflict?

There was not any conflict during the focus group. All students either agreed with one another or respectfully stated their own responses.

What were the contradictions in the discussion?

Something I found interesting was that although Cam didn’t really seem to like writing, he was able to see that writing helped him “a little bit.” He talked about how he could look back at things he wrote if he was confused about something as well as how writing in his journal helped him remember stuff. He was able to give me an example of a time that it was useful. He had written about inequalities in his journal and then found he needed to refer back to that entry to help him remember what they were when he was trying to solve some problems.

Another contradiction occurred with Bobbie. He stated he liked “choice” journal entries better than “topics” because he liked to be able to write about what he wanted. He said when he’s given a topic he really didn’t know what to write down. With further probing, he was able to tell me that he could take his math notebook home to help him write the topic entries.

Another contradiction seemed to arise when I asked if there were any ways they thought writing in math didn’t help them. Jorge, Lucas, and Collin didn’t feel the “choice” journal entries were helpful. Jorge felt sometimes when you write a “choice” entry you can get off-topic and then it isn’t really math-related. Lucas’s reasoning was that those types of entries are typically about something you learned in the past which he didn’t feel would be helpful anymore. Finally, Collin echoed Lucas’s thoughts and said
he didn’t feel “choice” entries really helped because you only put in one or two math-related things. Conversely, Bobbie and Cam chimed in with their thoughts on how they felt “choice” entries were helpful. Bobbie said those entries could be good because they are a choice. He looked at them as an opportunity to write about anything in math you choose. Some examples he gave were that it didn’t just have to be a story you came up with, but could also be about what you did in math class that day or things you would have liked to have done in math. Cam added to that by saying the “choice” entries can be a place for you to ask questions you wouldn’t want to ask in front of the whole class.

**What common experiences were expressed? / What topics produced consensus?**

There were a number of common experiences or consensus on topics that were shared by the majority. As a warm-up, students were asked to draw what they felt a math student looked like. All eight pictures had a person (five students drew themselves as the person) with a smile on his or her face and all drew a person of their same gender. Half of the students chose to include books, supplies or a desk in their picture too. When asked how they felt about writing in math, four of the students expressed they were sometimes unsure of what to write in their journals.

Four students shared that the one thing they disliked about math was taking notes. Most expressed this was because it was either boring or they felt it made their hand tired.

When asked how they felt writing in math could help them learn, all were in consensus that it helped them to remember stuff better because, as Ashley shared, you could go back and look at it.
It was interesting to hear that a number of the students who responded said that the only type of writing they had done prior to fifth grade was taking notes which they considered writing in math. All six students who responded when asked what type of writing they enjoyed best stated the Math Pledges.

When asked how they felt about having to explain their thoughts in words, the majority said that it was hard for them to get their thoughts on paper. In a follow-up question, all eight participants replied that it was easier for them to give an answer verbally than put it on paper. This was due to the fact they sometimes forgot what they wanted to say when they had to take the time to write it down, and that it’s faster to speak than write.

Was a particular member or viewpoint silenced?

There were no members’ viewpoints that were silenced. Most questions were answered by all eight students. The few questions that weren’t were only because they did not have anything they wanted to share. In those situations I always asked something such as, “Does anyone else have a story or something they would like to share?”

Was a particular view dominant?

I can’t say there was a particular view that was dominant as I would say there were dominant people who responded. Bobbie answered first six times whereas Jorge never chose to respond first. Otherwise, all others were pretty equal in choosing to respond first (ranging from three to one time). Cam and Collin were typically the last to respond to a question (four and five times respectively). All other ranged from two to zero times.
Reflecting upon those questions, after reading and rereading the transcript and making an analytic memo in order to begin performing data reduction, I looked for patterns to emerge that would aid in identifying codes. I approached it both deductively as well as inductively. As Stake (1995) contended, “It will be useful to use preestablished codes but to go through the data separately looking for new ones” (p. 79). My preestablished codes came from my research questions. Thus, deductively, I initially had codes for “positive attitudes,” “negative attitudes,” and “neutral attitudes.” In addition to those preexisting codes, I was open to inductive emergent patterns. As Miles and Huberman (1994) stated, “At the heart of analytic induction is the thesis that there are regularities to be found in the physical and social worlds” (p. 431). From the focus group data, other patterns emerged such as: students not knowing what to write in their journals, no prior experience with writing in math, writing helped students remember things better, and students enjoying poetic over transactional/expressive writing. I then combined those patterns to form broader themes and kept them to a manageable number, as Creswell (2007) suggested, of 5 or 6. At that point the themes I worked from were: Poetic trumps transactional/expressive, challenges of writing, benefits of writing, and attitudes which were classified as positive, neutral, or negative. Those codes and themes were considered tentative until other data sources were looked at and considered.

The next set of data I transcribed were interviews. Since I utilized Rubin and Rubin’s Responsive Interview model (2005), I continued to rely on them and used their model for data analysis as well. Therefore analysis occurred throughout the research as I continued to search for themes that emerged during the interviews. Two other themes
that emerged were *Bare Minimum* and *Need for Structure*.\textsuperscript{10} In the process of moving “from raw interviews to evidence-based interpretations that are the foundation for published reports” (Rubin & Rubin, 2005, p. 201) analytic memos were written to summarize the interview as well as reflect on how I felt the interviews progressed. Interview data were reexamined in order to find coherent and consistent themes with data that supported those themes. It was an iterative process as I refined things based on what I learned from my conversational partners. Therefore, things were refined as the cyclical process of analyzing, collecting data, analyzing, and collecting data occurred.

Copies of those transcripts were made and used for coding. I started with individual student files. Transcripts were reread and notes were made from each interview. Next I reread my written notes and looked for anything that confirmed what had already been said. For example, if a second interview repeated something that was stated in a first interview or if a student interview echoed what their parent had said, it was noted. I then went back and color-coded each response according to the theme it came under or created a new theme if needed. For example, any challenges students had with writing in mathematics were coded with a blue dot. Continuous revisits to the data also helped refine the names of each theme. Then, I wrote each theme on a large poster. On color-coded sticky notes (which coordinated to a colored theme), I listed any data source that had a reference to that theme to see if each student fell into every theme to make sure the themes were supported by data and participants. So any part of the

\textsuperscript{10}These two themes were not used even though they emerged as they did not directly address either research question and lacked support from all students in comparison to the other themes.
interview that referred to that specific theme was placed on the poster using a specific code for organizational purposes (ex: CAM I#1 = Cam’s 1st interview. For a full list, see Appendix N). This in turn became a working outline for my study. Each of the interviews were analyzed separately and then across interviews. The same process was used for the principal and parent interviews too.

In addition, the journals and documents collected were analyzed individually. All journals and documents were read through to see if they spoke to either of the research questions and/or confirmed or disconfirmed findings from the interviews. Categorical aggregation was used by looking at the sums of coded data which helped patterns emerge as well as confirmed themes (Stake, 1995). “Counting is a familiar way to see ‘what’s there”—and to keep oneself honest” (Miles & Huberman, 1994, p. 432). Therefore, I pulled each student’s file and looked collectively at all items in it that were mentioned above and checked for consistent themes and data which supported those themes. I also looked across cases to make comparisons to see if the themes held true. That was accomplished by creating a table that vertically listed the eight students down the side and horizontally listed the themes across the top. Using that, I was able to report the number of times supporting data was found for each theme across the students’ data (see Table 3).

Finally, I developed naturalistic generalizations, “generalizations that people can learn from the case either for themselves or apply to a population of cases” (Creswell, 2007, p. 163). I displayed such in a hierarchical tree diagram. Figure 3 shows the multiple sources of data at the base. Above that are the several themes that emerged and
Table 3

*Theme Analysis Table*

<table>
<thead>
<tr>
<th></th>
<th>One Hand Up, Maybe Two</th>
<th>Poetic Trumps Transactional/Expressive</th>
<th>Deepened Understandings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collin/Nina</td>
<td>26</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Cam/Kris</td>
<td>26</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Lucas/Haley</td>
<td>29</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>Larry/Marissa</td>
<td>42</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Ashley/Kathy</td>
<td>29</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Jorge/Emerson</td>
<td>30</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Fred/Renee</td>
<td>40</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>Bobbie/Rachel</td>
<td>40</td>
<td>4(^a)</td>
<td>17</td>
</tr>
</tbody>
</table>

Note. \(^a\)Bobbie did not complete a Math Nursery Rhyme Book

Finally the top shows the most general ideas (Creswell, 2007). This was a simplistic form to give readers an overall understanding and view of the inductive analysis that was conducted. In this way the data analysis was “presented to stakeholders in such a way that they can verify and validate the findings for themselves” (Patton, 1987, p. 159).
Students generally have positive attitudes toward writing in mathematics

Writing in mathematics has a positive impact on student learning

One Hand Up, Maybe Two

Poetic Trumps Trans/Exp

Deepened Understandings

FOCUS GROUP
INTERVIEWS
DOCUMENTS
AUDIO/VISUAL MATERIALS

Figure 3. Hierarchical Tree Diagram
Trustworthiness and Validity

Turning to validation, a number of strategies were utilized in order to establish credibility. Creswell (2007) defined validation as “an attempt to assess the ‘accuracy’ of the findings, as best described by the researcher and the participants” (pp. 206-207). The types of validation I employed were: triangulation, disconfirming evidence, member checking, peer review, researcher reflexivity, and thick, rich description. Yin (2003) cited four kinds of triangulation: data sources, investigator, theory, and methodological triangulation. The two I employed were data source and methodological triangulation. Using multiple data sources from the interviews with students and parents, especially, allowed themes to be verified from multiple respondents. Methodological triangulation was especially useful with the students as it allowed comparisons from the focus group and interview transcripts and journals to provide corroborating evidence. Closely related to triangulation is when the researcher looks for disconfirming or negative evidence (Miles & Huberman, 1994). I did cross-case (student) analysis to search for consistent themes and also found disconfirming evidence which is presented in chapter 5.

Another means of increasing trustworthiness was through the use of member checks. Lincoln and Guba (1985) considered this to be “the most crucial technique for establishing credibility” (p. 314). I achieved this during the interviews as I checked interpretations simply by asking questions such as “So am I hearing you say . . . ?” Transcriptions were sent out to three parents. I was unable to take interpretations, and conclusions back to the participants to read over and comment on their accuracy as they
were on summer vacation and unavailable. However, I utilized another doctoral student to peer review chapters 2, 4, and 5.

A fourth validation strategy described by Creswell and Miller (2000) was researcher reflexivity. This is a procedure for researchers to “self-disclose their assumptions, beliefs, and biases” (p. 127). This was mainly accomplished in the section “Situating Myself as a Researcher” where I explicitly disclosed my ontological, epistemological, and methodological beliefs and therefore positioned myself as a constructivist. I also shared that I found students consistently came to me with no prior experience with writing in mathematics. In the introduction I discussed being the teacher and researcher. Disclosing such things allows the reader to see my potential biases that may have influenced my interpretations.

“Another procedure for establishing credibility in a study is to describe the setting, the participants, and the themes of a qualitative study in rich detail” (Creswell & Miller, 2000, p. 128). This thick, rich description came from information gathered through interviews with the various participants to report a detailed description of the students and the context. Stake (1995) contended, “We seek to portray the case comprehensively, using ample but non-technical description and narrative. The report may read something like a story” (p. 134).

**Limitations of Study**

In this study, one limitation was researcher bias. I believe in using writing as a tool to teach mathematics and have used it extensively in my own mathematics classes. This deep belief in the value of having students write in math could have influenced the
study. To guard against that, I revealed those feelings in the “Researcher as Instrument” section of this chapter. It was my 10th year teaching at that school; the last six were teaching fifth grade math. Because I was the teacher and researcher, students may not have been fully honest in their interviews due to the power relationships between students and teacher (Brookfield, 1995). Therefore, an outside person conducted the individual student interviews. Methodological triangulation was also utilized.

Classroom practices vary in different classes and districts which may in turn affect students’ attitudes. Positive student attitudes may be dependent upon their teacher’s belief in utilizing such a tool. In addition, being able to implement writing into a math class may not be a strength for everyone. Future implementation may therefore need to be modified based on individual skill and comfort level. Thick, rich description was utilized to provide a detailed description of the case and context for the study.

The sample could also be viewed as a limitation of the study. The study only included eight gifted students in the fifth grade. To that end, it could lay the groundwork for future studies looking at student attitudes toward writing in math by making comparisons to students of various other ability levels.

**Conclusion**

This case study sought to understand mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in the mathematics classroom. Students provided valuable first-hand, descriptive, and rich information from a variety of sources gathered in the case study. Educators will be able to utilize this knowledge to continue to foster the generally positive attitudes students displayed.
In short, the focus group, interviews, journals and other documents collected provide an in-depth look at this case study for a deeper understanding of mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in the math classroom. In the next chapter I provide profiles for the participants which include background information on the students and their parent who participated, academic performance and attendance, information about some of their beliefs when it came to mathematics and writing in mathematics as well as various writing samples.
CHAPTER IV
BUILDING BACKGROUND: DESCRIPTION OF PARTICIPANTS

Introduction

The purpose of this study was to investigate and describe mathematically gifted students’ attitudes toward writing in mathematics and its impact on their learning through a case study approach. More specifically, the research questions were: What are mathematically gifted students’ attitudes towards transactional/expressive and poetic writing in mathematics? How do transactional/expressive and poetic writing in mathematics impact student learning? Eight students from a small rural school district in northeast Ohio were immersed in various transactional/expressive and poetic writing projects throughout the year. Interviews, document analysis, and a focus group were conducted to determine these attitudes and how writing in mathematics impacted their learning.

Figure 4. Collin’s picture of a math student.
Figure 4 represented Collin’s vision of what a math student looked like as students were asked to make a drawing at the start of the focus group. In this section I paint pictures of the teacher and each of the eight students who participated in the study. These profiles include background information on the students and their parent who participated, academic performance and attendance, information about some of their beliefs when it came to mathematics and writing in mathematics, as well as various writing samples.

Teacher and Student Backgrounds

The Teacher/Researcher

At the time of the study, I was completing my 14th year as a K-12 educator. My teaching experiences spanned grades 4–8 in urban, suburban, and rural as well as both private and public school systems. I had the opportunity to teach all content areas yet the majority of my experiences were teaching mathematics. I had served as both a Middle School Math Coordinator (5–8) and Math Department Chair (K–6). My bachelor’s degree was in Elementary Education and I had a master’s degree in Educational Administration. My decision to continue my studies and pursue my doctorate was based upon my desire to transition to higher education and work with pre-service teachers.

I taught fifth grade mathematics at Baylor Elementary School which included teaching four sections of mathematics and one period of core enrichment during which a lot of the poetic writing occurred. I saw approximately 100 students a day who were gifted and special education clustered while the other two classes were heterogeneously grouped. I had the gifted cluster students in my homeroom. That was determined as the
district took the combined score of fourth grade Reading and Mathematics Ohio Achievement Assessment (OAA) results and those who scored a 900 or higher were placed into the gifted clustered homeroom.

As stated in chapter 3, I recognized the prior knowledge my students brought with them. That prior knowledge was going to shape newly constructed knowledge, and that would then change as they continued to move through the educational system. I did not just impart my knowledge on the students but rather we constructed it together through on-going class discussions and probing questions. As a constructivist I wanted my students to be active participants in the learning process and therefore worked to create situations in which knowledge could be co-constructed with their peers. To that end, I believed students learned from actively engaging and participating in meaningful and relevant activities.

Writing in mathematics had not always had a place in my classroom as I, like many other practitioners, grew up learning mathematics in a very traditional way and felt writing was reserved for language arts class. The only writing my students were doing was transactional as they had to be able to explain their answers on the high-stakes state tests. Teaching in a field dominated by positivist views, writing in mathematics was not a high priority of mine until about two years ago.

Coming to see that students were able to pass tests by computing the correct answer but did not necessarily know why they performed steps they did or how to apply the same concepts elsewhere concerned me. To that end, I started encouraging students to use mathematical words in their everyday vocabulary. I began to read the literature
and saw how other educators were using writing in mathematics in a variety of ways to foster student conceptual understanding. I began asking my students to write in math and found they had no prior experience with writing in mathematics. My students questioned why we were going to be writing in math as did my colleagues. One responded, “What do you mean writing in math”? At the time of the study, writing very much had a place in my classroom and had for the past two years.

The Students

Collin. Collin was very well respected by his peers and often referred to as the “Math Einstein.” Whenever someone could not figure out a problem in class they depended on him to find the correct answer. Though Collin was extremely shy in class and never showed much emotion, he was not shy about expressing his love for math. His Math Autobiography clearly demonstrated this as well as his interviews and comments during the focus group. Math was clearly his favorite subject though he also liked to read lengthy chapter books. He liked everything about math and in fifth grade particularly he enjoyed the review games they played before tests. When asked what he disliked about math, he responded, “There is really nothing I do not like about math” (Collin, September 28, 2010).

Collin shared how he was not challenged enough in third grade, and boasted about things such as making it into the Principal’s Math Club every year, scoring above a 500 on his Mathematics Ohio Achievement Assessment (OAA), and scoring at the 12th grade level in Star Math (August 31, 2010). Principal’s Math Club was for students who successfully mastered 100 addition, subtraction, multiplication, and division facts in five
minutes each with an accuracy of 98% or higher. In addition, the school utilized a computerized assessment program, Star Math, to collect data for progress monitoring. Students tested twice each grading period, once before midterms and then again prior to the end of the grading period.

Collin’s mom, Nina, described him as being “excellent” in math and said it was something that always came easily to him though he was definitely more of a mental math person. He viewed math in more of a traditional sense, that it just involved working with numbers and doing problems. She stated he also loved science and was not a fan of Language Arts (Nina, September 30, 2010).

Nina was 35 years old and married. She has three children: a 3-year old boy, a third grade girl who was 8, and Collin who was 10 years old. Nina was a registered nurse and her highest level of education was a bachelor’s degree. Nina and Collin shared in common their love for math and working with numbers. She described him as one who sought out math on a daily basis yet struggled to put it into writing; however, by the end-of-the-year he shared his ability to do this in his final journal project. Collin wrote about a time when he went to a Cleveland Indians’ game and they scored 10 runs in the fourth inning. He went on to state, “they scored 2 runs on a single, 3 runs of a double, 3 more runs of a homerun, 1 run on a single, and 1 more run off another single” (Collin, May 24, 2011). He then found the average number of runs every time they scored as well as the mode, range, and median.

Collin always thought about numbers even though math was not promoted any more than reading prior to starting school. “It’s like he almost has to only see them
once and he memorizes [them], like sporting statistics and things like that. If it’s a number, it seems it just sticks with him” (Nina, January 28, 2011). Collin was a huge NASCAR fan and kept statistics on the drivers. He himself raced as well. He raced quarter midgets (see his Writing Samples below) and won 25 races in the last 4–5 years he raced (Collin, May 24, 2011).

When it came to schoolwork, Nina described him as being “indifferent” as there was not a lot that got him excited, and his teacher echoed this when it came to the classroom. They both felt he was very reserved. Collin never had problems completing homework and was good about getting it done on his own without his mom having to constantly remind him (Nina, September 30, 2010). He worked well independently and utilized time at school to start his homework.

Prior to fifth grade, Collin demonstrated a drive to complete challenges provided by his teacher, such as Brain Teasers. In our second interview Nina talked about a competitive streak in him when it came to math. He always wanted to be the first at something or have the most points for whatever challenges his teacher had thrown his way. During fifth grade, Collin did not exhibit that desire though tasks and challenges were provided. Nina stated she could not get a pulse on the reasoning. When she questioned him on this, Collin simply responded, “I just don’t want to” (Nina, January 28, 2011).

Although Collin may have lost that initiative, it certainly was not lost when it came to his academic performance. Collin was very bright and always did well in school. Collin made Honor Roll (3.5–4.0) all four grading periods. He consistently received
comments on his report cards such as, “It’s a pleasure to have you in class” and “Displays excellent work habits.” In math, Collin consistently received A’s all year (101%, 97%, 95%, and 94%). For his final year-end grades, he averaged the following: Reading – 92%; Language Arts – 97%; Math – 97%; Social Studies – 95%; and Science – 94%. On average Collin missed approximately four days each grading period and was never tardy.

Collin started the year scoring a grade equivalent of 12.9+ on Star Math, meaning he scored as well as an average student in 12th grade at the ninth month would have scored. The entire rest of the year he scored 12.9+ which was the highest score a student in fifth grade could achieve. That placed him in the 99th percentile, well above the national average. His Math OAA scores paralleled his Star Math results. In third, fourth, and fifth grade he scored in the “advanced” range and received a 480, 504, and 487, respectfully. Finally, Collin not only made Principal’s Math Club (5 minutes for facts) and Super Math Club (3 minutes), he was one of only seven students (out of 108) who made it into his teacher’s math club which meant he completed his facts in two minutes!

When it came to writing in math, students made two entries each week. One of them was a “must do topic” that was assigned to check for student conceptual understanding on a particular topic. The other entry students made that week was either “choice” which had to include mathematical connections or another topic that had been given as an option based on what they were studying at the time. Since Collin was very math-orientated, it surprised Nina that he had not completed more “choice” entries as she thought those would have been less challenging since he easily saw math around him.
However, after he initially wrote about racing, he soon ran out of ideas (Nina, September 30, 2010).

Collin did not like writing in general but Nina felt he was good at it. In third and fourth grade she recalled books he wrote for school and that he never enjoyed those either. “I was always surprised when the finished product came home, how well he had done on it for a kid that complains so much that he didn’t like writing stories” (Nina, September 30, 2010). When asked in that same interview if she thought he was “creative,” she said it was dependent on his mood, however, she felt he leaned more towards the creative side especially if he allowed himself to be.

In the beginning of the year, Collin shared his journals with his mom when she asked but never put it out there for her or initiated it. By early December it changed to him not wanting her to read it. She was not quite sure why because she never got a definitive answer from Collin when she questioned him about it. She said it could have been because he was a private person or again blamed it on the type of mood he was in at the time.

Collin did not think the writing done in math should have been graded because if you could not think of something to write about it would have impacted your grade (speaking of the “choice” journals). He did not think the “topic” entries should be graded either because “there might be some kids that get it real well but then other kids that don’t get it” (Collin, November 8, 2010). Though he did not think they should have been graded, Collin was proud of some of the entries he wrote. In his first interview he gave his Math Autobiography as an example of one of them. His reason was “I was able to do
the entire page real quick and get it done. Then she [his teacher] put stuff around it like ‘Me too;’ ‘I hope so;’ and ‘Excellent’” (Collin, November 8, 2010).

Though his handwriting was sometimes challenging to read and he struggled with spelling, Collin’s journal entries showed a high level of thought compared to most other entries done by students. The majority of his entries had more than the minimum of five sentences that were required. Collin’s entries had mathematical connections in them, showed mathematical understanding, and included very detailed explanations. He had only one mathematical misconception which was that he thought the Associative Property worked with subtraction. In his Math Nursery Rhyme Book which he dedicated to his younger brother, Collin took the nursery rhyme *The Wheels on the Bus* and turned it into “The Decimals on the Bus.” He wrote about adding, subtracting, and multiplying decimals. All examples were mathematically correct and the book was nicely illustrated. This was a page from his book:

The decimals on the bus

can make .73 by subtracting .95 - .22,

make .73 by subtracting .95 - .22, make .73

by subtracting .95 - .22. All through

the math class.

*Writing samples.* “Must do topic” Journal: Explain to your parents how to add integers and give examples.

Adding Integers

Dear Mom & Dad,
One way to add Integers is to do the x, o stratigy. You draw X’s (-) and O’s (+) and take out any that overcross. If there’s more X’s, it negative however many’s remaining. The same for O’s. The other way is to follow the rules. One rule is if you add a (+) and a (-) you see which one has the greatest absolute value. The Absolute value is how far it is away from zero and it’s always (+). After you find the greatest absolute value, you subtract and then put the (-) or (+) sign in front of it. It has to be the sign the absolute value number has. The second rule is to add (+) and (+). Then you just add regular. The third and last rule is when adding (-) and (-) numbers. You just add except put a negative sign in front of the sum.

Exs: rule 1:  +7 + (-8) = (-1) (He marked -8 with an arrow as the one with the greatest absolute value.)
rule 2:  +5 + (+3) = 8
rule 3:  -7 + (-4) = -11

(Collin, December 9, 2010)

“Choice” Journal:

Quarter Midget

I race quarter Midgets. They are ¼ of a midget. I race on 1/20 mile tracks usually. I’ve raced on a 1/10 of a mile track. I might race on a 1/15 and a 1/7 of a mile tracks. I run lap times around 5.990 seconds in one car, 6.000 in another, and 6.299 in the other. They can go about 40 mph.

(Collin, September 9, 2010)
Math Pledge:

Adding and Subtracting Decimals

I pledge my mind to adding and subtracting decimals of the classroom and to the adding and subtracting signs for the sum and difference, one decimal under Mrs. Treharn and decimals for all.

\[
\begin{array}{c}
1.23457 \\
+0.56789 \\
\hline
1.80246
\end{array}
\]

\[
\begin{array}{c}
56.234
-36.789
\hline
19.445
\end{array}
\]

\[
\begin{array}{c}
56.234
+23.765
\hline
80.009
\end{array}
\]

\[
\begin{array}{c}
\text{Aug. 25}
\text{Day 1-21-08}
\end{array}
\]
Fifth Grade Math Important Book:

The IMPORTANT thing about 5th grade MATH is...

Median

because

it is the middle number. You have to

order the numbers from least to greatest, then

you cross out the first number, then the last, and

continue the pattern. When there are two

numbers, you find the average of the two numbers.

If there is 1 number left, then that is the median.

BUT the IMPORTANT thing about 5th grade MATH is...

Median
**Cam.** Teachers often commented that Cam was a pleasure to have in class. He could be described as a very quiet student who typically did not volunteer much or participate in classroom discussions unless it was Science. Science was his favorite subject. He shared in his Math Autobiography that he never liked math until fourth grade when he had a teacher that made it fun because with his prior teachers, it was not. “I used to not think math was that great but I like it more this year” (Cam, November 8, 2010). He went on to talk about some of the things he liked this year such as playing review games before a test and having homework from the math book with problems that were more challenging and not as time-consuming as what he had in the past. By his second interview he stated, “I like math but it got harder” (Cam, February 17, 2011).

During the focus group when asked what he did not like about math, he said taking notes and completing homework. “I don’t like doing homework because there’s a lot of other things I could be doing” (Cam, September 28, 2010). When asked what those were, he shared things like playing video games and watching TV. Cam is supposed to come home and start his homework right after school, however, nobody’s home after school besides him and his sister who was in fourth grade. So he often chose to watch TV and blamed his sister for turning it on or had friends come over and they played outside (Kris, September 22, 2010). Cam often told his mom that his work was done when it was not. It wasn’t until she started asking him specific questions like “Did you do your math journal?” that he then said he forgot (Kris, January 21, 2011).

Cam’s mom, Kris, was 38 years old and married. She has three children: a 3-year old boy, a fourth grade girl who was 9, and Cam who was 10 years old. Kris was a
medical coder/abstractor. Her highest level of education was an associate’s degree. Kris shared that she liked math, had always been good at it, and that it was her favorite subject. It was her husband’s strong point too; therefore she thought it was “genetic” (Kris, September 22, 2010).

Kris got frustrated as it was very difficult to get any kind of information from Cam. He never elaborated or got excited about anything. “It’s like squeezing blood from a turnip” (Kris, January 21, 2011). She did not think he ever thought about school unless he had to. Cam never really commented or seemed to recognize the math in stuff they did or things around him. To that end, he was able to recognize the math in football as he talked about it in his first interview. Cam shared one of his “choice” entries which he wrote about football. He talked about the score, the time they arrived at the game, the time they left, and how much money they spent on food (Cam, November 8, 2010).

Through interviews with Kris, she shared that he had always done well in school even though education was never a focal point for him at home before entering kindergarten. She described him as being creative mechanically but not in an artistic way. “I mean he can build something out of nothing, you know, and that’s creative” (Kris, September 22, 2010).

Kris and the teacher both shared common sentiments regarding Cam’s social skills. Having recess duty, his teacher noticed very quickly at the start of the school year that Cam really did not play with anyone out on the playground. Most other students played tag, football, or four square, whereas Cam normally walked around by himself. The teacher approached him early on and asked if he wanted to play one of the games
with the other boys and he said, “No.” After my first interview with Kris I shared with her that his teacher noticed he kept to himself at recess. I let her know the teacher tried encouraging him in the past to join in football and/or four square that most kids played at recess and he did not want to. Kris got very emotional and began crying. She said this had been an on-going issue and that it usually got better as the year progressed.

Cam was in one of the counselor’s groups on making friends last year and his teacher recommended him for that group again this year. Kris shared that he had a friend who lived by them that was a girl but they felt weird about hanging out with one another at school. Kris talked to him about this as well. Within a week or two his teacher observed that he had really made a concerted effort at recess to mingle in and play with others as well as seemed happier. It did not seem to be an issue anymore on the playground.

Kris also shared in her first interview that Cam was easily distracted. She thought he had attention deficit disorder although nothing had been medically diagnosed. Since he had started school she said it had been brought up by every one of his teachers. Kris described it as being worse at the start of the year and then got better as the year progressed. I told her that his teacher did not see any signs in the classroom but would keep a close eye on things.

Although Cam did well in school, both his mother and teacher agreed he did not work up to his full potential. This was due to what she described in her first interview as him not being driven, putting forth effort, or studying. Cam made Merit Roll (3.0–3.49) the first, second, and fourth grading periods. The third grading period he received Cs in
both Language Arts and Social Studies which prevented him from making Merit Roll. There were many times he scrambled to get missing work turned in before the end of the grading period in Language Arts and Social Studies. In math, Cam consistently received Bs all year (90%, 90%, 91%, and 86%). Some of those could have easily been A’s but he had missing work after the grading period ended and had to take zeroes for those assignments. For his final year-end grades, he averaged the following: Reading – 91%; Language Arts – 87%; Math – 89%; Social Studies – 84%; and Science – 92%. Cam had good attendance and only missed six days of school and did not have any days tardy.

Cam began the year scoring a grade equivalent of 12.5 on Star Math. The entire rest of the year he scored a 12.9+ which placed him in the 99th percentile, well above the national average. That was something he was very proud about and even noted in one of his journal entries about how students felt they were doing in math. His Math OAA scores paralleled his Star Math results. In third, fourth, and fifth grade he scored in the “advanced” range and received a 459, 484, and 452, respectfully.

When it came to writing in math, Cam did not feel their writing should be graded “because writing doesn’t really have a whole lot to do with math” (November 8, 2010). He felt math was more just operations and problem-solving. He described how he made a journal entry. He first stated the topic he was writing about and then he explained how to do it. Although his mother thought he liked doing the “topic” entries, Cam expressed he liked the “choice” ones. He chose mostly all “choice” entries for his second one.

Cam’s journal entries often omitted dates and titles. His handwriting was sometimes challenging to read as he did not space his words out very well. Some of his
entries showed conceptual understanding while others did not have math connections in them at all (see his “Choice” entry in the Writing Samples below). In his Math Nursery Rhyme Book which he dedicated to his teacher, Cam took the nursery rhyme Baby Beluga and turned it into “Little Fractions.” There were portions of it that showed conceptual understanding of the parts of a fraction (numerator and denominator) as well as how to simplify fractions. He showed how 5/10 simplifies to 1/2. Other parts showed misunderstandings of fractions that equal a whole yet he self-corrected by the last page. Initially he said fractions like 3/4, 7/8, and 2/1 equal a whole. On the last page he wrote,

Little fractions on the paper,
written so small and written with glee
numerator above and the denominator below.
And all the little fractions that equal a whole.
You’re just little numbers that equal a whole.

His illustration here showed that 1/2 + 1/2 = 1 and 1/3 +2/3 = 1.

Writing samples. “Must do topic” Journal: Explain the difference between an expression and an equation. Provide examples. (No date given)

This is a paragraph about the differences between expressions and equations. One thing that is different about them is that one has equal signs and expressions don’t. Since expressions don’t have equal signs you have to write your answer under the question. This what a expression look like: 4 + 4
This is what an equation looks like: \(4 + b = 11\). That is my paragraph about expressions and equations. (Cam, End of September)

“Choice” Journal: (No title or date given)

Over the weekend I went fishing in Lake Erie for perch. While I was out there I caught three perch and a bunch of white bass. The boat we were on held 30 people but there were only 20 people on it.

(Cam, End of October)

Math Pledge:

I pledge allegiance to the decimal in which has been added and subtracted from. And to line up the decimal points and add a zero if needed when adding or subtracting for which they stand. One classroom under decimals for adding and subtracting all day.
The IMPORTANT thing about 5th grade MATH is...

an obtuse angle

because

It is greater than 90°.
It is bigger than a right angle.
It is smaller than a straight angle
It has a vertex.

BUT the IMPORTANT thing about 5th grade MATH is...

an obtuse angle
Lucas. Teachers often commented that Lucas was a pleasure to have in class and had a positive attitude. He could be described as a quiet student who typically did not take the initiative to volunteer in class but would answer if called upon. Although he was quiet, Lucas was very well-mannered and respectful. He shared in his Math Autobiography that math had always been one of his favorite subjects. Lucas described an experience with his sister as the moment he decided he liked math. His sister, who was 11 at the time, taught him how to count to 100 before he was five! (Lucas, November 8, 2010). Fractions and decimals were his favorite topics in fifth grade math.

During the focus group when asked what he did not like about math he said, “I just like math altogether,” music to any math teacher’s ears (Lucas, September 28, 2010). Although, he did come back and note that he did not care for Principal Math Club tests because they were timed and that made him nervous. He felt he was not good at them because he could not write down his facts fast enough. This was something he worked on at home. He passed addition, subtraction, and multiplication by October and division in February, and made it into Principal’s Math Club. Lucas was very proud of that.

Lucas felt special when he was asked to participate in this study. His mom shared his sense of excitement throughout her journals. She noted that he was really looking forward to the focus group after school, and was eager to do the Math Pledges and Nursery Rhymes which he called songs. “He felt special for being one of the students selected and never complained once about his responsibility to uphold all year” (Haley, May 22, 2011).
Lucas’s mom, Haley, was 42 years old and married. She has three children: Lucas who was 10, an 11th grade girl who was 15, and a 22-year-old boy. Haley was a state tested nurse’s assistant (STNA). Her highest level of education was a high school diploma. When asked what was the first word she thought of when I said “math,” she responded, “dread” (Haley, October 28, 2010). She felt she was not good at math anymore. She did well in math and described liking it until high school Algebra and Geometry which was when she got behind and struggled. She shared that she was not focused enough in high school and always wished she was better at math. However, when she realized the career she wanted to pursue required math that became her motivation to learn it (Haley, October 28, 2010).

Haley described Lucas as one who had always been good at math ever since he started counting. He watched educational programs on TV such as Sesame Street, and always had an interest in numbers even though math was not something that was emphasized at home early on; he took an interest in it on his own. Prior to starting school there were several math related experiences with Lucas that she recalled. He played with coins and practiced counting money. He also collected various things such as Pokémon cards and toy figures and always counted them. “He has hundreds of them. He knows exactly how many he has and if one is missing” (Haley, October 28, 2010).

Lucas was seen as someone who made mathematical connections on his own. He always thought mathematically and saw math in his everyday life. Haley viewed that as a process where he came up with an idea, knew what information was needed, and then sought out answers to his questions. Here was one occasion she recalled:
I was cooking dinner and he saw that I had a new measuring cup. This is the first measuring cup I’ve had for a long time. He said, “What are you making?” I told him what I was making. He’s like, “How much do you put in it?” I was telling him measurements of the ingredients that were going in. Next thing I know he runs and goes in his room. I go down there and I said, “What are you doing?” He goes, “Writing in my journal” (Haley, October 28, 2010).

Although Lucas had always done well in math, Haley felt he did not get it from her. She thought he knew more than her when it came to math and believed he would find a math-orientated career. Lucas was interested in computers and played video games. Haley said he wanted to create video games. Lucas had already been working on some writing of his own. She did not portray it as a journal but rather called them “cheat codes” from the Internet. She described them as being codes used for video games. “From what I get, when you’re on the screen at a certain time somehow you enter the codes or the codes tell you where to go in order to beat the game or something” (Haley, October 28, 2010).

Other insights that his mom shared during the interviews included how much pride Lucas took in his journal. Lucas asked his mother how to spell words as he was very concerned about getting everything just right, not something he did with his other schoolwork. Mom expressed how she was a stickler when it came to spelling, and when she found errors in his other work she expected him to fix them. Lucas responded, “Well they [teachers] know what I mean!” (Haley, January 20, 2011). When it came to writing in math, initially Lucas thought it should not be graded because “it should be for fun and
it helps you understand stuff better” (November 8, 2010). Funny enough, when asked about spelling and if it should get marked, he said, “I probably wouldn’t get spelling errors because I ask my mom” (Lucas, November 8, 2010).

Although Lucas’s older sister had not had any experience writing in math, Haley felt it was something she would enjoy and that it would have been beneficial for her. Her strength was writing and she was about a C average student in math. “If she would have had a program like that when she was younger or even now, I believe that being able to write about it would probably help her bring her grade up” (Haley, October 28, 2010). Haley also felt writing in math should be done with higher level math. She thought it would be good for struggling students too as it would help them understand better. That may have been due to her personal struggles with math, though it was not stated.

While Lucas was very bright, his teacher did not think his report card accurately reflected his ability due to the high number of absences he had. Lucas missed 29 days of school and was tardy five times. His teacher thought it was challenging for him to get caught up while trying to keep up with his current work at the time. Lucas made Merit Roll the first and second grading period. He had incomplete work in Social Studies the third grading period and in Language Arts the fourth grading period. That prevented him from making Merit Roll. In math, Lucas consistently received Bs all year until the final grading period in which he missed a B by one percent (89%, 89%, 87%, and 84%). For his final year-end grades, he averaged the following: Reading – 86%; Language Arts – 84%; Math – 87%; Social Studies – 81%; and Science – 89%. The three repetitive comments made by his teachers throughout the year were: “It’s a pleasure to have you in
Lucas’s Star Math scores were somewhat inconsistent. He scored a grade equivalent of 6.1 meaning he achieved as well as an average student in sixth grade at the first month would have scored. He then showed a positive trend as he increased to an 8.6 and then 12.9 by the end of the first semester. The entire rest of the year his scores fluctuated ranging from an 8.2 to 12.8 and averaged out to be 11.0. The variability of his scores obviously impacted his percentile rankings which ranged from 76 to 97. Lucas’s Math OAA scores better paralleled the first semester of his Star Math results rather than the second semester. In third, fourth, and fifth grade he scored in the “advanced” range receiving a 468, 465, and 456, respectfully.

When it came to writing in math, Haley described Lucas as creative. He wrote his own stories and created his own characters since about third grade. She recalled a time when she cleaned his room and was going to throw away a crinkled up piece of paper. “That’s part of my story. You can’t throw that away; that’s part of my story” (Haley, October 28, 2010).

“Math this year has been fun. The reason for that is because we wrote in math journals” (Lucas, May 26, 2011). Although Haley did not think he preferred “choice” over “topic” because he just enjoyed writing period, when it came to completing his second journal entry he chose “choice” twice as many times as he completed a “topic” entry. Though he liked the “choice” ones better because he had the freedom to write about what he wanted, he shared that the “must do’s” were also easy because he did not
have to come up the idea on his own as his teacher was the one who provided it to him (Lucas, November 8, 2010). In one of Lucas’s entries he expressed that he liked both the creative writing and journals because “it helps me remember things better when I write them down” (January 5, 2011).

Lucas loved creating problems in which you had to construct a logic box in order for his “choice” entries to be solved. During his first interview he not only eagerly shared his logic boxes but also explained how he worked backwards when he constructed them. He first made the boxes and then the names and topics and checked them off. Finally he went back and wrote the actual problem last. He had a similar approach for his “topic” entries in which he started with the sample problems first and then the written portion (Lucas, November 8, 2010).

All of Lucas’s journal entries had mathematical connections in them. You clearly saw the time and effort he put into them as well as the level of his thinking. They were neat, he typically wrote more than the minimum of five sentences that was required, and oftentimes included examples. Just about all of his entries showed conceptual understanding. In an entry that he wrote a letter to a friend explaining how to change a fraction into a decimal, he explained it correctly yet his examples showed an error. He put the numerator as the divisor and the denominator as the dividend while it should have been the reverse.

In his Math Nursery Rhyme Book which he dedicated to his friends and family, Lucas took the nursery rhyme *Camp Granada* and turned it into “Camp Angle.” He wrote about a kid going to camp and the other characters were the various types of
angles. Although he did a nice job rhyming, he really did not teach the reader about these angles or their characteristics although his illustrations were correct. These are the first two pages from what he wrote:

I went hiking with an obtuse angle,
it started to get tangled.
You remember that acute guy,
turns out he is very shy. (p. 1)

Hello acute, hello obtuse,
here I am at camp angle.
Camp is very hard,
they said we’ll do some math
if we clean the yard. (p. 2)

Writing samples. “Must do topic” Journal: Tell me what you know about perimeter and when you think you would need to use it in real life.

Perimeter
I am going to tell you what I know about perimeter. I know that perimeter means the boarder of something. I will tell you when you would use perimeter. You would use perimeter when you do something like boarder for a blackboard. Say one congruent side was 2 yards, the other sides were 5 yards. You need to buy 14 yards of boarder. I got this by multiplying 5 x 2 then 2 x 2 and then added them together. That’s how you use perimeter. (Lucas, September 29, 2010)
“Choice” Journal:

Logic Box

Brinnana, Nick, Nathan, Bob, and Fred. Their favorite fruits are grape, apple, banana, orange, and pineapple. Nick likes apples. Nathan doesn’t like grapes or oranges. Fred likes pineapples. Brinnana likes orange fruits.

<table>
<thead>
<tr>
<th></th>
<th>grape</th>
<th>Apple</th>
<th>orange</th>
<th>banana</th>
<th>pineapple</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brinnana</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nick</td>
<td>X</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nathan</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Bob</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fred</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
</tbody>
</table>

(Lucas, October 16, 2010)
Math Pledge:

I pledge allegiance to division.

Problems that we divide that when we divide we get the quotient that sometimes has a remainder. To all division questions that we need to check by multiplying the quotient by the divisor and adding the remainder and if you get the dividend it’s right.
The IMPORTANT thing about 5th grade MATH is...

Parts of a circle

because

The parts of a circle are radius, diameter, center, chord and central angle. Radius is half the diameter. The diameter is a line segment that goes through the middle of a circle. A chord is a line through the circle. A central angle is made by two radii.

BUT the IMPORTANT thing about 5th grade MATH is...

Parts of a circle
**Larry.** Larry was a student who loved to be challenged and got bored when he was not. At the beginning of the year, Larry was quiet but as the year progressed he became more social with his peers. He had many friends and was involved in sports. He could always be found on the playground playing football. When it came to the classroom he sometimes volunteered to participate in discussions but was always thinking as it showed on his face. He would like to be the one to get the answer first and therefore honed his mental math skills and did the least amount possible on paper.

Math had always been his favorite subject but he also enjoyed reading as well, two things that were emphasized at home. In his Math Autobiography, Larry shared that he always loved math but initially struggled with multiplication and long division. He shared a lot about his mom who definitely had a strong influence on him and was someone he looked up to. Some of the things he said his mom taught him were exponents, that multiplication was the same as repeated addition, and long division. He had a fascination with exponents ever since his mom taught him about them the summer prior to fifth grade. He was sure to include an example at the end: $2^3 + 3^4 = 89$ (Larry, November 8, 2010). During the focus group when asked what he did not like about math he said taking notes and homework, although he enjoyed the review games they played before tests because they refreshed anything he had forgotten (Larry, September 28, 2010).

Larry was very focused and methodical on things from start to finish. This was something he realized as he shared this comment with mom; “That’s the way I am. If I
start something, I have to finish it before I move on” (Marissa, September 13, 2010). She also saw these behaviors displayed at home. She went on to describe them as follows:

When he’s focused and on-task, he’s on-task and doesn’t want any interruptions. It’s almost like the blinders on the horse. Even if he gets frustrated, he’ll just keep pushing himself to finish it rather than taking a breather or walking away from the table for a minute and coming back. He just keeps hammering away.

(September 13, 2010)

Larry’s mom, Marissa, was 40 years old and divorced, but got remarried the summer after Larry finished fifth grade. She has two children: a second grade girl who was 8, and Larry who was 10 years old. Marissa was a registered cardiac sonographer and her highest level of education was an associate’s degree. When asked what was the first word she thought of when I said “math,” she responded, “fun because it’s controlling. You can just like plug and chug” (Marissa, September 13, 2010). Marissa had a very traditional view of mathematics and noted when she graduated college in the early 1990s she felt her lack of experience and knowledge with writing in mathematics was due to the fact they were “very much segmented, extremely segmented” (September 13, 2010).

Marissa described Larry as being very creative. She said he was creative with acting and drawing his own characters but not writing. He preferred to act his ideas out versus put them on paper. She said he was also musically creative as he played the piano and drums. He had written three songs on the piano with no prior lessons. He grew up,
however, listening to his mom play the piano and his uncle play the drums. Therefore, she believed he picked up on it just by listening (Marissa, September 13, 2010).

Growing up Larry was accustomed to a learning environment as Marissa used to be both a preschool and kindergarten teacher before she switched careers. She was actually his preschool teacher for two years and described herself as always being in teacher mode, both at school and home. She read to him as a child and made math a part of their daily activity when she cooked in the kitchen. She shared how easy math came to him and that he always did it mentally (Marissa, September 13, 2010).

Math was also something Larry used to relax. When his parents got divorced he turned to math. “If it was going to be like a stressful situation where he knew there was going to be a court date or initially when we were starting to go between the two homes, he would manipulate numbers to help him relax” (Marissa, September 13, 2010). Math was something “he knew how to do and that the answer was going to be okay” (Marissa, September 13, 2010). He felt completely out of control when it came to the divorce, but felt in control of numbers. He would sit in the backseat with his notebook doing problems while heading to his dad’s house.

His use and love of mathematics paid off in the classroom too. Larry was very bright and always did well in school. He made Honor Roll all four grading periods. He consistently received comments on his report cards such as, “It’s a pleasure to have you in class” and “Attitude is positive—I enjoy that!” In math, Larry consistently received A’s all year (98%, 95%, 94%, and 97%). For his final year-end grades, he averaged the following: Reading – 92%; Language Arts – 95%; Math – 96%; Social Studies – 93%;
and Science – 93%. Attendance was not an issue as he only missed two and a half days and was only tardy once.

Larry started the year scoring a grade equivalent of 8.5 on Star Math. He scored an 8.0 the second time and then scored a 12.9+ the rest of the year which his teacher felt more accurately depicted his ability. That was the highest score a student in fifth grade could achieve. It placed him in the 99th percentile, well above the national average. His Math OAA scores echoed his Star Math results. In third, fourth, and fifth grade he scored in the “advanced” range and received a 440, 504, and 479, respectfully. Finally, Larry not only made Principal’s Math Club and Super Math Club, he was one of only seven students (out of 108) who made it into his teacher’s math club which meant he completed his facts in two minutes!

When it came to writing in math, Larry routinely shared his journal with his mom. Sometimes he read it to her while she cooked dinner and other times he left it for her to read. Throughout the year Marissa thought he preferred to complete “topic” entries because they provided structure, but he actually wrote six times as many “choice” entries when he had the option. That was something he confirmed in his first interview when he shared, “They’re [choice entries] way easier because you don’t have to write about one thing and if I don’t get the concept about that, it’s pretty hard for me to write about it” (Larry, November 8, 2010). In reading his journals (see below) however, his “choice” entries showed little if any mathematical connections and it was evident he struggled to complete them. His teacher suggested early on that he consider completing two “topic” entries if he was struggling, but he continued to write “choice” entries. He then
contradicted himself in his second interview and said he liked “topic” entries better because then he did not have to come up with an idea although he still continued to write “choice” entries (Larry, February 17, 2010).

Larry did not feel the journals should be graded and had various reasons. He thought “choice” entries should not be graded because it was a place to ask questions, yet he felt “topic” entries should be graded. He stated,

‘Cause, well, she’s [his teacher] asking us basically a question. So if we answer it, it should be for a grade because it has to do with math and we’re just writing it out. Explain, like we would do on a test. (Larry, November 8, 2010)

Larry’s journal entries were brief in nature as he typically wrote the minimum of five sentences and some were even fewer. He struggled to stay on topic and included very few examples. He always tried to include something about exponents as they and making it into his teacher’s math club were repeated topics of discussion. In doing so, he often did not finish explaining a concept or left out an important piece. An example of that was when he tried to explain how to change a fraction to a decimal where he left out adding a decimal point before just adding zero(s) to the dividend (Larry, November 3, 2010). When he wrote about exponents he often made conceptual errors and did not show that he had a clear mathematical understanding as you can see here (Larry, November 2, 2010):

\[2^2 \times 2^2 = 64\]

\[2 \times 2 = 4 \times 2 = 8 \times 8 = 64\]
In his Math Nursery Rhyme Book which he dedicated to his sister, his teacher was very surprised it was not about exponents. Larry took the nursery rhyme *The Candy Man* and turned it into “The Operation Signs.” His pages were very repetitive and he did not teach the reader much about operation signs nor did his illustrations. The illustrations were mainly a number of enlarged colorful operation signs and did not include many problems which may have made his writing more apparent. It was unclear on pages what he meant by what was written. These are two pages from his book:

The operation signs make all
problems they create easy-peasy-lemon
squeezy. Talk about adding and
subtracting. You can even divide
or multiply. (p. 3)

Who can take an equation add it
by two, subtract all the extras
and come up with an answer
too? The operation signs, the operation
signs can; the operation signs can ‘cause
they add, subtract, divide, multiply and
make the world full of math. (p. 4)

*Writing samples.* “Must do topic” Journal: Write a letter to a friend telling him or her what you know about equivalent decimals.

My Letter
Dear Jim,

I think equivalent decimals are easy. It’s 2 decimals with the same value.

So 3.70 is equal to 3.7 and 3.700. So you can tell it’s easy. Well that’s all.

Sincerely,

Larry

(September 2, 2010)

“Choice” Journal: (No date given)

Journal

I sorta don’t know what to write about. I wrote about exponents. I wrote about comparing expressions and equations. I wrote about how I study. So what am I going to write about? Bye.

P.S. On Mondays I get my stat sheet for football.

(Larry, End of September)
Math Pledge:

Adding and Subtracting Decimals

I pledge my mind to adding and subtracting decimals of the classroom and to the adding and subtracting signs for the sum and difference, one decimal under Mrs. Treharn and decimals for all.

\[
\begin{array}{c}
\text{123.457} \\
\text{643.827} \\
\text{80.973.94}
\end{array}
\]

\[
\begin{array}{c}
\text{565.789} \\
\text{-382.678} \\
\text{183.111}
\end{array}
\]
The IMPORTANT thing about 5th grade MATH is...

Rounding decimals

because

if you don't round when they tell you to you'll get it wrong. Don't forget 5 and above give it a shove. 4 and below and let it go. Here's an example, 7.97 rounded to the nearest tenth is 8.0 because 7 is above 5 so give it a shove.

BUT the IMPORTANT thing about 5th grade MATH is...

Rounding decimals.
Ashley. Ashley characterized herself as a visual and kinesthetic learner. “I am not an auditory period. I’m not a listener. I’m a toucher and visual, that’s my two” (Ashley, November 8, 2010). Ashley definitely was not a listener when she was not interested in something. She always worried more about her silly bands, erasers, or any other gadget of the week she had. It did not come as a surprise that her favorite subject was science. The fifth grade science teacher had a very hands-on classroom in which students always did experiments or watched demonstrations.

Ashley was excited that she was the only girl who participated in this study and felt very proud as she shared in her first interview. Something she also talked about was that she had not really enjoyed math in grades one through three. It was not until fourth grade that she started liking math again because her teacher made it fun (Ashley, November 8, 2010). One thing Ashley liked about fifth grade math that was fun was when they played review games before a test as students were up and moved around.

Ashley was a happy girl who always entered the classroom smiling and ready to catch up with friends. During the focus group she drew herself as the math student with a thought balloon singing the words to a Justin Bieber song. Ashley’s mom, Kathy, and her teacher both noticed this newfound emphasis on socialization. It was a comment she received on her report card too: “You need to spend less time socializing in this class.” Something else they both agreed on was Ashley’s lack of organization. “She’s a total disorganized wreck” (Kathy, January 13, 2011). Ashley often had mounds of papers that filled her locker. No matter what they did to organize her she walked in with a pile of books that had papers exploding out of them everywhere. She was always the last one to
homeroom and the last to get packed up at the end of the day, and received this comment on her report card: “You need to be more organized for class.”

Kathy was 37 years old and married. She has four children: a 1-year-old girl, a 5-year-old boy, a second grade boy who was 8, and Ashley who was 10. Kathy was a homemaker. Her highest level of education was a bachelor’s degree. When asked what was the first word she thought of when I said “math,” she responded, “confusion because I am a very chaotic thinker” (Kathy, September 29, 2010). She never liked math and felt that Ashley was better at it than her. Kathy said she never did as well as she could have and lost concepts early on. Both her and her husband purposefully got degrees in Spanish to avoid math. Because they gave up, they were surprised how good Ashley was at math. Kathy admitted she gave up in high school when she focused more on language arts, something she felt good at. She shared she did the bare minimum to get by and was happy when she got a C. Both of Ashley’s parents regretted that they did not stick with it (Kathy, September 29, 2010).

Being at home, Kathy spent a lot of time working with Ashley on such things as counting, the alphabet, and numbers before she entered school. At 18-months Ashley arranged fruit snacks by color. “I would actually laugh because I would lift up couch cushions and find like orange fruit snacks all lined up, then green fruit snacks, then yellow fruit snacks” (Kathy, September 29, 2010). When she brought this to the doctor’s attention, he told her Ashley would probably be pretty bright in math. Once Kathy realized this was an early math skill, she worked with her on it but stated that prior to that Ashley initiated the patterning on her own. Another math skill Kathy worked with her on
before kindergarten was addition and subtraction. Ashley liked working on those types of things with her mother. Kathy showed her addition both numerically and pictorially. “I would do [draw] like three smiley faces and then add one smiley face. Underneath that I would put $3 + 1$ so she would know” (Kathy, September 29, 2010).

Kathy felt math always came easily to Ashley and that when she made an error it was due to silly mistakes such as “skipping questions, not paying attention to the full question, and not completely answering the question” (September 29, 2010). Therefore, when Ashley missed things her mom felt they were not due to conceptual misunderstandings. Her teacher agreed with this but also felt some of Ashley’s errors were due to the fact that she relied too heavily on mental math at times just to get done. Ashley was a very “black and white” person who preferred things to be straightforward and struggled more with story problems which required her to “dig a little deeper” (Kathy, September 29, 2010).

Kathy described her as being “even-tempered” and an easy child (September 29, 2010). Things that upset others just rolled off Ashley. For example, she did not get upset if someone was mean to her, but got emotional and freaked out about other things such as having ants in her locker from an apple she left in it (Kathy, September 29, 2010). Ashley beat to her own drum and her parents allowed it as she knew school was her responsibility. She knew what her parents expected of her when it came to grades and as long as she kept them up they pretty much left her alone and she did her own thing.

Ashley was also one who quickly formulated opinions instead of entering with an open mind and therefore did not like to try new things. She did this when it came to food
and activities but Kathy would push her to try it anyways which was a good thing because she oftentimes ended up enjoying them. Playing softball was just one example her mom shared. “The first year I’m dragging all of the kids there and the games were miserable. She’s crying, throwing her bat, not wanting to do it. Now she’s loving it and is in pitching and hitting clinic” (Kathy, January 13, 2011).

When it came to academics, Ashley was used to getting good grades and got upset when she did not think she did well. According to mom, Ashley never had to work for her grades in the past but was challenged by fifth grade and had to work harder. “Ashley thinks that she should be able to figure things out like (snapped her finger) and when she can’t it drives her crazy” (Kathy, January 13, 2011). Kathy noticed changes in Ashley that year. Ashley was no longer excited about a lot of things like she used to be. “She’s becoming very blasé about school and assignments” (Kathy, January 13, 2011).

Ashley was not the type of student who asked for help either. Ashley was an independent worker. She actually preferred working alone than in a group because she did not like being told what to do but would rather do things that she chose. “She is the type that if she has to do it, even if it’s something that she probably would have chosen to do, it instantly becomes boring or something she doesn’t want to do” (Kathy, September 29, 2010).

She did not ask questions in class nor did she utilize her journal to do so. This was something her mom noticed at home as well when she described a typical evening at their house. Ashley needed at least a half hour after school to get a snack and unwind. She then headed down to her desk in the basement with no one else around while mom
was upstairs with the other kids. Ashley never came up to ask her mom anything and whenever her mother questioned her she would just tell her it was done. Ashley did not ask her mom any questions when it came to writing in math either except on a rare occasion that she needed information to complete a journal entry.

Although Ashley did well in school both her mother and teacher agreed she did not work up to her full potential. “If I could be on her 24/7, she’d probably have straight A’s” (Kathy, January 13, 2011). Ashley made Merit Roll (3.0–3.49) the first, second, and third grading periods and made Honor Roll (3.5–4.0) the final grading period. She consistently received comments on her report cards such as, “It’s a pleasure to have you in class” and “Attitude is positive—I enjoy that!” In math, Ashley consistently received Bs all year (88%, 87%, 89%, and 89%). For her final year-end grades, she averaged the following: Reading – 91%; Language Arts – 90%; Math – 88%; Social Studies – 94%; and Science – 92%. Ashley missed 14½ days of school and was tardy 11 days.

Ashley scored a grade equivalent of 12.4 on Star Math at the beginning of the year. From there, she roller-coasteried up and down, but scored > 12.0 six of the eight times she tested. Four of those were 12.9+ which better indicated her ability. Therefore, on average she scored in the upper 90th percentile, well above the national average. In third grade she scored in the “accelerated” range on the Math OAA receiving a 440. In fourth and fifth grade she scored in the “advanced” range receiving a 476 and 472.

When it came to writing in math, Ashley did not think it should be graded but thought feedback should be given. She was very private with her journal. She only shared it with her mom twice and that was only when she needed information to complete
her “choice” entries. One was about making cookies (see *Writing Samples* below) and the other dealt with shopping. Kathy predicted Ashley liked the “choice” entries over the “topic” ones because she was creative. Ashley always liked to write and Kathy kept the notebooks of her drawings and stories. She still remembered a story Ashley wrote when she was in kindergarten about a baby bird that lost its mom (Kathy, September 29, 2010). Ashley confirmed her mom’s prediction and said she liked “choice” entries better as she felt they were easier and she got to write about whatever she wanted (November 8, 2010).

Ashley’s journals often included drawings or examples. Some of her “topic” entries were very detailed sequentially and a number of them were even more than the minimum of five sentences. The majority of them were mathematically correct. An example of one that was not was her “Cookies” entry. She showed how to double a recipe but made an error with two of the ingredients. She put “¼ salt” but never indicated what it was a fourth of. The other error she made was when she doubled ¾ she got 2¼ cups of butter instead of 1½ cups (Ashley, December 5, 2010).

Other times she showed correct examples yet left out a step when she explained it in words though the conceptual understanding was there, and her teacher felt it was a matter of rushing. The entries had mathematical connections and she applied math to her daily life. In one entry she shared that even some of the videogames she played had math in them. She wrote about a game called “Big Brain Academy” and stated that the game had five categories to choose from: analyze, think, compute, memorize, and identify. Her two favorites were think and memorize (Ashley, September 15, 2010).
Ashley’s Nursery Rhyme Book, which she dedicated to her friends and family, was very well done. She took the nursery rhyme *100 Bottles of Milk* and turned it into “100 Polygons on the Wall.” She wrote about polygons and showed how they changed when another side was added. She started with a triangle and went up to a tridecagon. Her illustrations matched the written portion and at the bottom of each written page she included a picture that represented the progression that occurred. For example, on the bottom of her “heptagon” page, she had a triangle, quadrilateral, pentagon, hexagon, and heptagon drawn. This was a sample from what she wrote:

95 octagons on the 
wall, 95 octagons, if they 
should happen to add a side, 94 
nonagons on the wall! (p. 6)

Finally, in the “5th Grade Math Important Book,” Ashley wrote about the Associative Property of Addition. Though her example was correct, she had a conceptual error in her writing. She started out correct but her last sentence (see *Writing Samples* below) described the Commutative Property of Addition. “You can change the order of the numbers and still have the same sum.”

**Writing samples.** “Must do topic” Journal: Explain how to rename mixed numbers when subtracting and provide an example.

Renaming Mixed Numbers

Here are the steps to renaming

\[
\frac{2\ 1}{2} - \frac{1\ 3}{4}
\]
1. Copy the problem vertically.

\[
\begin{array}{c}
2 \frac{1}{2} \\
- \frac{3}{4}
\end{array}
\]

\[
\frac{1}{2} \quad \frac{2}{4}
\]

2. Turn \( \frac{1}{2} \) into \( \frac{2}{4} \)

\[
\begin{array}{c}
2 \frac{1}{2} \times \frac{2}{2} \\
- \frac{3}{4}
\end{array}
\]

3. Cross out 2 and write \( \frac{4}{4} + \frac{2}{4} \)

\[
\begin{array}{c}
1 \frac{2}{4} + \frac{4}{4} \\
- \frac{3}{4}
\end{array}
\]

4. Subtract the fractions

\[
\begin{array}{c}
1 \frac{6}{4} \\
- \frac{3}{4}
\end{array}
\]

\[
\frac{3}{4}
\]

The Answer is: \( \frac{3}{4} \)  

(Ashley, November 30, 2010)
“Choice” Journal:

Cookies!!

Yesterday, I made cookies. I had to double the recipe. Here’s what it is:

\[
\frac{3}{4} \text{ cups of butter} \quad 1 \text{ teaspoon vanilla} \\
\frac{1}{2} \text{ cups of sugar} \quad \text{grated rind of 1 lemon} \\
1 \text{ egg} \quad \frac{1}{4} \text{ salt} \\
1 \text{ egg yolk} \quad 2 \frac{1}{2} \text{ cups flour}
\]

The doubled recipe:

1 cup of sugar
2 \frac{1}{4} \text{ cups of butter}
2 eggs
2 egg yolks
2 teaspoons vanilla
Grated rind of 2 lemons
\frac{1}{2} \text{ salt}
5 cups flour

The regular recipie makes 30. This one makes 60.
P.S. Today my sister is turning 2.

(Ashley, December 5, 2010)
Math Pledge:

"We stand tall for measurement."

We pledge allegiance to mad measurement, and The purpose for which it measures. One nation of miles, yards, feet, and inches under measurement, and math for all.

\[ 5,280 \text{ ft} = 1 \text{ mi} \]

\[ 3 \text{ ft} = 1 \text{ yd} \]

\[ 36 \text{ in} = 1 \text{ yard} \]

\[ 12 \text{ in} = 1 \text{ foot} \]
The IMPORTANT thing about 5th grade MATH is...

the associative property

because

It has parentheses. It's called the "grouping property." It can have multiplication too. You can change the order of the numbers and still have the same sum.

BUT the IMPORTANT thing about 5th grade MATH is...

the associative property.
Jorge. Jorge was a much chattier student but not disruptive. He talked at appropriate times either at the beginning of class or when he finished class work. He willingly participated in class discussions and often volunteered to answer questions. An example of this was when the teacher asked the students at the beginning of class to review what they learned the day prior. Jorge not only discussed the difference between when it was okay to estimate versus when you need to find an exact answer but also provided an example of each. This was common for him as he enjoyed math and school in general. He shared that in his Math Autobiography. He said he liked math and always had (Jorge, November 8, 2010). In fifth grade math, Jorge revealed that he liked the review games they played before a test because “they kind of refresh those things that we learned” (September 28, 2010).

Jorge talked about how his dad was a computer programmer. He shared in his Math Autobiography that he taught him “math is the universal language because everyone in the world does math the same” (Jorge, November 8, 2010). His dad shared his love for math with Jorge and even taught him to count in binary. Jorge was so excited he wrote an entry about it in his journal because he thought he would teach his teacher something. He was sure to let her know he knew it was the same as base two (Jorge, December 2, 2010).

Jorge’s mom, Emerson, confirmed his love for math and agreed it was his strength. She felt he was much better at math than Language Arts. Although she did not characterize him as creative, she noted when he did get an idea he would run with it. She
felt he had a unique way of thinking about things and almost thought too much at times. She described him as being a pretty easygoing child (Emerson, September 16, 2010).

Emerson was 42 years old and married. She has two children: Jorge who was 10 and a ninth-grade daughter who was 14 years old. Emerson was a kindergarten teacher and her highest level of education was a master’s degree. When asked for the first word she thought of when I said “math,” she responded, “my husband because he constantly stresses to the kids they have to be strong in math” (Emerson, September 16, 2010). Though Emerson was a teacher, she had a very traditional teacher education experience when it came to mathematics and noted she had no prior experience with writing in mathematics yet alone even learned about it. Therefore, she pushed the language at home and her husband pushed the math (Emerson, September 16, 2010).

In her first interview she described Jorge as one who liked to please others. He was hesitant when it came to something new because he did not want to do the wrong thing. This was evidenced with his math journal as his mom really walked him through this in the beginning. They first verbally discussed an idea or the topic and then he wrote his entry. Jorge did not take the initiative to dive into things on his own. She also portrayed him as a very literal person. As an example she noted, “Yeah, he’s kind of like Amelia Bedelia. Those stories, you know when you say, ‘You’re a couch potato.’ He pictures a couch sitting on a potato” (Emerson, September 16, 2010).

Emerson felt her son was so smart he lacked common sense when it came to day-to-day things. Jorge was in band and played the bells. Therefore he carried his bells to school as well as his band book and backpack on band days. Emerson vividly recalled
the days he had band and brought those items which he did not know how to handle. When she picked him up at the end of the day he had everything in his hands. Instead of either setting something down or putting his backpack in the car first, he squeezed in every time while carrying it all (Emerson, January 10, 2011).

Though Jorge did not make getting in the car look easy, he definitely made succeeding in the classroom look that way. Smart he was and it paid off academically. Jorge was a bright student who always did well in school. He made Merit Roll the first grading period and Honor Roll the entire rest of the year. Time and again he obtained comments on his report cards such as, “It’s a pleasure to have you in class” and “Attitude is positive—I enjoy that!” In math, Jorge consistently received A’s all year (96%, 96%, 95%, and 95%). For his final year-end grades, he averaged the following: Reading – 92%; Language Arts – 96%; Math – 96%; Social Studies – 93%; and Science – 93%. Attendance was not an issue as he only missed five days of school and was never tardy.

At the start of the year Jorge scored a grade equivalent of 8.3 on Star Math. He then fluctuated on the next two tests going up to a 12.7 and then down to a 9.8. From February until the end of the year he consistently scored above a 12.5 every time. His last test score was a 12.9+, the highest score that could be achieved by a student in fifth grade. That placed him in the 99th percentile, well above the national average. His Math OAA scores echoed his Star Math results. In third, fourth, and fifth grade he scored in the “advanced” range and received a 451, 504, and 479, respectfully.

When it came to writing in math, Jorge did not feel his teacher’s feedback influenced how he wrote future entries. He never went back and responded to any of the
comments or questions posed, nor did he use his entries to ask questions. Jorge stated, he “kind of” felt the writing should be graded because it could have helped your grade but then also realized “when you mess something up in it, it can bring it [your grade] down” (November 8, 2010).

During the first interview, Jorge shared he did not really have a preference when it came to “choice” or “topic” entries. This was because sometimes he did not understand what the topic was asking and other times he simply could not think of something to connect to math for a “choice” entry (Jorge, November 8, 2010). Three months later, in his second interview, he stated he liked “choice” entries better because “I get stuck on topics but when I have an idea it’s easy to write it” (Jorge, February 17, 2011). From analyzing all the data, I did not find this to be a contradiction but rather a transformation that occurred with him. This is further discussed in the themes section.

Jorge’s “topic” journal entries were very detailed and were more narrative in nature than numerical. Even though some of his entries were only the minimum of five sentences, most were longer especially as the year progressed. A few entries (the five multiplication properties and explaining how to add or subtract fractions with unlike denominators) were a full page or more! Jorge definitely made mathematical connections to things in his daily life: going on vacation, making brownies, his birthday, and the pumpkin farm, just to name a few. He also used things he was learning and applied them elsewhere. An example of this was after he learned how to find the percent of a number, he wrote an entry about shopping (see Writing Samples below). Although his numerical examples were mathematically correct, at times he needed to go further with his
explanation. As evidenced below in his entry on the “5 Multiplication Properties,” he accurately showed the distributive property in his example, yet his explanation was unclear and lacked conceptual understanding.

In his Math Nursery Rhyme Book which he dedicated to his teacher and math class, Jorge took the nursery rhyme *The Animals Came in Two by Two* and turned it into “The Fractions came in Two by Two.” He shared different concepts about fractions in his illustrations; he identified the parts of a fraction (numerator and denominator), equivalent fractions, and what a mixed number looked like. The main one he focused on was equivalent fractions. The common thread throughout was that he started with ¼ and kept showing different fractions on each page that were equivalent to it but used larger and larger digits to do so. He started with ¼ and went all the way to which still equals ¼. This was a sample from what he wrote:

The fractions came in six by six,

viva la confused.

The simplifying was up to its tricks,

viva la confused. (p. 5)

**Writing samples.** “Must do topic” Journal: Write what you know about the five multiplication properties we learned and provide an example of each.

5 Multiplication Properties

We just learned about the 5 multiplication properties. The first property is the commutative property. The commutative property means no matter what order you put a factor in, the product stays the same. An example is 5 x 7 = 7 x 5. The
next property is associative. Associative means no matter where you put the parentheses, the product stays the same. An example is \((4 \times 5) \times 7 = 4 \times (5 \times 7)\).

The next is Zero property. Zero property means if you multiply any number by zero, it equals zero. An example is \(200,000,000 \times 0 = 0\). The next one is property of 1. It means multiply any number by 1, it equals itself. An example is \(10 \times 1 = 10\). The last one is Distributive. Distributive is shortening up a problem you don’t know. An example is \(6 \times 43\).

\[
6 \times (40 + 3) = (6 \times 40) + (6 \times 3)
\]

\[
= 240 + 18
\]

\[
= 258
\]

(Jorge, October 5, 2010)

“Choice” Journal:

Clothes Shopping

Since tomorrow is picture day, my mom took me shopping for new clothes. I got two new shirts at 50% off. One was $20.00 and we got it for $10.00, and one was $24.00 and we got it for $12.00. We got undershirts for $8.24 but they were originally $10.99. We got it for 25% off. I got a jacket that was originally $50.00, but we got it for $35.00. We got it for 30% off. At the end, we got a 15% off coupon. We saved almost $50.00!

(Jorge, October 3, 2010)
Math Pledge:

I pledge allegiance to the perpendicular lines that make right angles. And to the direction in which they point, one nation under parallel lines that never touch at all.
The IMPORTANT thing about 5th grade MATH is...

Perpendicular lines

because

they make 4 right angles, 
They intersect and give a special kind of intersecting lines. 
Perpendicular lines cross like an intersection on a road.

BUT the IMPORTANT thing about 5th grade MATH is...

Perpendicular lines
Fred. Teachers often commented that Fred was a pleasure to have in class and had a positive attitude. He could be described as a quiet student who typically did not take the initiative to volunteer in class but would answer if called upon. However, if there was something he did not understand, he raised his hand and asked for help. Fred was very polite and respectful to both his teachers and peers.

“Ever since I learned that 1 + 1 = 2, I have loved math” (Fred, August 31, 2010). Though he liked math, Fred thought it was hard at times because occasionally he did not understand a concept at first and needed some additional practice. His favorite topic in math was multiplication because he liked doubling numbers. In his first interview, Fred commented that fifth grade was his favorite year in math so far. One thing he liked about it was the review games they played the day before a test (Fred, September 28, 2010).

Fred’s mom, Renee, confirmed that he always loved math and that it was his strength. She remembered working with him at home before he started school and noted both reading and math were areas she emphasized. One example was when they built stuff with blocks and then counted how many blocks they used. This was something she did with him before he started preschool. While he was in preschool she worked with him on addition and went up into the hundreds but used problems such as 200 + 300 which he correctly answered (Renee, September 27, 2010).

Renee was 35 years old and married. She has two children: a third grade girl who was 8, and Fred who was 10 years old. Renee was an administrative assistant and her highest level of education was an associate’s degree. When asked for the first word she thought of when I said “math,” she responded, “algebra because I wasn’t good at it”
(Renee, September 27, 2010). Renee had a very traditional experience with math when she was in school. She said she loved math up to that point in high school but became lost once it involved variables. “I got lost with letters. Letters did not belong with numbers” (Renee, September 27, 2010).

Both Renee and his teacher noticed he was an auditory and kinesthetic learner; therefore it was no surprise that music was his niche. Though he tried various sports (football, baseball, basketball, and soccer), he was not overly enthused about any of them like he was when it came to drumming. Fred loved playing the drums. He had a drum set in his bedroom and played for the Praise Band at church (Renee, January 27, 2011). His music teacher learned this and quickly had him practicing too. At the end of the year she gave him a solo part in the school’s Spring Concert where he played his drums. He was very excited and proud to get chosen.

Fred definitely wanted his independence that year. Renee said, “He’s trying to pull away and have his privacy kind of a thing” (September 27, 2010). He knew she would honor this unless he gave her reason not to. For example, if his grades started to drop, she and her husband would have checked his work again, something they did up until fifth grade. Renee said she walked a fine line with his privacy request when deciding as a parent how much was too much and was worried that she would find out about something she should have intervened on when it was possibly too late. She recalled a situation at home that concerned her a bit. She was getting ready to go in his book bag for something when he responded, “I don’t like it when you go through my backpack because I feel like you’re invading my privacy” (Renee, January 27, 2011).
After he went to bed that evening she went in his backpack because she thought he was hiding something from her but was relieved when she did not find anything. He really just wanted to be more independent that year as he would be going to middle school the following year.

Renee noted he was also more independent when it came to completing his homework. Rarely did he ask either of his parents for help. Although, she expressed that if he could have talked his sister into doing his homework for him, he would have. Fred was a “take the easy road” child who his mom wanted challenged. He liked doing mental math, an issue that his mom and dad did not agree on. His mom encouraged it and his dad opposed it. He talked to Fred several times about needing to show his work so he knew how Fred came up with his answers (Renee, January 27, 2011). This was something that the teacher noticed in the classroom as well. Fred liked doing problems in his head but often made calculation errors until he wrote it out on paper.

Although Renee described him as being “pretty laid back,” he certainly was not when it came to his academics (January 27, 2011). Fred did well in school. He made Honor Roll the first three grading periods and Merit Roll the last grading period. He regularly obtained positive comments on his report cards and his music teacher noted that he was “Highly motivated in class.” In math, Fred consistently received Bs all year (91%, 92%, 92%, and 91%). For his final year-end grades, he averaged the following: Reading – 90%; Language Arts – 94%; Math – 92%; Social Studies – 95%; and Science – 93%. Fred had excellent attendance as he only missed a half day of school and did not have any days tardy.
At the start of fifth grade Fred scored a grade equivalent of 10.7 on Star Math. From that point on he consistently scored a 12.9 or 12.9+ the rest of the year. That was the highest score a student in fifth grade could achieve which placed him in the 99th percentile, well above the national average. His Math OAA scores paralleled his Star Math results. In third, fourth, and fifth grade he scored in the “advanced” range and received a 459, 452, and 461, respectfully.

When it came to writing in math, he felt it should not be graded because “it’s kind of like math and if it was reading and we had to write about math, then yeah” (Fred, November 8, 2010). He thought of it as though his writing would be graded and never considered it could be graded for mathematical content. When Fred did write his journals, he did it pretty independently. Renee only recalled one time he asked her for an idea. It was for a “choice” entry and she suggested Legos since he liked playing with them. He did not typically share his journals with her but if she asked he usually shared them verbally. Although Renee did not typically read his journals, she felt he would have only done the bare minimum of five sentences (January 27, 2011). His journals actually disconfirmed that as at least nine of them were longer than five sentences.

Fred stated, “I don’t think I do any of the topic ones, I only do choice and must do’s” (February 17, 2011). The fact that he completed eight “choice” and seven “topic” entries when it was his option refuted his statement. He really tried to be creative with some of his entries. For example, he wrote one about fractions at war and called it “Fractions War II.” In an entry about how to make a Lego Light Saber, he wrote out detailed steps and provided a nine-step diagram for the reader to follow. The interviewer
herself even commented on it. “I think I could even make a light saber following your work here. That’s pretty nice how you drew those” (Interviewer, November 8, 2010).

He made mathematical connections in a number of his “choice” entries. He connected math to Cedar Point, drumming, and working at Dairy Queen, just to name a few.

Though he rarely remembered to date his entries, a lot could be garnered from them. In one entry he shared that he needed some extra practice with multiplying decimals. There were other entries in which mathematical misconceptions were caught and calculation errors were found. One example of a mathematical misconception was when he confused perimeter with area and said you multiplied the length and width. In an entry about renaming fractions, he simply forgot to subtract the whole numbers when he got his answer and only put the fractional part. At times, had he read over what he wrote, he would have caught some of his errors. For example, in his letter to a friend explaining how to estimate quotients using compatible numbers (see Writing Samples below), he got to the end and said, “5 divided by 85 is 17” whereas it should have been “85 divided by 5 is 17.”

Fred was in the same group as Cam for their Math Pledge. They wrote about adding and subtracting decimals. Fred described their picture in detail:

We made it like the American flag except where the stars are it’s got little decimal points on it. It has an addition sign in the middle. We put lines on it and every other line would be a subtraction sign. (Fred, November 8, 2010)

He went on and discussed the pledge as well as provided an example. He knew you needed to add a zero sometimes to make it easier to get the decimals lined up. “Like if
this number was 5.07 and this number was 5.007, then you have to add a zero next to the seven in 5.07” (Fred, November 8, 2010).

In his Math Nursery Rhyme Book which he dedicated to his teacher, Fred took the nursery rhyme *10 Little Monkeys* and turned it into “Ten Little Exponents.” He tried to show the concept of exponents and what they looked like when the base was 10, but his illustrations did not go far enough. He just started with 10,000,000,000 instead of 10^{10} as well. Instead of showing it both in exponent and standard form he only showed the standard form which did not really teach the reader about exponents. He illustrated the decrease in standard form on each page when the exponent decreased by one and went all the way down to what would have been 10^0 but only showed that it equaled 1. This was the first page from what he wrote:

Ten little 0’s sitting in a row.
One subtracted one to the exponent 10. #1 called the doctor
and the doctor said “You’ve only
got 9 in you (your) row of 10.” (p. 1)

**Writing samples.** “Must do topic” Journal: Write a letter to a friend explaining how to estimate quotients using compatible numbers. (No date given)

Letter about estimating [estimating] quotients

Dear Bobbie,

If you are going to estimate a quotient you must first line up your division sentence correctly (meaning \(5\overline{8794}\)). Then take you first two dividends, and
underline them \( \underline{5)8794} \). Next use the up/down method by taking 87 and boosting it up one. Now you have 88. 88 can NOT be evenly divided so you have to lower it. You now have 86 can 86 be evenly divided by 5? No sooo . . . boost up again [and] you have 89 it does not work. (Holy cow I should’ve picked a different number) Shoot it down you have 85 (YaY) [yeah] it can finally be evenly divided by 5. 5 divided by 85 is 17. All the numbers behind what is now 5 become zeros. So your answer is 1,700.

sincerely,

Fred (End of October)

“Choice” Journal: (No date given)

Cedar Point Attendance

On monday 120 kids tickets were ordered. On tuesday 150 Adults ordered tickets. Each ticket costs $50 for adults and $20 for kids 13 and under. The employees had to figure out how much they’ve made. They multiplied $50 with 150 and got 7,500 dollars. They also multiplied 20 to 120 and got $2,400. They then added the two numbers together and got $9,900.

\[
\begin{array}{ccc}
150 & 120 & $7,500 \\
\times 50 & \times 20 & +$2,400 \\
$7,500 & $2,400 & $9,900 \\
\end{array}
\] (Fred, Mid-September)
Math Pledge:

I pledge allegiance to the decimal in which has been added and subtracted from. And to line up the decimal points and add a zero if needed when adding or subtracting for which they stand. One classroom under decimals for adding and subtracting all day.
The IMPORTANT thing about 5th grade MATH is...

equivalent fractions

because

this is how to find equivalent fractions. You take a fraction and divide by a number. Or multiply the number. You need to multiply or divide the same number by the denominator and numerator.

BUT the IMPORTANT thing about 5th grade MATH is...

equivalent fractions.
Bobbie. Bobbie was the most talkative of the bunch. He was sometimes too chatty in class and had to be reminded to be quiet. He was quite the leader of his class and liked to take charge during group work. This showed in the focus group as well. He responded first to six of the questions and was never the last one to respond. Bobbie was a leader at recess too. He always played quarterback on the football team out in the field. He was an athlete who loved sports. He shared his favorite two were football and basketball (Bobbie, November 8, 2010).

He was one who needed challenged as he got bored when he was not or found things too easy. Bobbie willingly participated in class and took the initiative to problem solve. He was very social and tried to be the class clown at times too. His teachers often commented on his report card: “You need to spend less time socializing in class;” “Needs to put forth more effort;” and “You need to improve your behavior in class.”

Bobbie was hard to analyze as he and his mom often contradicted themselves during the interviews as well as within an interview. One example came in the first interview when he discussed his Math Autobiography. He said he wrote about how he learned fractions and decimals in fourth grade and hoped to learn about square roots in fifth grade (Bobbie, November 8, 2010). After I read his Autobiography, I found he had not shared any of that information. Rather, he stated, “I like math sometimes and I hate it sometimes.” He added that his least favorite part of math was “adding and subtracting numbers that’s too easy” (Bobbie, August 31, 2010). His mom felt he always liked math but noted he got frustrated at times when he did not understand something. “He wants a quick answer now and that’s just his personality” (Rachel, September 15, 2010). An
example she provided was when he learned long division. He struggled with it and it bothered him because he was used to things coming easy. She tried to get him to slow down sometimes as she probed him with questions. Then he usually did better.

Bobbie’s mom, Rachel, was 45 years old and married. She has three children: a first grade girl who was 6, Bobbie who was 11, and a seventh grade boy who was 12 years old. Rachel was a high school special education teacher and her highest level of education was a bachelor’s degree. When asked for the first word she thought of when I said “math,” she said she could not think of one. She just commented that it had always been her favorite subject and she was good at it. Her father was a high school math teacher for about four years so it was something that was emphasized when she was a child (Rachel, September 15, 2010).

Rachel described Bobbie as being pretty creative. She said he was the “storyteller” at home. At the time he had just gotten a cell phone. She shared how he used it to record himself doing skits or imitating people such as Steve Urkel. Rachel recalled a Little Red Riding Hood skit he did on his phone where he had done voices for the grandmother, Little Red Riding Hood, and the Big Bad Wolf. He then played it for his family who had a good laugh (Rachel, September 15, 2010).

Rachel also expressed that Bobbie did not like to try new things. He was tough on himself and if he thought he was not going to do well, he would back away from it. Speaking of sports she said, “He will size up the competition and he really has to know he’s going to do okay” (Rachel, January 25, 2011). This played out in the classroom as well. He wanted his peers to think he was smart and they did. Therefore, he did not like
it when he missed something. If he gave an incorrect answer, he would try to make a joke out of it or immediately say something like, “Okay, I see what I did wrong.”

When it came to academics, Bobbie’s teachers did not feel he applied himself. They felt his grades were not a true reflection of his ability as they indicated in their comments that were noted above. For example, from second to fourth grade he had always maintained an A average in math as shown in his permanent records. That year, he averaged a solid B. Sports were where he really excelled. The physical education teacher often noted, “It is a pleasure to have you in class.” Bobbie did not make Honor or Merit Roll the first grading period due to the Cs he received in Reading and Language Arts. The second and fourth grading period he made Merit Roll and the third grading period best reflected his ability as he made Honor Roll. In math, Bobbie consistently received Bs all year with the exception of the last grading period in which he earned a C (91%, 90%, 87%, and 83%). For his final year-end grades, he averaged the following: Reading – 92%; Language Arts – 92%; Math – 88%; Social Studies – 95%; and Science – 87%. Bobbie had good attendance and only missed six and a half days of school and did not have any days tardy.

At the beginning of fifth grade Bobbie scored a grade equivalent of 7.5 on Star Math. From that point he consistently scored higher each time and reached a score of 12.9+ until the last test he took in which he scored an 8.4. Based on the consistency of his scores, I considered his last test to be an outlier. Therefore, his scores placed him in the 90th percentile at the beginning of year and by the end of April he had placed in the 99th percentile, well above the national average. His Math OAA scores echoed his Star
Math results. In third grade he scored in the “accelerated” range and received a 435. In fourth and fifth grade he scored in the “advanced” range and achieved a 452 and 439, respectfully.

When it came to writing in math, Rachel felt he liked the “choice” entries better yet did not struggle with the “topics” either. She thought he preferred choice entries because “he’s got a lot of ideas going on in his head” (Rachel, September 15, 2010). Bobbie confirmed this as he wrote 14 choice entries and only one topic when it was his option. He felt the topic entries should be graded but not the choice ones. He said topics were something “she [his teacher] should check to make sure you got it done and see if you understood about it. Choice, where you can write about whatever you want, is just a story that could be like language” (Bobbie, November 8, 2010).

Bobbie’s journals mostly just made general statements that did not tell the reader a whole lot. “Today we rounded numbers in math” (September 6, 2010). They rarely included examples which made it difficult at times to assess his mathematical understanding. He also wrote a number of fictional entries that lacked mathematical connections. When he included math it was typically below grade level. For example, in his entry titled “The kid that did math,” his problems were “2 + 2 = 4, 5 + 5 = 10, 10 + 10 = 20 and 20 + 20 = 40” (November 11, 2010). In another entry which had a mathematical connection, he got length and width mixed up. He wrote about the size of a football field and said it was “100 yards in width and 53 yards in length” (September 29, 2010). Some of his “topic” entries showed partial understanding of concepts. When he wrote his entry on adding integers he was supposed to include examples; he only
included one. The example he included was incorrect (see *Writing Samples* below) and his explanation for when you have one positive and one negative integer was vague (December 12, 2010).

Bobbie was the only one who participated in the study that was in a different math class. He had math last period of the day which was about 5 minutes shorter than the other class. His class did not get to write their own Math Nursery Rhyme Books due to the length it took them to complete their Math Pledges and their teacher having to use their core enrichment time to review/reteach concepts they struggled with. Therefore, I cannot report on his Math Nursery Rhyme Book.

*Writing samples.* “Must do topic” Journal: Explain to your parents how to add integers and give examples.

how to add integers

3 examples.

How to add Integers. First you get your two numbers. They can be negative or positive numbers. If the two numbers are both negative your sum will be a negative number. If the two numbers are positive your sum will be positive. If ones negative and ones positive you look for absolute value.

exanpe \(-9 + (+5) = -9\) \hspace{1cm} (Bobbie, December 12, 2010)

“Choice” Journal: (No date given)

my walk

When I went on a walk I walked 1 + 2 which would be 3. Yes 3 miles. Then after I walked 3 miles I went to bed to take a nap. When I woke up it was
3:00 A.M. Then I made dinner. After dinner I went to bed. (Bobbie, Beginning of October)

Math Pledge:
The IMPORTANT thing about 5th grade MATH is...

Perpendicular lines

because
they cross in the middle and
form 4 right angles. They are
two lines that also don’t have
dendpoints. They always go
straight.

BUT the IMPORTANT thing about 5th grade MATH is...
Perpendicular lines
Summary

Profiles of the teacher and each of the eight students who participated in the study were presented. These profiles included background information on the students and their parent who participated, academic performance and attendance, information about some of their beliefs when it came to mathematics, and writing in mathematics, as well as various writing samples that exhibited both transactional/expressive and poetic student writing. A discussion of the findings of the study is found in chapter 5.
CHAPTER V

FINDINGS

Introduction

Math journals are my thing. They can be annoying, but they helped me a lot. Writing in them was fun, but at the beginning of the year, I thought it was dumb. Now, I like it more now. I think everyone should do [a] Math journal.

Writing in my math journal helped me learn because when I see and hear something, it helps me retain the information. Therefore, when I wrote in my math journal, I could just re-read it and say it aloud at the same time to remember it better.

At first, I thought writing in math had no point. Then, after I figured out that it helped me in learning math, I realized it was beneficial. I felt this way because it helped me do better in math.

The above two excerpts were from students’ final journal projects which they wrote at the end of the school year. The comments of these students and others about the use of writing in mathematics start to reveal their attitudes and realization of how transactional/expressive and poetic writing in mathematics impacted their learning.

In this chapter, I explore the data of the study. The data came from interviews, document analysis, and a focus group. I used the data to answer the research questions of this study; therefore this chapter is arranged by research questions along with the themes which emerged from the data. Themes developed as I read through the focus group and interview transcripts.
Research Questions

1. What are mathematically gifted students’ attitudes towards transactional/expressive and poetic writing in mathematics?

2. How do transactional/expressive and poetic writing in mathematics impact student learning?

To answer each question I have included excerpts from the focus group, interviews, and documents to indicate the mathematically gifted students’ attitudes toward writing in mathematics as well as how they felt it impacted their learning.

Research Question One: What Are Mathematically Gifted Students’ Attitudes Towards Transactional/Expressive and Poetic Writing in Mathematics?

Two themes emerged from the data which answered the first research question: One Hand Up, Maybe Two, and Poetic Trumps Transactional/Expressive. Next, each theme is presented followed by information uncovered from the data which supported that theme.

One hand up, maybe two. Imagine a student sitting in a desk. One hand is raised if his or her parent has a positive attitude towards writing in mathematics and the other is raised if he or she has a positive attitude. As stated in the title of this theme, one hand was clearly raised and possibly the other. All parents and three students’ hands were up, and the other five students had hands half-way up at the conclusion of the study. In the beginning there were some beliefs and challenges unveiled by both students and their parents that may have led to their initial ratings presented below. Table 4 summarizes my
Table 4

*Student/Parent Attitudes Toward Writing in Mathematics*

<table>
<thead>
<tr>
<th>Student / Parent</th>
<th>Focus Group</th>
<th>Parent Int #1</th>
<th>Student Int #1</th>
<th>Parent Int #2</th>
<th>Student Int #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Student</td>
<td>Student</td>
<td>Parent</td>
<td>Student</td>
<td>Student</td>
</tr>
<tr>
<td>Cam</td>
<td>Kris</td>
<td>-</td>
<td>+</td>
<td>N</td>
<td>-</td>
</tr>
<tr>
<td>Ashley</td>
<td>Kathy</td>
<td>-</td>
<td>-a</td>
<td>+</td>
<td>N</td>
</tr>
<tr>
<td>Fred</td>
<td>Renee</td>
<td>N</td>
<td>-</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Larry</td>
<td>Marissa</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Jorge</td>
<td>Emerson</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Bobbie</td>
<td>Rachel</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>-</td>
</tr>
<tr>
<td>Collin</td>
<td>Nina</td>
<td>N</td>
<td>+</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Lucas</td>
<td>Haley</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

*Note. (+) = Positive; N = Neutral; (-) = Negative.*

aKathy said positive during the 1st interview but disconfirmed it in her 2nd interview.
findings of student and parent attitudes from analysis of the responses from the focus group and interviews.

**Initial beliefs and challenges.** Writing in mathematics was uncharted territory for both students and their parents. The first round of parent interviews gave me an idea of this based on information gleaned from parent responses. Writing in mathematics confused parents because they did not understand what it was. One parent said, “I don’t understand what you would write about. Math is math. Math is numbers. Writing is letters. So, until you get into algebra then that makes sense” (Haley, October 28, 2010). When I asked parents what the first thing they thought of when I said “writing in mathematics,” one parent, Renee, could not think of anything except Fred sitting on the couch with his journal. Another parent, Kris replied, “I’ve never even heard of it before” (September 22, 2010).

None of the parents interviewed had any prior experience with writing in the math classroom and did not initially understand what writing in mathematics was. Emerson and Rachel, who were both teachers at the time, expressed they had not had experiences nor had they learned about it during their teacher education training (September, 2010). The rest of the parents expressed that they never wrote in math when they were in school. The only thing Kris associated with writing in mathematics was word problems (September 22, 2010).

Kathy, in the initial interview, revealed she thought writing in mathematics just meant taking notes. However, by our second interview, she shared how it made much more sense to her since she had done some journals with her daughter, Ashley. She saw
how Ashley applied math to her everyday life and wrote about it (January 13, 2011). This realization about writing in math was echoed by other parents. Renee commented, “At first I was like, ‘Oh, this just seems really strange. I don’t get it. What would be the purpose?’ But now, I definitely understand the purpose. I like it and I think it’s a wonderful idea” (January 27, 2011).

Initially Haley was also confused by the whole concept of writing in mathematics because she really did not know what it was about or what her son, Lucas, would actually be doing. She thought he was just going to be writing word problems, but once she started reading his journals she was “amazed” by what he wrote (January 20, 2011). Marissa felt very similar, but after seeing it in action for five months with her son, Larry, she understood it better. “There’s more you can do with it [writing in mathematics] than what I initially thought” (January 14, 2011). Writing in mathematics was something she learned Larry could be more creative with than she realized. Though she may not have been able to put it into words, I heard the excitement in her voice. “Even though there might be underlining foundations and rules, for lack of better words, the angles and twists and even just curiosity of you know, you can really expand it. It doesn’t just have to be this or this” (Marissa, January 14, 2011).

When we discussed writing in mathematics in our first interview, Nina stated, “I’m not sure how they’re related. I guess it’s just not something that when I was younger that we ever looked at the two as being together” (September 30, 2010). By her second interview she still stated she did not see much correlation yet she noted she saw relationships when she read some of Collin’s journals: “In ways I never thought about it,
but I guess just ‘cause I never had to do it. I mean just things in life that you don’t necessarily think of as being math” (Nina, January 28, 2011). So I believe she did see some correlations and was more aware of math in everyday life as time progressed based on her reading what Collin wrote.

While it was apparent that the parents were initially confused by the whole concept of writing in mathematics, it was no wonder that the students were perplexed as well. They too saw writing and mathematics as two very separate subjects. When Ashley was asked to write her Math Autobiography she was a bit confused because she saw math as just doing problems. “I’m like, really, this isn’t reading. I thought this was math” (November 8, 2010). She viewed writing and math as oil and vinegar as others did initially. When Larry was questioned how he felt when he was asked to write his Math Autobiography, he replied, “me and a few other people were like, ‘This is math, why do we write in math?’” (November 8, 2010). It was a struggle for them in the beginning to see how the two could be connected.

None of the students had any prior experiences with writing in mathematics before they entered fifth grade. When asked if they had done any writing in mathematics prior to fifth grade, Larry, Collin, and Bobbie said they took notes. Jorge said he had not done any and Ashley, Fred, and Cam did not even respond. Lucas felt being asked to “explain” was writing in mathematics. I then asked if there were other types of writing besides taking notes and a few of them noted: writing out your own word problems (Ashley and Bobbie), explaining how you got your answer (Cam), and the math journals
and Math Pledges (Fred) they were working on at the time (Focus group, September 28, 2010).

The lack of prior experience led to their initial confusion of “why” they had to write in math. It was something that was expressed by all eight students. According to their parents, Cam and Fred initially saw it as a “waste of time” (Kris, January 21, 2011; Renee, September 27, 2010). Even though the purposes were discussed in class, students still struggled to explain it to their parents. Marissa tried explaining it to her son, Larry. She told him it could make him a better writer and improve his math skills. However, Larry did not understand why he had to write about something he could just do in his head. Marissa, in our initial interview, shared what she explained to her son. “Well, I know it just comes to you but there is a reason why. You have to go backwards and think about the steps and start thinking more and putting words to the reason, the whole thought process” (September 13, 2010). At first Larry was like “Ahhhhhhhhhh . . .” when he was asked to write in math, but a few months later, he said, “it’s pretty easy. Now you actually know WHY you are writing in them [journals]” (November 8, 2010).

By the second round of parent interviews which occurred in January, both Rachel and Renee still felt their children, Bobbie and Fred, did not understand why they were writing in math class. However, Bobbie’s first interview disconfirmed this. He stated, “She [his teacher] wants to know what you feel about it [writing in mathematics], what you know, and what you think you know [about math]” (November 8, 2010). Renee suggested that her son, Fred, better understood how writing in math served his teacher but not necessarily how he benefited (January 27, 2011). Although, in his second interview
Fred noted that his journal was a place where he could ask questions if there was something he did not understand (February 17, 2011).

At the end of the focus group, students were asked if they had anything else they wanted to share or if they had any questions. Bobbie inquired, “What’s writing in math supposed to help you do?” (September 28, 2010). I asked the other students if they knew how it was supposed to help them or if they had any thoughts to share in response to Bobbie’s question. Ashley, Fred, Collin, and Jorge were not sure how it was supposed to help them. “I don’t understand the point of writing in mathematics” (Ashley, September 28, 2010). Larry felt it would make you a better writer, and Cam thought it allowed the teacher to see what students knew about a particular topic in math. Initially, Lucas did not respond. After I discussed that one purpose was getting students to take a closer look at things around them and how math was involved, Lucas gave an example from his daily life: “When you pour cereal you could say I poured like two ounces or something” (Lucas, September 28, 2010).

All students felt it was much easier to verbally explain something than to write it on paper. When asked why, Larry responded, “By writing it down sometimes I forget what I want to say or what I want to write down. If I just say it out loud, it’s not as easy to forget what I want to say” (September 28, 2010). Fred and Lucas agreed with Larry, and Lucas added that verbalizing it was faster too. Collin responded, “If you write it, you might think of something else and then get off-topic when you’re explaining” (September 28, 2010).
The ability to explain was definitely an initial challenge for all students because they did not know how to get their thoughts into words. Jorge, Bobbie, Larry, and Collin said they did not know what to write. Emerson shared in an interview that she never realized how much her son, Jorge, struggled with getting his thoughts on paper. “When he’s completely having to come up with the whole thing [ideas] on his own and he’s stuck, he’s very stuck and I wasn’t aware of how stuck he gets and how much he really struggles with that” (Emerson, January 10, 2011).

One of the reasons Collin struggled was because he was used to doing mental math. His mother, Nina, stated,

I think his biggest catch is going to be he can’t always put it on paper. He does it in his head but he can’t always put it on paper, yet he is still able to come up with the correct answer. (September 30, 2010)

Larry echoed that initial struggle when it came to his journals because he did not know how to write them or even what to write because in the past he always did it mentally. As the year progressed and he wrote more and understood how to do it, it became much easier for him. Larry’s mother reflected, “I would say at least twice as easier than initially. You could almost see the pain [on his face] when he first started doing this [his journals]” (Marissa, January 14, 2011). For others like Cam, he felt explaining was difficult because he was not good at it. “I think it’s hard because I’m not very good at writing my thoughts down on paper” (Cam, September 28, 2010). In the focus group, Lucas shared he sometimes forgot what he wanted to say by having to take the time to write it down.
When it came to the poetic writing, Bobbie and Ashley shared an initial struggle with the Math Pledge was coming up with a topic (Bobbie, March 3, 2011; Ashley, November 8, 2010). Fred felt another challenge, related to the Math Pledge, was working in a group. “With yourself it’s easier; you know what you’re going to do. With a group you have to agree on something, you have to compromise” (Fred, February 17, 2011). There were three challenges described when it came to their Math Nursery Rhyme books. Fred thought it was difficult to initially “get the concept of it, like to figure out what you’re going to do with it [the original nursery rhyme]” (February 17, 2011). Although, it should be noted he was one of the first to start his final draft. Lucas felt it was challenging at times to think of rhyming words, and Larry shared it was hard when you ran out of ideas (Lucas, March 3, 2011; Larry, February 17, 2011).

There were many more challenges initially when it came to the transactional/expressive writing students did in their journals. Ashley was the only student at the onset who enjoyed writing expressive entries better because it was something she had control over. Kathy felt the transactional entries were more challenging for her because “she finds it hard to write about the topic if she doesn’t come up with it” (November 5, 2010). On the other hand, Cam, Larry, and Fred said they preferred “topic” (transactional) entries because they did not have to come up with something on their own to write about. When Cam did not have a topic, he did not know what to write which is why Kris felt topic entries were easier for him because at least then he had an idea of what to write (September 22, 2010). Cam said, “At the beginning of the year I thought it was pretty hard to come up with something mathematical to write
and now it’s pretty easy” (February 17, 2011). In the beginning, Larry also struggled to come up with something to write about if he was not given a topic. Larry’s mom, Marissa, commented:

If you give him a piece of paper and a pen and say do whatever, he’ll draw characters and design characters till tomorrow. If it comes to actual writing and he’s given a topic or idea, he’ll run with it but he’s not at the point where he’s initiating it on his own. (September 13, 2010)

Fred felt writing was difficult at times because he got home and forgot what he did in class that day or how he solved a certain type of problem. Then he had to go through his notes again to try and remember. Fred said writing about changing a fraction to a decimal was the hardest writing for him (November 8, 2010). Bobbie and Lucas also utilized their notebooks as a resource when they got stuck. An example of this was when Bobbie shared he took home his notebook to help him write an entry about the difference between an expression and an equation (September 28, 2010). Lucas also recalled needing his notebook to explain how to change a fraction to a decimal. He used it to look back at some of the sample problems he had done in class (November 8, 2010).

I believe this initial preference for transactional entries stemmed from the need for structure so they did not have to come up with something on their own to write about. However, once students became acclimated to writing in their journals that preference changed. Through the duration in which student journals were collected, they completed a total of 31 entries. Sixteen of those were a specific topic (“must-do”) the teacher assigned in order to assess students’ conceptual understanding. One of those was
assigned each week dependent on what they were studying at the time. The second entry students completed each week was either a “choice” entry of their own, or they could have chosen another “topic” that was provided by the teacher. As demonstrated in Table 5 all but one student, Collin, completed more “choice” entries.

Table 5

*Journal Summary Table*

<table>
<thead>
<tr>
<th>Student Name</th>
<th>“Must do” Topics (Should be 16)</th>
<th>“Choice” (Up to 15)</th>
<th>Chosen Topic Entries (Up to 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collin</td>
<td>16</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Bobbie</td>
<td>16</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Jorge</td>
<td>16</td>
<td>12</td>
<td>4(^{a})</td>
</tr>
<tr>
<td>Larry</td>
<td>16</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Fred</td>
<td>16</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Lucas</td>
<td>16</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Cam</td>
<td>16</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Ashley</td>
<td>16</td>
<td>10</td>
<td>6(^{a})</td>
</tr>
</tbody>
</table>

*Note.* \(^{a}\)4 and 6 indicate those two students chose to do a third entry one week.

In the beginning Collin usually wrote more of the expressive entries but quickly changed to the transactional ones when he ran out of ideas. His journal entries confirmed this as he wrote only four “choice” but 11 “topic” entries when he was given the option.
He no longer liked “choice” entries because he struggled to come up with ideas. He liked being given some direction on his writing, and the provided topics helped him figure out what to write. “I don’t like choice when there’s all the topics you can do but if there was like two topics you can choose from, I like it” (Collin, November 8, 2011). Collin was very mathematical and saw math play out in his daily life but did not make the connection that he could then write about it (Nina, parent of Collin, January 28, 2011).

Jorge by far revealed the most challenges when it came to writing in mathematics. During our first interview, Emerson shared her son had “writer’s block” (September 16, 2010). She talked him through his journals in the beginning because he struggled to come up with an idea. Once they talked about it, then he was able to write his entry. His “block” caused him anxiety for about the first month or month and a half. She said he just drew a blank. He was completely stumped and not sure how to even approach writing his journal. “He would bring it [his journal] up to the counter and he would open it up and he would look at me like ‘what should I write?’” (Emerson, September 16, 2010). She had to prod quite a bit. He knew the information and could tell her things but there was a disconnect of how to just take those words he said verbally and put them on paper. Therefore, writing in mathematics was initially stressful and a challenge, but things improved (Emerson, January 10, 2011). Below are passages from Emerson’s journal, including direct quotes, documenting her son’s initial challenges and progression.

9/7/10: “He has suffered from writer’s block since 2nd grade. His teacher said he would sit for 30-45 minutes trying to think of a topic on which to write.”
9/22/10: He finished an entry that had seven sentences. It was the first time he wrote more than the minimum.

10/6/10: She didn’t even know what he wrote in his journal “because he actually completed it at school, WITHOUT MY HELP!:)”

10/21/10: Jorge wanted to write about their visit to the Pumpkin Farm. She noted that he was seeing math in his daily activities without her having to prompt him.

12/2/10: Jorge was still coming up with his own ideas. She gave an example of an entry he wrote about when they went on a cruise.

12/18/10: Jorge lost one of his journals and had to make it up; therefore, he completed three in one week instead of two. “He managed to do three entries in no time! That’s a huge difference from the beginning of the year when he would spend an hour just thinking about ONE entry!”

1/17/11: She reported that his journal had become easier over the year. He came up with ideas without any help from her.

Data obtained from the focus group, interviews, and documents revealed that some of the initial beliefs and challenges were no prior experience with writing in mathematics on the part of the parents or students. In addition, neither students nor their parents understood what writing in mathematics was or what it looked like. Finally, students displayed an initial inability to get their thoughts on paper.

The section that follows is broken down by student. It provides a description of each of the eight students’ attitudes toward writing in the math classroom. I explicate
what was shown in Table 4 by including evidence that led to the findings of student and parent attitudes from analysis of the responses from the focus group and interviews.

**Cam.** Kris’s positive attitude reflected how she felt about Cam having to write in math class. Like Cam, Kris expressed she had a hard time getting her thoughts on paper (September 22, 2010). She would not want to write in math but thought it was good for Cam because “anytime you push somebody and it causes them to grow, it’s good. I mean, it’s great” (September 22, 2010). Kris described Cam’s attitude as being negative which confirmed his own thoughts from the focus group. On the back of the paper in which he drew what a math student looked like, I discovered Cam drew an additional picture that showed three people. The first person had a frown and above it he wrote “random writing,” the second person had a straight face titled “writing in math,” and the final person had a smile face which he titled “not writing” (Cam, September 28, 2010). He really did not like writing in the beginning but Kris, his mother, hoped he eventually would and that it would get easier for him, which it did. She felt his dislike was genetic as she did not like it and her husband “despised” it. “I mean, he just finished his college degree he started twenty years ago because he was missing one English class because he hated it so bad” (Kris, September 22, 2010). When it came to writing his journals, Cam procrastinated and left them to the very last minute. Kris felt he just did the bare minimum if that.

By Cam’s first interview which occurred in early November, his attitude shifted to being more neutral. Though he agreed and said he procrastinated completing his journal, when asked how he felt about writing in math, he responded, “I’m not happy.
I’m not really mad” (Cam, November 8, 2010). He stated several times that he liked writing “choice” entries which his journals confirmed. He shared some specific entries (The Birthday Party and Going Fishing in Lake Erie) that he said were his favorite (November 8, 2010). He liked when he had the opportunity to do poetic writing because he felt he had more ideas to draw from.

Kris even noted what she considered a temporary change. At the end of January she shared that he actually kept up with his journals for a while and thought maybe things had become better, but then he was back to waiting until the last minute. She felt his journals were not quality material; “A mess with no title and no date” (Kris, January 21, 2011). From that point on she continued to characterize his attitude as negative. Cam’s teacher did not believe he enjoyed writing in his journal either but felt he enjoyed the poetic writing. If it was writing he could do in class, he seemed to enjoy it. When he had to take his journal home he just looked at it as being extra “homework” and often times turned it in late (Cam, November 8, 2010). However, Cam continued to categorize his attitude as neutral. “It’s [writing in math] okay. I can’t say I like it but I can’t say I hate it” (Cam, February 17, 2011). He stated in his journal that he could not wait to do his nursery rhyme and used words like “fun” and “cool” when he described his Math Nursery Rhyme and Math Pledge (Cam, November 10, 2010). The end of October was when Kris noted in her journal that writing in math was getting easier for Cam and by early December she wrote, “Cam says he doesn’t like writing in his math journal but he doesn’t hate it. He said that writing in math is ‘easy’” (December 6, 2010).
*Ashley.* Kathy, Ashley’s mother, expressed a positive attitude from start to finish. She was delighted that her daughter had the opportunity to write in math, something she wished she would have had. “I’m excited for her to not close the door on some opportunities that maybe I should have pursued when I was younger” (Kathy, September 29, 2010). Initially Kathy described Ashley’s attitude as being positive as well. She expressed it as such because Ashley did not complain about it at home. According to Kathy, “If she isn’t enjoying it, she’s very verbal. I know that if she’s not complaining, she’s pretty much okay with it” (September 29, 2010). Yet, Ashley disconfirmed her mother’s perspective a day prior at the focus group. Although Ashley had not commented or complained at home about writing her math journal, she certainly expressed how she felt amongst her peers.

> I just don’t like writing [the math journal]. I like to read. Like sometimes when I don’t feel like writing, but it’s a ‘must-do,’ I’m like ‘get me out of this death trap.’ It takes me forever to think about something. I’m like, ‘what do I write?’ (Ashley, September 28, 2010)

Ashley revealed two reasons in her interview that she did not initially like it: (a) she was not used to writing in math class and (b) she was keeping a personal journal at home at the time. Once she started writing more she liked it better, but still preferred her personal journal. She did not like to *have* to relate writing to math. Although, by early November she shared that if she had to choose between completing math problems and writing a math journal, she would have chosen the journal (Ashley, November 8, 2010).
So there was a shift that occurred in her attitude after the first few months, going from negative to neutral. Kathy confirmed this in her second interview when she too categorized Ashley’s attitude as neutral. At this time she also recognized when she initially characterized it as positive that it was not probably accurate. Kathy was very excited when she was contacted to participate in the study and realized her earlier categorization was based more on her own expectation for Ashley and her love of writing rather than what Ashley actually felt (January 13, 2011). Now, she admitted that Ashley did not like it but also did not complain. She accepted having to complete her math journals and realized it was not always going to be easy to write about a specific topic but that she had to put forth more effort (Kathy, January 13, 2011).

Ashley corroborated her attitude as being neutral in her second interview. When asked about her attitude towards writing in math, she noted, “I’d have to say about in the middle” (Ashley, February 17, 2011). She attributed the change to having kept her own journal at home because she realized it was not much different to write in the two. Her change in attitude was also evidenced in her final journal project. Ashley was the author of the first excerpt which started this chapter. Over time Ashley got used to completing her journals and enjoyed the “choice” entries more than when she had to write about a specific topic. I believe the opening excerpt showed a glimpse of her attitude progression and paralleled what was stated in her profile. Thinking back to the softball example that Kathy so vividly painted, I think this was another example of her not giving something a chance and formulating her opinion before even trying it.
Fred. Renee, Fred’s mother, was the only parent who started out with a neutral attitude. I think she was a bit skeptical at first but wanted to support whatever the school asked of her son. In our first interview she commented, “I encourage whatever is being taught. I neither agree or disagree, but I encourage it” (Renee, September 27, 2010). In that same interview she described Fred’s attitude as being negative because she felt he did not understand the purpose of why he was writing in math class. She also attributed it to the fact that he complained twice at home about keeping a math journal. Although she could not recall his specific comments, she noted both times he felt his journal got in the way of something he wanted to do. One occasion was when he wanted to watch a show on television but knew he had to complete his homework first. The second time was when he wanted to visit with family from out of town. In both instances, his comments were directed toward “choice” entries yet he chose choice entries just as often as he picked a topic (Renee, September 27, 2010).

As time passed and Renee became more familiar with what writing in math was all about and saw some of what Fred produced, she described her attitude as being positive. In fact, she said if she taught, she would definitely have her students keep math journals. She felt her attitude changed because she did not understand what writing in math was or its purpose initially, but when she did she started thinking differently about math.

Math is you sit down and you figure out these problems. You get the answer.
You go to the grocery store, you use math. You use math in everyday life, but writing in math was a whole concept that I had never even considered. So it was
foreign to me. But now that I look at it, I think that [it] makes so much sense.

(Renee, January 27, 2011)

Though Renee initially categorized Fred’s attitude as being negative, other data sources including some of her own journal entries disconfirmed this and indicated it was neutral to slightly positive at times. In her very first entry she indicated that he “excitedly” told her he was going to write an entry about how math was associated with Cedar Point (Renee, September 7, 2010). Fred never made any negative comments in regards to his attitude in either of his interviews or the focus group. Some of his comments even showed his attitude to be more on the positive side. For example, Renee recalled two occasions in her second interview that Fred got excited about what he wrote. Those entries were “Drumming” and “How to Make a Lego Light Saber.” He wrote a page and a half for his Lego entry and came downstairs and wanted to share it with her. “Look what I did; this is my longest journal ever” (Renee, January 27, 2011). It was times like those that affected how she later rated his attitude. In her second interview she felt it was neutral. On a scale of one to 10, she rated it a seven. That was based on the excitement she saw from him at times and the fact that he actually wanted to share some entries with her, not something that typically happened (Renee, January 27, 2011).

Initially Fred was not sure how he was going to feel about writing in mathematics. In regards to his Math Autobiography, Fred stated, “Whenever I was asked to write at the beginning of 5th grade, I was like, ‘Writing? 5th grade?’ Then, after I got it all done and stuff I finally started thinking that it was okay” (September 28, 2010). Although it sounded weird to him at first, he said that writing was sometimes “fun” and described his
attitude as being neutral. In his first interview he shared some of his initial challenges of not knowing what to write and therefore taking awhile to complete them, but after writing a number of them and becoming more familiar with them he said, “Now I’m like zipping through” (Fred, November 8, 2010). In his second interview he was asked to reflect on his attitude from the beginning of the year up to that point. He shared that at the beginning of the year he was not sure how he was going to like writing in math, but then he got used to it. He went on and said he felt “kind of normal and just you’ve got a math journal and hey, not so bad” (Fred, February 17, 2011).

**Larry.** Marissa, Larry’s mother, was always so excited when we spoke and gave vivid descriptors when she responded. When I first asked what she thought of when I said “writing in mathematics” she responded, “Intriguing, slowing the thought process down. To be able to put adjectives to numbers, something that’s black and white, so you’re adding color to it” (Marissa, September 13, 2010). Marissa had a positive attitude from beginning to end. In fact, she noted in our final interview that she needed to introduce writing in math to her younger daughter who was in third grade at the time because she wanted her to have the experiences Larry had. Moreover, in the final call to parents at the end of the year she stated, “I am planning on having him [Larry] continue the journal writing over the summer (about once a week) and when he transfers [to his new school] next year” (Marissa, May 17, 2011).

She originally described Larry’s attitude as being neutral because he did not come home excited nor did he complain about writing in math. Larry confirmed that during the focus group when he stated, “Sometimes I feel like writing and sometimes I don’t”
(September 28, 2010). From Larry’s perspective his attitude changed just after a few short weeks. He said it clicked for him after his teacher responded back to one of his journal entries where he asked why he had to keep a math journal. Now if he had to describe writing in math to a student from another school he would tell them “it’s pretty fun. Once you get the hang of it, it’s easy. You could write a whole page or two about one topic and it helps you out a lot in math” (Larry, November 8, 2010).

Marissa also noticed that his attitude went from neutral to positive. She too attributed it to the fact that he now understood why he was writing in math. “When the light bulb went off his attitude, no pun intended, the switch, it just changed” (Marissa, January 14, 2011). She noticed he now came up with ideas on his own more than in the beginning when she helped him. Marissa shared how he talked about his journal with a little excitement in his voice and how he left it out for her to read or asked her to listen to him read it out loud. He now initiated what mom had initiated before. In fact, she even noted how he completed his journal first for homework and left everything else in his book bag (Marissa, January 14, 2011).

There was not a particular experience or entry in which the awareness occurred for her, but she felt that it was something that evolved over the first few months. The evolution was evident in her journals as well. Her word choice in each entry got more positive and was apparent that Larry’s attitude became more positive too. This was her last entry.

I have been thinking about Larry’s “journey” with the math journal . . . it is amazing how much his attitude has changed. I truly anticipated he would
eventually not mind doing them but did not think he would like it as soon as he did. I think he caught on pretty quickly to the benefits of writing with math. I even noticed lately that he seems to be putting more thought into what he is writing rather than just doing it. He went from “why do I have to do this? I don’t get why,” to “I kind of like writing in the journal. I now get why we are doing this . . . it helps us understand math more.” (Marissa, January 6, 2011)

Larry corroborated her sentiments in his second interview. He said he enjoyed it much more than what he did in the beginning. At the beginning of the year he thought, “this is math, we’re supposed to do math problems not writing.” Then he felt, “You can take something and turn it into something else or you could just write down some stuff about math and make it into a fun little book or whatnot” (Larry, February 17, 2011). Larry felt his mom and teacher may have influenced his attitude toward writing in math. There was not a reason given for his teacher but he said his mom liked it and gave him some ideas (February 17, 2011).

**Jorge.** Emerson’s attitude stayed positive throughout and Jorge’s remained neutral. Emerson saw the purpose of writing in math probably because she was a teacher who had a language arts background. She thought it was a good idea for students to get their thoughts on paper (Emerson, September 16, 2010). Plus, Emerson saw how her son, Jorge, benefited from thinking about how he solved and worked through problems. She commented, “It’s not always about spitting out the answer; it’s about how you get the answer and how you see math everyday” (January 10, 2011). When I asked what she would say to teachers who were not incorporating writing into math she said she would
ask why, and would encourage them to use it. “We [teachers] always say we have a hard
time getting to everything. We can’t do this if we’re doing this. You’re blending two
really hard skills, math and language arts” (Emerson, January 10, 2011).

Emerson described Jorge’s attitude towards writing in math as neutral because she
did not think he understood the purpose initially which he confirmed during the focus
group. Although he never complained about it to her, she felt he did it because he was
supposed to but did not see the connection to why he was doing it (Emerson, September
16, 2010). As stated previously, writing in math eventually got easier for Jorge. He even
expressed in his journal that he liked writing in it more but they were still difficult for
him (Jorge, November 10, 2010). What Jorge enjoyed more was the poetic writing. He
shared in one of his journal entries that he liked the Math Pledges and felt they were more
fun than the journal (Jorge, November 10, 2010). I felt one reason was because he
worked with a group and since he struggled to come up with ideas on his own initially, he
probably appreciated having others to collaborate with which he confirmed during the
focus group. He stated, “Whenever I’m writing something I do better writing it in a
group of people because they help me come up with more ideas” (Jorge, September 28,
2010).

During the focus group Jorge was pretty laid back and said, “Some days I just
don’t want to write. I really don’t think there is a because” (September 28, 2010). If you
recall, Jorge really struggled with writing in math initially. It was a success when he
completed his journal on his own or came up with his own ideas. Emerson shared a time
he came home excited about his journal because his teacher had given him four specific
questions to respond to, therefore he felt it would be easy to write five sentences if he just answered those questions. So he may not have loved his journal, but he did not hate it either (Emerson, January 10, 2011).

There were glimmers of a more positive attitude at times when it came to Jorge and writing in math. In his first interview he expressed how his attitude had improved from the beginning of the year. In fact, he said he “kind of” hoped his sixth grade teacher had him write in math because he felt it helped him (Jorge, November 8, 2010). In that same interview he was asked if he could choose between a math class that had writing and one that did not, which he would choose. He said he probably would have picked the one with writing “because when you write you can learn better.” So although the journals may not have been his favorite, he saw how they helped him which is discussed further in the final theme.

Bobbie. Rachel, Bobbie’s mother, consistently had a positive attitude towards writing in mathematics because she felt students could learn from different content areas and “subjects aren’t individual” (September 15, 2010). She realized we use math daily in almost everything we do. She thought writing in any content area was good because she felt children did not know how to write as well as they should, something her husband saw firsthand being a college professor. Rachel also thought writing in math challenged kids and made them look at things differently (January 25, 2011).

Writing in math may have challenged kids but trying to accurately depict Bobbie’s attitude definitely challenged me! When reviewing the data there were numerous contradictions between what Rachel and Bobbie said. There were certainly
times Rachel felt he had a negative attitude as I did, but then Bobbie’s comments spoke otherwise. I saw his overall attitude towards writing in math as neutral. He least liked writing transactional journal entries. I believe it was because they challenged him, not something he was used to. His favorite was when he got to choose what he wrote about and the Math Pledge. As stated in chapter 4, Bobbie did not write a Math Nursery Rhyme book.

Initially Rachel described his attitude as being neutral and said he did not have any problems completing his journal. She shared in our first interview that Bobbie liked to write and had always written stories. He even commented to her, “Yeah, I don’t mind [the math journal], I like it” (Rachel, September 15, 2010). Conversely, in Bobbie’s first interview, he stated, “I don’t like it [writing in math]” (November 8, 2010). Although, in the same interview he shared how he liked writing “choice” entries because he wrote about what he wanted. Bobbie even gave some examples of his favorite entries, “The Obstacle Course” and “The Race,” and said they were “fun.” He went on to contradict what his mom said and expressed that he felt better about his journal than when he first started writing in it. He felt more accustomed and would tell a student from another school how “easy” it was. Bobbie said he was “fine” with writing the more expressive entries and found the transactional ones difficult (November 8, 2010).

By Rachel’s second interview she described Bobbie as being very “black and white” and that he saw writing and math as two separate subjects. She felt his attitude was negative at that point. In fact it shocked her initially that he was fine with writing in math yet, “it didn’t really surprise me when he made that turn because I expected that
reaction from the get go with him. He doesn’t think you should have to do anything that doesn’t belong” (Rachel, January 25, 2011). She shared early on Bobbie did not mind keeping a math journal, now he did. He did not realize the writing he did was really math. Rachel tried explaining that to him but he just responded, “But that’s not math, mom; I shouldn’t have to write in math” (January 25, 2011).

His attitude may have led to an incident that occurred with his math journal at about the same time. Bobbie’s teacher communicated to Rachel that she had not received his math journal in four weeks. Rachel had already been aware of it as Bobbie told her he lost it. She made a point to pick him up from school one day to check his locker. As she dug through his locker, she found it. She believed Bobbie felt if it was lost, he would not have to write in it anymore (Rachel, January 25, 2011).

Rachel attributed the decline in his attitude to two things. First was that in the beginning it was something new and exciting but he then realized he had to do it every week and “it was more of a chore then. It became a chore” (Rachel, January 25, 2011). Secondly, she confirmed Bobbie’s previous statement that he liked writing when he got to choose the topic. Rachel felt he was challenged by the entries in which he was given a specific topic to write about because he struggled to get his thoughts on paper. He did not like having to slow down and think through how he solved a problem or came up with an answer because he was used to doing it mentally most of the time. She noted, “If he’s going to struggle a little bit he’ll back away from a challenge” (Rachel, January 25, 2011).
By the middle of the third grading period, Bobbie again commented that writing his math journal “got easier because now you know what you have to write about and you know what she [his teacher] is looking for” (March 3, 2011). Again he shared entries he enjoyed. In fact he shared a transactional entry about a mathematician he liked doing. When asked if he hoped he would have to write in math in sixth grade, he replied, “I don’t really care. I can deal with it either way” (Bobbie, November 8, 2010). To that end, I felt an excerpt from Bobbie’s final journal project probably summed up his attitude best.

How I feel about writing in my math journal is kind of happy and kind of not. When we have a “must-do” I feel mad because I hate having to write down a topic that someone gives me. When we have a choice journal I feel free and can write something spontaneous. So pretty much this year I feel fine about having to write and keep a math journal. (Bobbie, May 23, 2011)

Collin. Nina had a positive attitude towards writing in math throughout because she felt it got Collin thinking about things a little differently. Math came so easy to Collin that I think she hoped this would challenge him a little more. Nina shared that even if Collin did not have to write in math the following year, she would advocate he continued it on his own anyway (January, 28, 2011). She liked how he had to apply math to his everyday life. Nina said she had a positive attitude because “writing is just another way to look at things to broaden the spectrum for him” (January 28, 2011).

Nina described Collin’s attitude as neutral because he did not complain about it at home and typically if he did not like something he would let her know. Also, if there was
something he was really excited about he came home and shared that with her too. “This is kind of just middle-of-the-road to him” (Nina, September 30, 2010). Collin confirmed this both in the focus group and his first interview. During the focus group he commented, “I think writing in math is okay except sometimes it gets a little boring” (September 28, 2010). At his first interview he shared specific entries he spent a lot of time on, and was proud of when he finished (his Math Autobiography, the difference between expressions and equations, and estimating quotients using compatible numbers). He stated, “I’m okay with it [his math journal] except I’d rather do problems and stuff” (Collin, November 8, 2010). This neutral attitude was something Nina’s journals supported as well. She wrote how he never complained about his math journal; he just accepted having to do it and was pretty “indifferent” towards it (January 23, 2011).

After he delved further into the poetic writing, Collin’s attitude started to change. His teacher noticed that as well. She noted Collin was eager when it came time to work on his Nursery Rhyme book and had made great strides early on as compared to other students in the class. He only had one more stanza to write for his first draft and it was not even Thanksgiving! This was something students in the past had not typically completed until January (Terri, November 23, 2010). At the end of the first semester Nina reported she felt his overall attitude was still neutral yet described his attitude towards poetic writing as more positive (January 28, 2011). Collin confirmed that in his second interview. He shared the Nursery Rhyme books were “fun” because he was able to choose his own topic. He liked them because he was the illustrator and they provided some structure. “You have a nursery rhyme to begin with so you have a base” (Collin,
March 3, 2011). He did not have any negative comments to share about either the Math Pledges or Math Nursery Rhyme books. In fact, he noted there was not anything he did not like about doing them.

During Collin’s second interview he was asked to compare his attitude toward writing in math at that point as compared to the beginning of the year. He shared he liked writing in math and thought it was more fun now. He said he liked doing the poetic writing better because he got to be creative (Collin, March 3, 2011).

**Lucas.** Haley, Lucas’s mother, had a positive attitude from start to finish even though she was initially confused on what exactly you would write about in math class. In her journal she commented, “I had no idea how creative he [Lucas] was in writing about math. If there was any doubt about ‘how do you write about math’ that doubt has been cleared! This is getting very exciting” (Haley, November 6, 2010). Her enthusiasm and support continued throughout the year.

Lucas was the only student in the study who had a positive attitude from beginning to end. In fact, Haley described it as being “excellent” (October 28, 2010). One explanation for such a strong statement was that Lucas was good at math and enjoyed writing; therefore, writing in math allowed him to put the two together. Another reason was Lucas took pride in his math journal and felt a sense of responsibility with it. She never once heard him complain. Lucas normally completed one entry by Wednesday and the other by Friday. She would check in with him to make sure they were done. On a rare occasion she asked him and he realized he forgot, he immediately stopped
whatever he was doing and wrote. “That was kind of interesting because you certainly
don’t see him acting like that about homework” (Haley, January 20, 2011).

Lucas confirmed Haley’s feelings about his attitude. He eagerly shared in his first
interview that he liked writing in math and thought it was “fun.” He wanted to do it
again in sixth grade because he felt it helped him learn better. If given the option, he said
he would choose writing in math over a page of math problems (Lucas, November 8,
2010). This excitement never died and was a common thread throughout Haley’s
journals. She always commented how he continued to like writing in math or that he
looked forward to writing the Math Pledge and Nursery Rhyme book (Haley, November
21, 2010). Lucas also shared his enthusiasm with her when he recorded his Math Pledge
(Haley, January 20, 2011).

Ironically, he did not start the year sharing everything with her. Initially, he took
the whole concept of a journal being something that was private very literal. Lucas did
not think he was supposed to show it to her. After Haley talked with him about it he
happily started sharing it. She described it as going from him not wanting to share his
journal and keeping it private to expecting feedback when she read it. “He’s standing
there like a waitin’ puppy to go outside and just lookin’ at me. Just stand there, nice and
quiet. I read it over and I look at him. He’s waiting for my response, so that shows
interest” (Haley, January 20, 2011). She communicated how impressed she was with
what he was able to come up with on his own. Haley explained, “Writing and math, I
didn’t realize that he would like actually write about it and actually put diagrams and
math problems next to it to explain what he’s writing about” (January 20, 2011).
Lucas continued to enjoy writing in math. He thought it was neat to think of something and write about it mathematically. He said, “I think it’s really fun, like original. I didn’t think that I’d be like writing in math” (March 3, 2011). He noted that his positive attitude was somewhat influenced by his teacher and dad. Lucas went to his dad’s house on Wednesdays and they did various activities together. Lucas said his dad helped him think about how he could turn whatever the activity was into math. He did not speak specifically about how his teacher may have influenced his attitude but rather just mentioned her name (Lucas, March 3, 2011).

In conclusion, data acquired from the focus group, interviews, and documents illustrated that all parents had a positive attitude towards writing in mathematics from beginning to end except Renee. She started with a neutral attitude but it changed to positive by the end of the study. Five students had a neutral attitude overall, and three had positive attitudes at the conclusion of the school year. Some of the initial beliefs and challenges previously presented may have led to the lower initial ratings for five of the participants, four of which were students: Cam, Ashley, Larry, and Collin. In addition, students had not engaged in any poetic writing at the time of the focus group.

**Poetic trumps transactional/expressive.** Whereas the last theme just described students’ overall attitude, this theme shows that students actually preferred poetic writing over transactional/expressive. Students’ poetic writing mainly consisted of their Math Pledge and Math Nursery Rhyme book. The Math Pledges and excerpts from their Math Nursery Rhyme books were shared in the students’ *Writing Samples* in chapter 4. Some
of the students’ “choice” entries were poetic as well although the journals focused primarily on transactional/expressive writing.

During the study I was fortunate enough to have students’ current and former principals in the same building. The former principal, Thomas, had moved into another administrative position that was housed at Baylor Elementary (pseudonym). Both he and Joe, the current principal, had the opportunity to observe students while they worked on their Math Pledges. During each of their interviews I asked them to describe what they saw. Joe portrayed a classroom of students in small groups scattered around the room with a sense of enthusiasm towards their work (December 8, 2010). Thomas added that there was questioning that occurred not only between students and the teacher but between students as well. Students willingly asked him to read their work. He said they were “definitely engaged, very engaged; excited, wanting to share” (Thomas, December 7, 2010).

Students liked poetic writing from the aspect that it was something different from what they had experienced in a typical math class. It was not just completing a page of math problems for homework. Ironically, two students viewed the transactional/expressive writing as “extra homework.” Bobbie felt this way (according to his mother) and Cam shared similar sentiments in his first interview (Rachel, January 25, 2011; Cam, November 8, 2010).

Some students noted that they wanted to continue the poetic writing but not the transactional/expressive. Ashley shared in one of her journals that she wanted to continue doing the nursery rhymes because “I like to write my own thing” (January 5,
2011). It was something her mom, Kathy, confirmed as well. She shared that Ashley enjoyed writing the Math Nursery Rhyme book and was neutral about the journals (Kathy, May 17, 2011). Collin also expressed he wanted to continue doing the poetic writing but not the journals (January 5, 2011). Fred echoed similar feelings in one of his journal entries. He said he liked writing the Math Pledge because “we got to make up our own version of the pledge using math,” and felt “ok” about the journals (Fred, November 11, 2010). Later in the year when he was well into writing his nursery rhyme he commented that he liked the Math Pledge and Math Nursery Rhyme but not the journals because he would “rather do a big job then a lot of little jobs” (January 5, 2011).

Students expressed various other reasons they liked poetic writing. Cam felt he wrote poetically a little faster than transactional/expressive because he had more things to write about (November 8, 2010). Collin liked it because he got to contribute his own ideas (November 8, 2010). In his first interview Jorge shared he would rather complete a page of math problems over his journal yet he would do another Math Pledge over a math assignment (November 8, 2010). Jorge expressed he liked his journals more as compared to the beginning of the year yet he stated, “I like doing the Math Pledge. I think they are more fun than the journals” (November 10, 2010).

Students enjoyed the poetic writing because it provided them an opportunity to collaborate with others and be creative. During the focus group I asked students if there was a certain type of writing they enjoyed more. Six of the eight students said the Math Pledges (Focus group, September 28, 2010). Lucas and Bobbie did not respond; however, Bobbie’s class had not started their Math Pledges at the time of the focus group.
Collaboration. Jorge, Collin, and Cam all liked the Math Pledges because they worked in a group which allowed for collaboration of ideas. Jorge again confirmed this in his second interview when he commented, “Obviously it’s easier when I work with people and hear their suggestions” (February 17, 2011). Collin paralleled similar thoughts. He found working in a group fun because he was able to discuss ideas with his friends (November 8, 2010). Cam did not provide a reason for why he liked working in a group until his first interview which he shared it was more fun working with his friends than by himself. He shared how they were able to divide the tasks. Since one student in his group was artistic, he illustrated while they all wrote (Cam, November 8, 2010). Cam stated he felt the poetic writing was “fun,” and thought turning the Pledge of Allegiance into a Math Pledge was “cool.” He went on and said, “I can’t wait to do the nursery rhyme” (November 10, 2010).

Although Lucas did not respond during the focus group, he shared his thoughts during both of his interviews. Lucas liked working together as a group. Like Cam, he also talked about how they divided the tasks. He was the one who created their sample problem while another student wrote it and the third student illustrated it (November 8, 2010). The Math Pledge provided him the opportunity to be creative and he enjoyed that. “I liked it [Math Pledge] a lot. It was fun” (Lucas, March 3, 2011). Moreover, once Bobbie’s class started their Math Pledges, he shared it was “fun” because you picked your own topic and had a chance to illustrate the front and back cover of the class book if your pledge was chosen (November 8, 2010). Even though the Math Nursery Rhyme books were done individually, some collaboration still occurred. Although Cam found
them to be time-consuming as it took him awhile to decide on a nursery rhyme, he enjoyed sharing his ideas with others and getting some feedback and ideas in return (February 17, 2011).

**Creativity.** Larry, Ashley, and Fred all enjoyed the Math Pledge because it allowed them to be creative. Larry stated, “We get to take something and make it our own by putting in new words and taking out others” (Larry, September 28, 2010). He again talked about his Math Pledge in his first interview and how much he enjoyed it. He thought it was fun and different, not just because he got to work with his friends but also it was something he turned into math (November 8, 2010). Ashley also liked them initially because she got to be creative. However, she was the only one who did not end up enjoying them because she had to work in a group whom she became frustrated with because they could not make decisions. So while she initially commented to her mom the Math Pledges were “cool,” she found her group got behind because they could not decide on a topic (Kathy, September 29, 2010). Finally, Fred also liked the Math Pledge because of the creativity it provided. That was something he went home and shared with his mom. He was excited about the pledges. He explained to her what writing a Math Pledge meant. “So he explained it to me that it’s kind of like you take the American flag pledge and you put math terms with it” (Renee, January 27, 2011). In his own interviews he also described how he took the Pledge of Allegiance and made it mathematical by adding math vocabulary. He thought they were “neat” and verbally illustrated the picture in detail and what they wrote about (Fred, February 17, 2011).
Students also engaged in writing Math Nursery Rhyme books. They chose a favorite nursery rhyme and rewrote it mathematically as was shown in chapter 4. Collin enjoyed writing them because he was able to choose the math topic he wrote his nursery rhyme about, and the nursery rhyme provided some structure to help him get started. He also enjoyed the creative aspect as he was his own illustrator. In fact, he noted, “There is really nothing I didn’t like” (Collin, March 3, 2011).

When Haley talked to Lucas about his nursery rhyme before he actually started writing, she commented that he looked forward to it and called them “songs.” “He’s already racking his brain about what he wants to sing about. I can’t wait to see what he comes up with” (Haley, November 21, 2010). Larry echoed this excitement as he noted, “Now those [nursery rhymes] are pretty fun to me because you get to take a nursery rhyme that’s already made and you get to turn it into something else” (February 17, 2011).

The Nursery Rhyme books were also something both Collin and Ashley went home and initiated conversation about with their parents, whereas they did not talk about their journals unless asked. Though Nina could not recall specific comments, she remembered him talking to her about it when he was in the early stages of his writing. She expressed his attitude was more on the positive side toward the nursery rhyme as compared to the transactional/expressive writing which she felt he was neutral towards (Nina, January 28, 2011).

Ashley also volunteered information about her Nursery Rhyme book without her mom having to pry it out of her. Ashley shared that she was excited to write her book;
she liked the creative part of it. She told her mom the topic she was going to write about and the nursery rhyme she chose. “Ashley tends to be a procrastinator who really crams at the end, but she’s enjoying this project” (Kathy, January 3, 2011). Ashley let her mom know she was almost done and that it was not even due for a while yet!

Ashley liked writing stories in her own journal and liked being creative which is why she may have enjoyed the nursery rhyme so much. “She tends to like projects where she is in control of the creative process. When she is given a topic to write about, she is bored and disinterested” (Kathy, January 3, 2011). Ashley was in control and worked independently. She made all the decisions from choosing her topic to what illustrations she drew. Ashley liked to be in control. For this reason, I believe she did not enjoy the Math Pledge but liked the Nursery Rhyme book where she controlled all aspects of it.

When she worked in a group on her Math Pledge she could not always be in control. Ashley shared how she got frustrated at times when her group members could not make decisions which put them behind. She described an instance of this when they could not decide on a topic for their Math Pledge. “The two people in the group who were writing stuff, they were just like, ‘Why don’t you pick mine? Why don’t you pick mine?’ Then they look at me and say, ‘Pick one.’ And I’m just like, ‘I’m the drawer’” (Ashley, November 8, 2010).

Finally, students were asked during their interviews if they could do another type of writing what it would be. Five of the eight students who replied indicated a poetic type of writing. The other three students said they did not know. Cam, Larry, and Bobbie all said they wanted to write a math comic. Lucas responded, “Maybe we could
pick like a math word and do an acrostic poem” (March 3, 2011). Fred thought it would be nice to have students pick a favorite song and make it mathematical (February 17, 2011).

**Summary.** Analyzing data from interviews, documents, and a focus group, I have answered Research Question One: What are mathematically gifted students’ attitudes towards transactional/expressive and poetic writing in mathematics? Two themes emerged from the data to answer this question: One Hand Up, Maybe Two, and Poetic Trumps Transactional/Expressive. Some of the initial beliefs and challenges were no prior experience with writing in mathematics on the part of the parents or students, not understanding what writing in mathematics was or what it looked like, and the inability of students to get their thoughts on paper. These may have led to the lower initial ratings for five of the participants, four of which were students: Cam, Ashley, Larry, and Collin. In addition, students had not engaged in any poetic writing at the time of the focus group. All parents had a positive attitude towards writing in mathematics from beginning to end except Renee. She started with a neutral attitude but it changed to positive by the end of the study. Five students had a neutral attitude overall, and three had positive attitudes at the conclusion of the school year. Therefore, the eight mathematically gifted students generally did not mind writing in math or enjoyed it as they all displayed neutral to positive attitudes. Students preferred poetic writing over transactional/expressive because it provided them an opportunity to collaborate with others and be creative.
Research Question Two: How Do Transactional/Expressive and Poetic Writing in Mathematics Impact Student Learning?

One theme emerged from the data which answered the second research question: Deepened Understandings. This section encompasses information uncovered from the data that supported this theme. Information for this theme was not only garnered from students but their parents and the current and former principals too.

**Deepened understandings.** Not understanding the purpose of writing in mathematics, which started out as an initial challenge, turned into a realization of its benefits. Students, and especially their parents, saw how writing in mathematics led to developing deeper mathematical understandings in a variety of ways.

All students but Larry echoed a common belief. They all felt writing in mathematics benefited their teacher because it provided her insight into their thinking and allowed her to assess their conceptual level of understanding. They thought that was one reason they were even asked to write in math. Collin felt students wrote in math to “help us learn and see if we actually are learning and not just coming up with stuff” (March 3, 2011). Ashley believed the journals in particular provided the teacher a means to check student understanding (November 8, 2010). Lucas shared with his mother, “This [writing in math] is so the teacher can keep track of if we’re understanding what we’re doing in math” (Haley, October 28, 2010). Bobbie took it a step further and thought writing in math not only served as an informal assessment, but also allowed the teacher to see whether or not students could apply their understanding in the poetic writing (March 3, 2011).
While students felt writing in mathematics benefited their teacher, parents felt it deepened the student’s level of conceptual understanding. Seven of the eight parents, four students, and their principal all paralleled that notion. Joe felt writing in math forced students to internalize what they learned. “It makes them [students] think through processes and computation, exactly why they did what they did” (Joe, December 8, 2010).

Reading the math journals offered parents a window into their child’s thinking they had not previously had. Lucas, and his mother Haley, felt he understood the material better when he wrote because he had to take the time to think through what he learned in order to write about it (January 5, 2011; January 20, 2011). From reading Collin’s journal, Nina was “amazed” by the content. She could not believe some of the things her son wrote and expressed. They were better than what she thought he was capable of doing. “Wow, I guess I didn’t stop and think he comprehends that now; that he can relate things” (Nina, September 30, 2010).

Larry told his mom he understood more when he wrote in math. Marissa (his mother) added, “I think it [writing in math] really solidified the learning process cause you’re putting both sides together instead of linear thinking” (September 13, 2010). Larry felt if students were struggling, having to write about it would help them better understand, something he himself experienced. Larry thought the Math Pledge helped him learn more about decimals because he did not really understand them that well until he worked with his group and they wrote their pledge (February 17, 2011). Marissa
noted writing in math was “going to make you think [about] more than just what’s in front of you, more than just the rules” (January 14, 2011).

Emerson also felt writing in math increased her son’s conceptual understanding because it made Jorge stop and think about what he was doing when he worked through problems (January 10, 2011). That same idea was paralleled by Rachel in both of her interviews as well (Bobbie’s mother, January 25, 2011). Renee described it as making Fred slow down his thought processes in order to get his ideas on paper and be able to explain something to someone else (Fred’s mother, January 27, 2011). Kathy expanded on this notion when she added that in order for her daughter, Ashley, to use math vocabulary in her writing, she had to know what it meant. Writing helped students “dig deeper and conceptualize it a lot better than what simply handing somebody a piece of paper with some problems on it is going to do” (Kathy, September 29, 2010).

Writing in math not only forced students to slow down their thought processes, but it also allowed them to reflect on their writing which clarified and built understanding. The math journals provided Collin an opportunity to self-correct when he went back and saw what he wrote. “If there was something that you thought but then you would try it in one of them [the journal entries] and you’ll figure out, ‘No wait, no that’s like the other way around’” (Collin, March 3, 2011). There were places in a few of his journals where I saw he had something and erased it but I cannot say with certainty what he had corrected. However, I noticed whenever the teacher asked him for an example or to figure out a problem he went back and replied.
Through reflection, Fred realized how cognizant of the reader he really was when he wrote his journals. He put more thought into them than I think he initially realized. He shared in his interview how he wrote his “topic” and “choice” entries differently. When he wrote to explain a concept to someone else he used smaller numbers so it was easier for them to understand. However, when he wrote “choice” entries he used larger numbers and more complex problems to challenge the reader. “Whenever you’re writing it to somebody else you want to start out small. And then whenever you’re doing other stuff you want to have like big numbers” (Fred, November 8, 2010). His journals confirmed this with the exception of his letter to Bobbie that was presented in chapter 4 in which he realized he should have picked a different number. For instance, when he wrote about equivalent decimals he used simple examples such as 3.9 = 3.90 (Fred, September 2, 2010).

Reflection taught Collin to look at things from a different perspective. He commented, “I learned that you can learn different things that you thought you already knew except you didn’t, from the math journal and the Math Pledge and other writing assignments” (Collin, November 8, 2010). Two parents, Kathy and Rachel, had similar sentiments. Rachel stated, “It [math journal] has made him [Bobbie] look at math in a different way, not just as numbers and operations” (January 9, 2011).

**Historical artifact.** Journals served as a historical artifact for students which allowed them to review concepts previously learned. Fred commented, “It [writing in math] was kind of bringing back stuff we learned and making it fresh” (February 17, 2011). The journal served as a resource that students either referred to if they forgot
something or assisted them in completing their homework (Bobbie, May 23, 2011). Lucas noted that he went back and looked at his writing which he found helpful (September 28, 2010). Ashley thought the poetic writing also helped her review concepts previously learned (February 17, 2011). In order to write her Math Pledge and Math Nursery Rhyme book she had to understand the topic before she could apply it. Lucas added that an advantage to writing the Math Nursery Rhyme book was that it helped him remember what he wrote about (March 3, 2011).

**Vehicle for communication.** Three ways students utilized writing in math as a vehicle for communication were to ask questions, express feelings, and foster their creative skills. Although all students felt their journals provided a means to ask the teacher questions, only half of them used it in that manner. Larry utilized it the most to ask questions he did not want to ask in front of the class. His questions ranged from “Why do we have to write in this journal?” to asking how he did on a test and when he was going to learn about exponents (Larry, various journal entries). Though Lucas shared that he normally asked the teacher questions in class, he also used his journal to pose questions. He wondered what the upcoming poetic writing project was going to be and also expressed he had difficulty understanding the Distributive Property (Lucas, November 11 and 23, 2010). Fred and Jorge also used their journals as a forum to ask questions. Fred let his teacher know he needed more practice with multiplying decimals (October 12, 2010) and Jorge expressed that his journals were difficult to write (November 10, 2010).
Writing in mathematics provided Collin the vehicle to open up more and share his thoughts. “I’m surprised that some of his comments were so candid, that he actually kind of put more of his thoughts or feelings onto paper because in the past he really shied away from that” (Nina, parent of Collin, January 28, 2011). One instance occurred when his teacher asked him to write about one thing he would change in math class. He was forthright and said he wished there was more time between tests (Collin, December 7, 2010).

Lucas’s mother, Haley, felt writing was a good way for students to communicate with their teacher. “It’s [writing in math] a good way to express how you’re feeling about math if you’re having trouble because some may be shy” (October 28, 2010). She acknowledged this was the case with Lucas. Since she felt she could not always help him when it came to math, his journal provided him a way to communicate with the teacher and express how he felt about certain topics.

Students felt the poetic writing also allowed them to be creative. They worked both individually and collaborated with others on their creativity. Collin liked that he got to be creative and contribute his own ideas (November 8, 2010). Larry stated, “We get to take something and make it our own by putting in new words and taking out others” (September 28, 2010). Moreover, the students’ former principal believed it allowed the students to be more creative in their thinking about math in general. “I think it [writing in math] makes the kids more creative. I think it makes me more able to look at situations and come up with various solutions to find the answer” (Thomas, December 7, 2010). He
added that he felt writing in math made stronger students in general as it built upon both their math and language arts skills.

**Impact of feedback.** Six of the eight students said the feedback they received from the teacher changed how they wrote future entries, whereas Jorge and Ashley did not feel the teacher’s feedback impacted their writing. Cam, however, was the exception of these six students as his journals disconfirmed his interview responses. He said he went back and responded to teacher comments whereas his journals showed he only responded twice, both occurring before the first interview. He did not respond to any teacher feedback the rest of the year. Cam also stated he was going to explain more in future entries; yet, he did not (November 8, 2010).

Collin did change the way he wrote future entries and looked forward to the teacher’s comments. He felt her feedback changed the way he thought about what he did (Collin, November 8, 2010). Early on, his teacher asked him to explain more and provide examples. Here is an example of an entry he wrote at the beginning of the year.

Learning about equivalent decimals is interesting. I know that learning this will help me in life. Learning equivalent decimals is very fun. I think that I will use equivalent decimals all the time. I like equivalent decimals.

He later went back and added, “Decimals that have the same value. They would have to have the same value,” and provided this example: .5 = .50 (Collin, September 2, 2010). From that point, Collin then wrote more detailed explanations and included examples, as evidenced by this entry on renaming mixed numbers when subtracting.
You rename a mixed number when your subtracting by finding the LCD. (Lowest common denominator) If the numbers you subtracting are $7\frac{1}{2}$ and $5\frac{5}{8}$. You would have to change $\frac{1}{2}$ to $\frac{4}{8}$ because $\frac{4}{8} = \frac{1}{2}$. Then you would have to borrow and change $\frac{4}{8}$ to $\frac{12}{8}$ because your borrowing a whole. Then subtract it. That’s how you would rename a mixed number when subtracting.

Ex. 

\[
\begin{align*}
7\frac{1}{2} - 5\frac{5}{8} &= 6\frac{12}{8} \\
9\frac{2}{3} - 8\frac{12}{12} &= 8\frac{20}{12} \\
&\quad - 3\frac{9}{12} \\
&\quad - 4\frac{4}{12} \\
&\quad \frac{1}{8} \\
&\quad \frac{11}{12}
\end{align*}
\]

(Collin, November 30, 2010)

Lucas also added more examples in his future entries after his teacher suggested it in an entry he wrote about the Addition Properties (Lucas, November 8, 2011).

Larry believed his teacher’s feedback impacted his learning. An example he gave was when he stated he was going to practice his basic facts 15 minutes a day, twice a week because he wanted to make it into Principal’s Math Club. In a journal entry he shared he had not been practicing, and his teacher questioned why. He said after that comment he started practicing. “I finally started doing that [practicing] after she reminded me, and now I can do 100 addition problems from 1 to 9 in under 2 minutes” (Larry, November 8, 2010).

The teacher also questioned Bobbie in some of his entries. Bobbie wrote a “choice” entry on making pies. In it he exaggerated and wrote the man used two tons of
sugar in the recipe. His teacher inquired whether he really meant the man used two tons (Bobbie, September 1, 2010). Afterwards Bobbie stated he would “make it [his entries] more real, make it more nonfiction” (November 8, 2010). In a later entry in which he wrote about making tacos, Bobbie was much more realistic in his ingredients and procedures (October 13, 2010).

Fred also felt obtaining teacher comments in his journal changed the way he wrote. An example he gave was when he wrote an entry about perimeter and got it mixed up with area. “I meant to put length plus width and I put length times width” (Fred, November 8, 2010). Her comments made him pay more attention to detail because he realized one small error could make a big difference. He fixed his perimeter error in his final journal project which included that same entry.

I know that perimeter’s formula is $2l + 2w$. You should use perimeter when you are building a fence. You need to know how long you want to build the fence, then how wide you want it. Then add the length and the width and multiply it by 2 to get the perimeter. (Fred, May 24, 2011)

**Learning aid.** Students all felt writing in math helped them remember things better because as Larry stated, “I learn more by writing because when I see and hear something at the same time, it gets stored in my head” (May 26, 2011). This was something he repeated in his interview and journal. He gave an example that by writing he felt it helped him better understand the difference between expressions and equations because he got them confused. When asked in his interview to explain the difference, he was able to (Larry, November 8, 2010). Lucas echoed those same thoughts in both of his
interviews and the focus group. He recalled examples regarding inequalities and using a protractor. Collin added that the repetition of writing the words helped him remember (September 28, 2010). He and Ashley believed they understood their thoughts better when they wrote them on paper (Collin, November 8, 2010; Ashley, May 26, 2011).

During the focus group students were asked how writing in mathematics could help them learn. Cam, Fred, Jorge, and Bobbie all shared that they felt writing in math helped them “remember stuff better” (September 28, 2010).

Teacher/facilitator. Students’ deepened level of conceptual understanding allowed some of them to serve as a teacher/facilitator to others. Larry’s mother, Marissa, detected how he had slowed his thinking and provided much more detail in his thoughts; he explained to others “from a teacher/facilitator perspective rather than an almost 11-year old boy” (January 14, 2011). One example of this was when he helped his sister, who was in second grade, with math. He brought it down to her level which surprised Marissa because she did not think he would have been able to do that as in the past he was bored with lower level math (Marissa, January 14, 2011). Larry also worked with another fifth grade student who struggled in math. Marissa eavesdropped at times and listened to his explanations which she reported were mathematically correct. She was impressed by what she heard and said it was a complete change from a year prior when he could not explain how he got the answer. She noted he would have gotten frustrated and said, “Well, you just, you just get it. This is just how it is” (January 14, 2011). She added, “I’m not sure without having to write in math if he would have been able to.
Sitting down and having to write the journal has given him more patience with math” (January 14, 2011).

Fred also worked with another fifth grade student two to three days a week in math. Like Marissa, Renee (his mother) too was impressed with how her son worked with the other child. She often listened in to make sure they were working and later she and Fred discussed how he felt it went. He said, “Well, what I do is I have him do the problem and then I do the problem and if we get two different answers I explain to him why I got the answer I got and why his answer wasn’t correct” (Renee, January 27, 2011).

Though Lucas did not actually work with another student, Haley (his mother) witnessed the same teacher-like qualities. She saw a change in the level of his conceptual understanding as now he was able to explain math concepts to others. Haley knew she did not help him with his journals so when she read them she was in awe of some of the things he wrote. At times she saw him as a teacher and shared it with him. “Some of these journals that you’re writing almost sounds like you’re the teacher and you’re trying to explain how to do a problem in the classroom. I can’t believe you did that all on your own” (Haley, January 20, 2011).

**Mathematical connections.** All students and/or their parents except Bobbie noticed mathematical connections being made in their daily lives. Some of those connections were recognized at home, while others occurred at school. I believe they stemmed from students’ “choice” journals in which they had to make mathematical connections. Collin’s mother, Nina, commented, “He’s relating it [math] even more to
things around him in ways that he didn’t necessarily think about math” (September 30, 2010).

In Cam’s second interview he shared how math was incorporated into the video games he played. He gave examples such as the scores and buying and selling items in order to advance levels (Cam, February 17, 2011). Ashley also became more aware of math in her daily life. Kathy (her mother) gave an example from when Ashley had some Christmas money to spend. They were at the store and Ashley knew she had $50.00 but the game she wanted was $49.99. She figured out that with tax it would be more than what she had, so she asked her mom to cover the tax (Kathy, January 13, 2011).

Another parent, Emerson, also reported that writing in math made Jorge more aware of math in his daily life. She said that he looked for it more in the things he did. Some examples she provided were sports, collecting things, and watching/helping her cook (Emerson, January 10, 2011). Jorge also journaled about some connections he made. In an entry from late November he wrote:

I have discovered that there is math in everything you do. You use math everyday. You use math in sports. When you play baseball, the statistics tell how good you’re doing in hitting with percentages. Your batting average is also a decimal. (Jorge, November 28, 2010)

Fred made connections while at home watching TV. He said, “Like whenever something has happened that would be like I’ve seen or heard on TV or something about like numbers or math or something, then I write about that” (February 17, 2011). Haley also witnessed Lucas making connections at home. He would ask her questions when she
cooked and even about how much money she made at her job. He asked her how many hours she worked in a day and in a week (Haley, October 28, 2010).

Students also made connections from the writing they did in math to other content areas at school. Haley believed Lucas became a better writer because of all the writing he did in math that he would not have done in a typical math class. Though it cannot be reported as a direct connection to the writing in math students were immersed in all year, it should be noted that all students’ spring writing fluency scores were well above the norm. Students were tested three times throughout the year: Fall, Winter, and Spring. For each assessment, students were given the first few words of a sentence (This summer I . . .). They thought about the prompt for one minute and then wrote about it for three minutes. The numbers in the table indicate how many words they wrote during the three minutes.

Finally, Marissa saw where Larry’s newfound elaboration and detail flowed over to other subjects. An example of that was with a Revolutionary War project he did in Social Studies. She shared that prior to writing in math her son wrote things like, “Born, date. Died, date” and that was it (January 14, 2011). As he wrote in math more, he expanded his thoughts and provided more detail. Fred too made connections with other subject areas. He related things he learned in math to science. “I’ve discovered math isn’t some rinky dink problem you work on. It has some things to do with science. Such as a variable, anything that can change in an experiment. Variable: an unknown number. They’re both unknown” (Fred, November 28, 2010).
Table 6

*Writing Fluency Table*

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Norm: 37 words per 3 min.</td>
<td>Norm: 45 words per 3 min.</td>
<td>Norm: 45 words per 3 min.</td>
</tr>
<tr>
<td>Collin</td>
<td>26</td>
<td>74</td>
<td>79</td>
</tr>
<tr>
<td>Bobbie</td>
<td>62</td>
<td>a-</td>
<td>74</td>
</tr>
<tr>
<td>Jorge</td>
<td>54</td>
<td>76</td>
<td>80</td>
</tr>
<tr>
<td>Larry</td>
<td>40</td>
<td>64</td>
<td>60</td>
</tr>
<tr>
<td>Fred</td>
<td>32</td>
<td>48</td>
<td>61</td>
</tr>
<tr>
<td>Lucas</td>
<td>37</td>
<td>54</td>
<td>56</td>
</tr>
<tr>
<td>Cam</td>
<td>37</td>
<td>58</td>
<td>62</td>
</tr>
<tr>
<td>Ashley</td>
<td>29</td>
<td>37</td>
<td>66</td>
</tr>
</tbody>
</table>

*Note.* a- indicates he was not tested in the Winter.

**Summary.** Using data from interviews, document analysis, and a focus group, I have answered Research Question Two: How do transactional/expressive and poetic writing in mathematics impact student learning? One theme emerged from the data to answer this question: Deepened Understandings. Six strands fell under this theme: Historical artifact, Vehicle for communication, Impact of feedback, Learning aid, Teacher/Facilitator, and Mathematical connections. These strands showed that transactional/expressive and poetic writing in mathematics positively impacted student learning and benefited the teacher as well.
Student journals served as a historical artifact in which they were able to review concepts previously learned. The journals offered students a forum to ask questions, express themselves, and foster their creativity. When the teacher gave feedback, it changed the way a number of students wrote their future entries by explaining with more detail and inserting examples to show what they learned. Writing in math served as a learning aid because it provided students another modality that helped solidify their learning. Writing forced students to slow down their thought processes and reflect more on sense-making. The resulting deepened level of understanding allowed them to explain concepts to others as though they were the teacher. Finally, students began making mathematical connections in their daily lives, both at home and school.

This chapter served to answer the two research questions regarding writing in mathematics by presenting the findings for each based on data from interviews, document analysis, and a focus group. It was shown that the eight mathematically gifted students generally did not mind writing in math or enjoyed it as they all displayed neutral to positive attitudes, though they preferred poetic writing. Both types of writing positively impacted student learning as just previously presented. In the next chapter, discussions and implications of the findings are related to the literature and recommendations for future implementation of writing in the math classroom are provided. Additionally, recommendations for future research are made, and I conclude with some final thoughts.
CHAPTER VI
DISCUSSION AND IMPLICATIONS

Introduction

Within the last 20 years writing in mathematics has been brought increasingly into the spotlight of mathematics education. What was once dominated by oral communication now has to share the stage with written communication. Reform efforts in mathematics education by the National Council of Teachers of Mathematics (NCTM) have prioritized communication in mathematics at all levels (1989, 2000). Beginning with the *Curriculum and Evaluation Standards for School Mathematics*, NCTM (1989) presented five general goals for all students, one of which was to communicate mathematically. Eleven years later, NCTM published *Principles and Standards for School Mathematics* (2000) which built upon the *Standards* (1989). Communication was still viewed as a crucial part of mathematics and was one of the 10 standards laid out in that document. Now we look to the *Common Core State Standards* (2010) where communication is essential. The new “Standards for Mathematical Practice” seem to encapsulate the former NCTM process standards of problem solving, reasoning and proof, communication, representation, and connections.

The purpose of this study was to investigate and describe mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in a classroom utilizing writing in mathematics and its impact on their learning. Students from a small rural school district were immersed in various transactional/expressive and poetic writing projects throughout the year. Interviews, document analysis, and a focus group were
conducted and analyzed to determine those attitudes and how writing in mathematics impacted their learning.

In this chapter discussions and implications of the findings are related to the literature and recommendations for future implementation of writing in the math classroom are provided. Additionally, recommendations for future research are made, and I conclude with some final thoughts.

**Discussion and Implications**

Using a constructivist paradigm, this study examined eight fifth grade mathematically gifted students’ attitudes toward transactional/expressive and poetic writing through a case study approach. More specifically, the research questions were:

1. What are mathematically gifted students’ attitudes towards transactional/expressive and poetic writing in mathematics?
2. How do transactional/expressive and poetic writing in mathematics impact student learning?

This study answered those questions based on data from interviews, document analysis, and a focus group. The results of the analysis showed that the mathematically gifted students generally did not mind writing in math or enjoyed it as they all displayed neutral to positive attitudes, though they preferred poetic writing. Both types of writing positively impacted student learning.

**Research Question One**

Two themes emerged from the data which answered the first research question: One Hand Up, Maybe Two, and Poetic Trumps Transactional/Expressive.
One hand up, maybe two. Data collected and analyzed from the focus group, interviews, and documents revealed that all parents and three students (Larry, Collin, and Lucas) had positive attitudes based on responses from the focus group and interviews. The other five students’ attitudes (Cam, Jorge, Ashley, Bobbie, and Fred) were characterized as neutral. Therefore, the eight mathematically gifted students generally did not mind writing in math or enjoyed it as they all displayed neutral to positive attitudes. These findings confirmed research previously conducted. Jurdak and Zein (1998), who looked at students 11–13 years old, found students had positive attitudes toward journal writing which included transactional and expressive types of writing prompts. In fact, 92.3% of the students reported in a questionnaire that they would like to continue journal writing in mathematics (Jurdak & Zein, 1998). A year earlier, Ciochine and Polivka (1997) also conducted a study with middle age students to find they enjoyed the various types of transactional (Problem of the Week), as well as creative (mysteries and number autobiographies) writing.

Research on gifted students’ attitudes toward writing in mathematics had been limited and lacking. Studies which involved all students (not just gifted students) showed students generally had positive attitudes toward writing in mathematics (Borasi & Rose, 1989; Ciochine & Polivka, 1997; Johanning, 2000). My study added to this body of research as it confirmed those findings.

Data showed there were some initial beliefs and challenges which may have led to the lower initial ratings for five of the participants, four of which were students: Cam, Ashley, Larry, and Collin. For example, there was no prior experience with writing in
mathematics on the part of the parents or students. In addition, neither students nor their parents understood what writing in mathematics was or what it looked like. Finally, students displayed an initial inability to get their thoughts on paper. I believe these beliefs and challenges I uncovered from the data both confirm and contribute to what others have written.

A main reason both students and their parents found writing in math to be such a new concept was none of them had any prior experience with it, and most of them had not even heard of it before. Based on the fact the parents were initially confused by the whole concept of writing in mathematics, it was no wonder that the students were perplexed. The inability to initially utilize their parent as a resource when writing their journals at home may have been a reason they exhibited some of the initial challenges. Both students and their parents originally saw writing and mathematics as two very separate subjects. This confirmed what a number of researchers had found. It was shown that many students and mathematics’ educators expressed concern about using writing in the math classroom; they believed writing should be reserved for language arts (Borasi & Rose, 1989; Ciochine & Polivka, 1997; Watson, 1980; P. E. Whitin & Whitin, 1997; Williams & Wynne, 2000; Zinsser, 1988). It was a struggle for them in the beginning to see how the two could be connected.

The lack of prior experience led to their initial confusion of “why” they had to write in math. It was something that was expressed by all eight students. All students felt it was much easier to verbally explain something than to write it on paper. One of the reasons Collin struggled was because he was used to doing mental math. Larry echoed
that initial struggle when it came to his journals because he did not know how to write them or even what to write because in the past he always did it mentally. Research has shown that mathematics educators who used writing in the classroom faced this battle with mathematically gifted students. They did not feel the need to write as they oftentimes went through the process mentally (Zupancic & Ishii, 2002). As Gopen and Smith reported, this not only occurs at the elementary level. They discussed how college students’ struggled to transition from using numbers and believing in absolute truths to realizing there could be multiple interpretations once words came into play. Students were being asked to think rather than let the numbers or formulas be their thoughts (Gopen & Smith, 1990).

Rachel felt her son, Bobbie, was challenged by the journal entries in which he was given a specific topic to write about because he struggled to get his thoughts on paper. He did not like having to slow down and think through how he solved a problem or came up with an answer because he was used to doing it mentally most of the time. This is a common characteristic displayed by mathematically gifted school age children as they are able to come up with the correct answers quickly and accurately (Rotigel & Fello, 2005).

One parent, Renee, felt her attitude changed because she did not understand what writing in math was or its purpose initially, but when she did she started thinking differently about math. I believe that was the case with those students (Cam, Ashley, Larry, and Collin) whose attitudes changed as well. They never thought of writing as having a place in the math classroom prior to being introduced to it in fifth grade. They experienced a change in their method to learning, and change is not always easy.
According to Walker and Soltis (2004), there are four stances teachers can take with regards to reform: embrace it, resist it, adapt it to your own purposes, or ignore it. Though they spoke of teachers, I find it demonstrates my point. Students needed to “embrace” this change of a mathematics classroom which utilized writing and did. To that end, Kersaint (2007) felt in order to promote mathematics literacy in the classroom students needed to be encouraged to think and reason, communicate, and use various representations as well as make mathematical connections with what they were learning, something their math teacher did.

**Poetic trumps transactional/expressive.** Data collected and analyzed from the focus group, interviews, and documents indicated students preferred poetic writing over transactional/expressive. Students enjoyed the poetic writing because it provided them an opportunity to collaborate with others and be creative. Working on the Math Pledges in a group allowed students to divide tasks and brainstorm together. Writing their own Math Nursery Rhyme book allowed them to take something and make it their own. Students were in control of the creative process as they acted as both authors and illustrators. This supported what had been written by others. Poetic writing encourages imagination and is often synonymous with creative writing, is for “readers to experience the writing, to be observers, to emotionally and intellectually give themselves over to the creation” (Romano, 2000, p. 137).

Writing in mathematics can rejuvenate students who become bored. It provides an opportunity for higher level math students to showcase their creativity. Ashley was bored when she had to write about a specific topic but when she engaged in poetic
writing she was in control of her creativity. Challenging tasks need to be designed that are authentic, develop metacognition, and increase motivation (Diezmann & Watters, 2005). In addition, it can be an individualized tool used in trying to make sense of a topic a gifted student may be stumped by for the first time (Birken, 1989). Bobbie’s mother, Rachel, thought writing in math challenged kids and made them look at things differently (January 25, 2011). Johnson (1983) wrote, “Writing is a device that can greatly aid in the problem-solving process and stimulate creative thought by the student” (p. 119).

Students liked poetic writing from the aspect that it was something different from what they had experienced in a typical math class. It was not just completing a page of math problems for homework. Another reason students preferred the poetic writing was probably because it was done at school while their journals were written at home. As Bobbie and Cam previously stated, they viewed the journal as extra homework.

**Research Question Two**

One theme emerged from the data which answered the second research question: Deepened Understandings. Data collected and analyzed from the focus group, interviews, and documents for this theme was not only garnered from students but their parents and the current and former principals too. Six strands fell under this theme: Historical artifact, Vehicle for communication, Impact of feedback, Learning aid, Teacher/Facilitator, and Mathematical connections. These strands showed that transactional/expressive and poetic writing in mathematics positively impacted student learning and benefited the teacher as well.
Deepened understandings. Writing is important in all school subject areas but is rarely used in traditional mathematics classes. When writing in mathematics is employed, it can be a tool for learning. Research has found that there could be many positive effects to both students and teachers when writing in the math classroom is utilized as was discussed in chapter 2 (Aspinwall & Aspinwall, 2003; Dusterhoff, 1995; Elliott, 1996; Gordon & Macinnis, 1993; Johnson, 1983; Krussel, 1998; Mayer & Hillman, 1996; Montague, 1973; Pugalee, 1997; Watson, 1980). In this study students, and especially their parents, saw how writing in mathematics led to developing deeper mathematical understandings in a variety of ways.

Journals served as a historical artifact for students in two ways. They allowed students to review concepts previously learned and served as a resource that students either referred to if they forgot something or assisted them in completing their homework. This notion was paralleled by other studies. According to Albert (2000), students expressed how they were able to use their writing as a record of their thoughts that they could go back and reread. They felt doing this would be beneficial in the future if they forget something. In addition, Johanning (2000) developed a writing program for two seventh grade gifted classes and one advanced eighth grade class. The act of students putting their thoughts onto paper introduced an added element in the learning process that was typically not there. Students themselves noted three benefits. Writing helped them “find their mistakes, helped them remember the problem better, and helped them understand the problem better” (Johanning, 2000, p. 154).
Bell and Bell (1985) cited two benefits of using expository (transactional) writing. Writing can provide communication dialogue between students and teachers, and it also offers teachers an opportunity to provide individual feedback to students in order to clear up any misconceptions. Student journals from the present study corroborated this as they utilized writing in math as a vehicle for communication to ask questions, express feelings, and foster their creative skills. In addition, six of the eight students said the feedback they received from the teacher changed how they wrote future entries. They looked forward to the teacher’s comments and felt her feedback changed the way they thought about what they did. Students started explaining with greater detail and including examples to show what they learned.

Writing in mathematics can be used in a variety of ways although Johanning (2000) felt the most important feature of writing is that it is reflective; it forces a person to think before doing, in contrast to orally communicating ideas. This reflection allows students to develop a deeper understanding of concepts. “Writing about a problem and including writing as an integral part of the thinking process helps students to slow their thinking for time to clarify thoughts, identify concepts, and refocus possible questions and solutions” (Barone & Taylor, 2006, p. 80). When students write, they supply themselves physical evidence of their thoughts which allows the opportunity for self-checking. Putting their thoughts on paper promotes metacognition. It forces students to think about their thinking which adds to their understanding. It is a recursive process between thinking, writing, and reflecting.
In this study, students all felt writing in math helped them remember things better. Writing provided students a way to see their thoughts. Haley and her son, Lucas, felt he understood the material better when he wrote because he had to take the time to think through what he learned in order to write about it. Emerson also felt writing in math increased Jorge’s conceptual understanding because it made him stop and think about what he was doing when he worked through problems. This notion was also paralleled by three other parents: Rachel, Renee, and Kathy.

Writing in math not only forced students to slow down their thought processes, but it also allowed them to reflect on their writing which clarified and built understanding. NCTM (1989) noted, “The simple exercise of writing an explanation of how a problem was solved not only helps clarify a student’s thinking but also may provide other students fresh insights gained from viewing the problem from a new perspective” (p. 142). The math journals provided Collin an opportunity to self-correct when he went back and saw what he wrote as well as look at things from a different perspective. By reflecting on what they have written, writing helps students find their mistakes. “Because when I work it out at the top, just using the numbers, I think I have it, and then when I write it out, I think about it more, and I catch my mistakes when I write it” (Johanning, 2000, p. 154). Writing is a way for students to make their thinking visible. Once they can begin to see their thoughts on paper, they can begin to see its usefulness. Expressive writing, also known as “informal writing” was believed by Barone and Taylor (2006) to have two goals:
1. Students’ clarification and extension of thinking about a content area (in this case mathematics) or topic.

2. Students’ and teacher’s understanding of misconceptions or incomplete knowledge of the content area or topic to serve as a basis for further instruction.

The students’ journals successfully achieved both of these goals.

Extending the literature on the benefits of writing in mathematics, my research showed how students’ deepened level of conceptual understanding allowed some of them to serve as a teacher/facilitator to others. It was previously stated how Larry, Fred, and Lucas were able to explain concepts to others as though they were the teacher. Larry demonstrated more detail in his thoughts and patience when working with others. Fred was able to explain to others why their solutions were incorrect. Lucas’s mother, Haley, saw a change in the level of his conceptual understanding as now he was able to explain math concepts to others.

Finally, students also focused more on making meaningful connections. All students and/or their parents except Bobbie noticed mathematical connections being made in their daily lives. Some of those connections were recognized at home, while others occurred at school. I believe they stemmed from students’ “choice” journals in which they had to make mathematical connections. This supported Dusterhoff (1995) when he claimed, “As the curriculum becomes more tightly packed with each new mandate and trend, it’s important that our students be able to connect the pieces into meaningful wholes that can be applied to their future lives and learning” (p. 48).
Recommendations

There are four major recommendations that should be considered based on the findings of this study: Recommendations for Practitioners, Administrators, Education, and Future Research.

Recommendations for Practitioners

By the time students leave elementary school, many do not view writing as an integral part of learning mathematics (Liedtke & Sales, 2008). Students need to be provided an outlet to demonstrate their level of mathematical understanding, not just that they can obtain the correct answer. The results of this study showed how the implementation of transactional/expressive and poetic writing can provide such an avenue. Therefore, writing should be used as a pedagogical tool in the teaching of mathematics. Borasi and Rose (1989) discussed how using journals can guide future curriculum making decisions. Once teachers read student journals and learn what students understand versus what they are still struggling with, they can plan to remediate or see students are ready to build upon their new knowledge. Though writing may provide windows for teachers to get to know their students, it has to be looked at as purposeful by the student; then, and only then can the dialogue be meaningful. In this study, students initially struggled to see the purpose.

As educators are just starting to implement writing into their classrooms, I feel they need to set realistic expectations. They need to encourage the students and note progressions. Fulwiler (1986) also argued that students need to have faith and patience when starting out and they will come to see where it can take them. “I begin writing with
a more or less clear direction in mind—in my head—and always discover that the act of writing takes me places I never imagined . . . I’ve learned to trust the process” (Fulwiler, 1986, pp. 22-23). He felt teachers needed to teach their students to trust the process too. As this study revealed, teachers need to show students more examples of writing from the beginning as well as be aware of the challenges that may occur. The initial beliefs and challenges unveiled in this study may better prepare educators who begin implementation of writing in their mathematics classrooms.

Kersaint (2007) contended, “mathematics literacy can be characterized as the use of oral or written language to make sense of mathematics and to communicate, solve problems, and engage in discussions and decision making” (p. 89). To promote this in the classroom students should be encouraged to think and reason, communicate, and use various representations as well as make mathematical connections with what they are learning (Kersaint, 2007). This notion was supported by Kembitzky (2009) who stated, “Literacy and writing need to find a place in the mathematics classroom to promote student success. This might seem a daunting task to what is already a complicated situation” (p. 45). One way to develop this mathematically literate citizen is to build discourse communities in the classroom. To do so students need to be encouraged to “explain, build and go beyond.” Sherin et al. (2000) stated,

The *explain* strategy involves giving a reason for a particular idea or stating how you arrived at a specific result. *Build* refers to building on other students’ ideas. *Go beyond* involves generalizing from a particular example to a broader mathematical issue. (p. 189)
Although that was initially intended to be used for oral discourse, I believe it could be applied to written discourse as well. In fact, with the technological advancements occurring, it can go well beyond the classroom. With technology at our fingertips, teachers can explore various avenues of writing. Students can write in math by engaging in blogs on the web or exchanging ideas with others through email. In doing so, it would still allow students to go back and read their own and each other’s posts, help review for assessments, and be used as a resource tool.

**Recommendations for Administrators**

Teachers will need support from administration for successful implementation. School administrators wishing to incorporate writing into their mathematics classes need to provide professional development opportunities for their teachers. Educators struggle with questions of how and when to use writing in their mathematics classrooms as was showcased in chapter 2.

Teachers sometimes find it difficult to change the way they teach and implementing writing in mathematics will require change in their pedagogical practices. Mewborn and Cross (2007) claimed,

> Beliefs that have been held for a long time are more resistant to change. Thus, teachers need sustained and consistent support if they are going to undertake a serious examination of their beliefs about mathematics and learning and the classroom practices that result from these beliefs. (p. 267)

Administrators can implement professional learning communities (PLC) as a support group for teachers centered on writing in mathematics. These PLC can be utilized by
administrators as a place to provide collaboration with Language Arts teachers who can help guide the planning of writing assignments, creation of rubrics, and other writing ideas and activities.

For teachers to buy into this change they need to be made aware of the benefits of using writing as a tool in the math classroom. Certainly this study can be utilized as a basis for providing them with numerous benefits to both students and the teacher as presented in Table 7.

Table 7

*Benefits of Writing in Mathematics (From This Study)*

<table>
<thead>
<tr>
<th>Students</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Foster creativity and collaboration with others</em></td>
<td><em>Provide a means to give individual feedback to students</em></td>
</tr>
<tr>
<td><em>Provide forum to ask questions, express themselves, and foster creativity</em></td>
<td><em>Be used to assess student understanding</em></td>
</tr>
<tr>
<td><em>Build conceptual understanding</em></td>
<td><em>Provide insight to student development in both the affective and cognitive domains</em></td>
</tr>
<tr>
<td><em>Clarify student thinking</em></td>
<td><em>Serve as informal assessment – provides window into students’ thinking</em></td>
</tr>
<tr>
<td><em>Help identify areas of difficulty</em></td>
<td></td>
</tr>
<tr>
<td><em>Help students keep track of their thoughts</em></td>
<td></td>
</tr>
<tr>
<td><em>Help students makes mathematical connections in their daily lives</em></td>
<td></td>
</tr>
<tr>
<td><em>Review concepts previously learned</em></td>
<td></td>
</tr>
<tr>
<td><em>Slow down student thought processes and reflect more on sense-making</em></td>
<td></td>
</tr>
</tbody>
</table>
Another benefit of writing in mathematics is that students are involved in active learning and critical reflection. The National Writing Project and Carl Nagin (2006) opined, “writing is a complex activity; more than just a skill or talent, it is a means of inquiry and expression for learning in all grades and disciplines” (p. 3).

**Recommendations for Education**

In this transitional era from the *Principles and Standards for School Mathematics* (NCTM, 2000) to the *Common Core State Standards* (2010), it is not only extremely important that the spotlight be on an interdisciplinary approach, but also written communication in mathematics. All students in grades 3 through 8 are annually assessed and will continue to be. Whether they are being tested in mathematics, reading, or science, they are still expected to be able to demonstrate their level of understanding through open-ended written responses. Writing can no longer be left to language arts class solely or used by the minority of mathematics teachers. Writing has to become a regular part of all content areas, including mathematics, though this study proved they are still viewed as separate entities.

The reasons Quinn and Wilson (1997) cited teachers used writing in math so sparingly were students’ poor writing skills, the class time it would take, and the time on the teacher’s part to grade students’ writing. Another reason may have been lack of teacher preparation. “Most teacher education programs do not furnish prospective teachers with extensive experience with mathematical discourse, nor do most graduate-degree programs for teachers” (Silver & Smith, 1996, p. 26). Therefore, teacher education programs can help by emphasizing the importance of writing in the content
areas as well as providing pre-service teachers with ideas of how to successfully implement writing into the math classroom.

**Recommendations for Future Research**

The present study looked at mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in a classroom utilizing writing in mathematics and its impact on their learning. A number of valuable studies could naturally flow from the present study. I look to fellow scholars to conduct longitudinal studies with mathematically gifted students in a variety of contexts. First, do these students continue writing on their own if they move to a class that does not utilize writing in mathematics as a tool because they have experienced the benefits of it? In communicating with Larry’s mother, Marissa, she shared that when he changed schools the following year she was still going to have him keep a journal even if it was not required because she saw the benefits of when he did. Additionally, a longitudinal study could be done to compare students who wrote in mathematics with those who did not when looking at their mean score per extended-response question on the annual state assessments.

In addition to conducting longitudinal studies, it would be valuable to have research which looked at how writing in mathematics affects other content areas from an interdisciplinary approach. For example, it was shown in the present study that Marissa saw how Larry’s newfound elaboration and detail flowed over to other subjects. An example of that was with a Revolutionary War project he did in Social Studies. She shared that prior to writing in math her son wrote things like, “Born, date. Died, date”
and that was it (January 14, 2011). As he wrote in math more, he expanded his thoughts and provided more detail.

Research on what helps students understand the purpose of writing in mathematics can be beneficial. As was documented in my initial interviews with parents, it was a repeated theme that their child did not understand “why” they were writing in math class initially even after several conversations in the classroom occurred. If this information was known and provided to educators, it would help make for a much smoother transition and allow students to use writing in math to their benefit earlier on.

Howley et al. (2005) opined, “The extant literature, though descriptive of gifted children’s attitudes toward mathematics, does not reveal much about the wider context that shapes the practices of mathematics learning and teaching for mathematically talented students” (p. 130). Therefore, more research on the wider context of teaching and learning mathematically gifted students can be done. This study sought to provide some of this context but surely is just a starting point for additional research.

Forthcoming, I will continue to focus my research interests on writing in the mathematics classroom as it lends itself nicely to my line of inquiry. Though I am sure it will continue to emerge and refine itself, my line of inquiry will center on creating the mathematically literate citizen. How does one do this? What does it look like? Why the need for such a creation? How can it impact student learning? What are the implications for teachers? What are the implications for students? Some of the main focal points in mathematics today seem to hone in on the students’ ability to think and reason, as well as their capacity to clearly communicate their mathematical reasoning. These highlighted
areas afford me the opportunity to continue to make original scholarly contributions and provide a rich research agenda to fellow colleagues with similar interests.

**Final Thoughts**

“In the United States and in virtually every Western democracy, there is a national clash as to what students should learn and how they should learn it” (Canestrari & Marlowe, 2004, p. ix). This study helped mathematics educators learn what mathematically gifted students’ attitudes are toward transactional/expressive and poetic writing in the math classroom. More importantly, it helped educators see the benefits of implementing writing into their classroom. By educating mathematics educators of the value and place writing has in the math classroom, it is hoped that it would create a domino effect. That effect would be an increase in the number of mathematics educators utilizing writing in their math classrooms and creating positive student attitudes towards it as well.

The road to reform educators are being asked to take will not come without its challenges. “‘Learning by doing’ and ‘learning from experience’ became the slogans that progressive educators took away from Dewey” (Walker & Soltis, 2004, p. 17). What slogans will educators take away from the *Common Core State Standards* (2010) in regards to the Standards for Mathematical Practice? Brooks and Brooks (1999) stated, “In order to understand, students must search for meaning. In order to search for meaning, students must have the opportunity to form and ask questions” (p. 54). Writing in mathematics is one way to afford students the opportunity to formulate and ask questions. Knowing that we construct our understandings from experience, the more we
can get students to become active participants in the classroom, the richer experiences we can provide them.

My vision for educators is to expand the teaching practices and curriculum of the traditional mathematics classroom to include written communication as explicated in the Common Core State Standards (2010). It is in these new standards that mathematical understanding and procedural skills are being weighed as equally important. “One hallmark of mathematical understanding is the ability to justify, in a way appropriate to the student’s mathematical maturity, why a particular mathematical statement is true or where a mathematical rule comes from” (p. 4). The new “Standards for Mathematical Practice” seem to encapsulate the former Mathematical Process Standards of problem solving, reasoning and proof, communication, representation, and connections. These eight Standards for Mathematical Practice include:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning. (pp. 6-8)

They each go on to nudge various aspects of communication.
Teaching needs to involve much more than the basics, much more than mere procedural understanding if we expect to develop students into 21st century critical thinking problem solvers. Teaching and assessment will need to involve innovative techniques and approaches. Maybe with the adoption of the Common Core State Standards (2010) that continue to focus on communication, more educators will see a need to learn how to implement those standards as the assessments in 2014 will be reflective of a more balanced emphasis between mathematical understandings and procedural skills.

We need writing in the mathematics classroom that involves the inclusion of student voice. We need to continue to push students’ thinking forward, especially the mathematically gifted students so they do not become bored or left behind. Students need to be pressed to mentally wrestle with ideas. We need to allow for creativity in the math classroom. It is not so much the type of writing they are doing that matters, but that we begin to change because “without thinking teachers, we do not have thinking schools. Without thinking schools, we do not have thinking students or future citizens who can think” (Page, 2004, p. 219).

This study investigated and described mathematically gifted students’ attitudes toward transactional/expressive and poetic writing in a classroom utilizing writing in mathematics and how it impacted their learning. The results of the analysis showed that the mathematically gifted students generally did not mind writing in math or enjoyed it as they all displayed neutral to positive attitudes, though they preferred poetic writing. Both types of writing positively impacted student learning.
In this chapter discussions and implications of the findings were related to the literature and recommendations for future implementation of writing in the math classroom were provided. Additionally, recommendations for future research were made, and I concluded with some final thoughts.
APPENDICES
APPENDIX A

PARENT CONSENT FORMS
Appendix A

Parent Consent Forms

Informed Consent to Participate in a Research Study

**Study Title:** Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

**Principal Investigator:** Terri Hrina-Treharn

You are being invited to participate in a research study. This consent form will provide you with information on the research project, what you will need to do, and the associated risks and benefits of the research. Your participation is voluntary. Please read this form carefully. It is important that you ask questions and fully understand the research in order to make an informed decision. You will receive a copy of this document to take with you.

**Purpose:** The purpose of this study is to investigate and describe mathematically gifted students’ attitudes toward transactional/expressive (expository) and poetic (creative) writing in a classroom utilizing writing in mathematics. My goal is to inform teacher practice as understanding these attitudes and using writing in the mathematics classroom has many benefits for both students and teachers.

**Procedures:** I would like you to take part in this project that (for your participation purposes) will predominantly last from September to January though I will make one final request for any other input in May. If you decide to do this, you will be asked to keep a journal (either written, emailed or tape-recorded) by making an entry at least once every two weeks and participate in two individual interviews (September and January). The interviews will last approximately 45-60 minutes. As a cue to complete the journal entries I will be sending you a reminder email or written note should you not have internet access. The information I am looking for in the journal entries are observations of your child’s experiences with writing in mathematics. I am seeking any comments your child may make during math homework that includes writing, experiences he or she may discuss relating to writing in math class, attitudes and behaviors when it comes to completing math assignments at home that involve writing, or anything else you deem would highlight this same sort of information.

**Audio and Video Recording and Photography:** The interviews will be audio taped so that they can be transcribed. No one outside the research study will have access to the audio tapes. Your interview responses will be kept completely anonymous through the use of pseudonyms in the project report, any conference presentations, and any professional publications. You have the right to hear these tapes before they are used if you so choose.

**Benefits:** This research will not benefit you directly. However, your participation in this study will help me to better understand student attitudes toward writing in math. This will
contribute to the scholarly literature regarding mathematically gifted student attitudes and may have implications on future curricular decision-making by mathematics teachers and teachers of the gifted in the elementary classroom.

**Risks and Discomforts:** There are no anticipated risks beyond those encountered in everyday life.

**Privacy and Confidentiality:** Your interview responses will be kept completely anonymous through the use of pseudonyms in the research report, any conference presentations, and any professional publications. The same will be done for any content from your journal entries that may be used.

**Voluntary Participation:** Taking part in this research study is entirely up to you. You may choose not to participate or you may discontinue your participation at any time and no one will hold it against you. Taking part in this study will not affect your child’s math grade in any way.

**Contact Information:** If you have any questions or concerns about this research, you may contact Terri Hrina-Treharn at 330-676-0956/ thrinatr@kent.edu or Dr. Susan Iverson at 330-672-0653/ siverson@kent.edu. This project has been approved by the Kent State University Institutional Review Board. If you have any questions about your rights as a research participant or complaints about the research, you may call the IRB at 330-672-2704.

Sincerely,

Terri Hrina-Treharn

**Consent Statement and Signature:** Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

I have read this consent form and have had the opportunity to have my questions answered to my satisfaction. I voluntarily agree to participate in this study. I know what I will have to do and that I can stop at any time. I understand that Mrs. Hrina-Treharn has looked at my child’s school record to see that he or she has been identified as superior cognitively gifted by the State of Ohio guidelines or mathematically gifted by the State of Ohio standards. I understand that a copy of this consent will be provided to me for future reference.

_________________________  ___________________________
Signature                        Date
Audiotape/Video Consent Form

Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

Terri Hrina-Treharn

I agree to participate in two audio-taped interviews about mathematically gifted students’ attitudes toward writing in math as part of this project and for the purposes of data analysis. I agree that Terri Hrina-Treharn may audio-tape these interviews. The date, time, and place of the interviews will be mutually agreed upon.

____________________________________________________________________________
Signature        Date

I have been told that I have the right to listen to the recordings of the interviews before they are used. I have decided that I:

_____ want to listen to the recordings  _____ do not want to listen to the recordings

Sign now below if you do not want to listen to the recordings. If you want to listen to the recordings, you will be asked to sign after listening to them.

Terri Hrina-Treharn may / may not (circle one) use the audio-tapes made of me. The original tapes or copies may be used for:

_____ this research project  ____ publication  _____ presentation at professional meetings

____________________________________________________________________________
Signature        Date

Address:
Appendix B

Student Consent Forms

Informed Consent to Participate in a Research Study

**Study Title:** Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

**Principal Investigator:** Terri Hrina-Treharn

Your child is being invited to participate in a research study. This consent form will provide you with information on the research project, what your child will need to do, and the associated risks and benefits of the research. Your child’s participation is voluntary. Please read this form carefully. It is important that you ask questions and fully understand the research in order to make an informed decision. You will receive a copy of this document to take with you.

**Purpose:** The purpose of this study is to investigate and describe mathematically gifted students’ attitudes toward transactional/expressive (expository) and poetic (creative) writing in a classroom utilizing writing in mathematics. My goal is to inform teacher practice as understanding these attitudes and using writing in the mathematics classroom has many benefits for both students and teachers.

**Procedures:** I would like your child to take part in this project for the 2010-2011 academic school year. If you decide to let your child do this, he or she will participate in a focus group (September) with the other students in the study, two individual interviews (November and January), and documents such as work samples and journal entries will be collected throughout as a regular part of their math class. The focus group will last approximately 45-60 minutes one day after school. Light snacks and a drink will be provided as students may be hungry after being in school all day or use to having a snack right after school. Interviews will last approximately 45 minutes.

**Audio and Video Recording and Photography:** Both the focus group and interviews will be audio taped so that they can be transcribed. No one outside the research study will have access to the audio tapes. Your child’s interview responses will be kept completely anonymous through the use of pseudonyms in the project report, any conference presentations, and any professional publications. You have the right to hear these tapes before they are used if you so choose.

**Benefits:** This research will not benefit your child directly. However, their participation in this study will help me to better understand student attitudes toward writing in math. This will contribute to the scholarly literature regarding mathematically gifted student attitudes and may have implications on future curricular decision-making by mathematics teachers and teachers of the gifted in the elementary classroom.
Risks and Discomforts: There are no anticipated risks beyond those encountered in everyday life.

Privacy and Confidentiality: Your child’s focus group and interview responses will be kept completely anonymous through the use of pseudonyms in the research report, any conference presentations, and any professional publications. The same will be done for any work samples or excerpts from work samples that may be used.

Compensation: Your child will be given a book and/or gift card as compensation for their time.

Voluntary Participation: Taking part in this project is entirely up to you and your child, and no one will hold it against you or your child if he decides not to do it. If your child does decide to take part, he or she may stop at any time. Taking part in this study will not affect your child’s math grade in any way.

Contact Information: If you have any questions or concerns about this research, you may contact Terri Hrina-Treharn at 330-676-0956/thrinatr@kent.edu or Dr. Susan Iverson at 330-672-0653/siverson@kent.edu. This project has been approved by the Kent State University Institutional Review Board. If you have any questions about your rights as a research participant or complaints about the research, you may call the IRB at 330-672-2704.

Sincerely,

Terri Hrina-Treharn

Consent Statement and Signature: Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

I have read this consent form and have had the opportunity to have my questions answered to my satisfaction. I voluntarily agree to allow my child to participate in this study. I know what he or she will have to do and that he or she can stop at any time. I understand that Mrs. Hrina-Treharn has looked at my child’s school record to see that he or she has been identified as superior cognitively gifted by the State of Ohio guidelines or mathematically gifted by the State of Ohio standards. I understand that a copy of this consent will be provided to me for future reference.

____________________________________________________________________________
Signature        Date
AUDIOTAPE/VIDEO CONSENT FORM

Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

Terri Hrina-Treharn

I agree to have my child participate in an audio-taped focus group and interviews about mathematically gifted students’ attitudes toward writing in math as part of this project and for the purposes of data analysis. I agree that Terri Hrina-Treharn may audio-tape this focus group and interviews. The date, time, and place of both the focus group and interviews will be mutually agreed upon.

__________________________________________
Signature                      Date

I have been told that I have the right to listen to the recording of the interviews before they are used. I have decided that I:

_____want to listen to the recordings    _____do not want to listen to the recordings

Sign now below if you do not want to listen to the recordings. If you want to listen to the recordings, you will be asked to sign after listening to them.

Terri Hrina-Treharn may / may not (circle one) use the audio-tapes made of my child. The original tapes or copies may be used for:

_____this research project   _____publication   _____presentation at professional meetings

__________________________________________
Signature                      Date

Address:
Appendix C

Principal Consent Forms

Informed Consent to Participate in a Research Study

Study Title: Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

Principal Investigator: Terri Hrina-Treharn

You are being invited to participate in a research study. This consent form will provide you with information on the research project, what you will need to do, and the associated risks and benefits of the research. Your participation is voluntary. Please read this form carefully. It is important that you ask questions and fully understand the research in order to make an informed decision. You will receive a copy of this document to take with you.

Purpose: The purpose of this study is to investigate and describe mathematically gifted students’ attitudes toward transactional/expressive (expository) and poetic (creative) writing in a classroom utilizing writing in mathematics. My goal is to inform teacher practice as understanding these attitudes and using writing in the mathematics classroom has many benefits for both students and teachers.

Procedures: I would like you to take part in this project that will last the entire 2010-2011 academic school year. For your participation purposes, if you decide to do this, it will involve one interview occurring sometime in December. The interview will last approximately 45-60 minutes and will focus on student attitudes toward transactional/expressive (expository) and poetic (creative) writing in the math classroom.

Audio and Video Recording and Photography: The interview will be audio taped so that it can be transcribed. No one outside the research study will have access to the audio tape. Your interview responses will be kept completely anonymous through the use of pseudonyms in the project report, any conference presentations, and any professional publications. You have the right to hear these tapes before they are used if you so choose.

Benefits: This research will not benefit you directly. However, your participation in this study will help me to better understand student attitudes toward writing in math. This will contribute to the scholarly literature regarding mathematically gifted student attitudes and may have implications on future curricular decision-making by mathematics teachers and teachers of the gifted in the elementary classroom.

Risks and Discomforts: There are no anticipated risks beyond those encountered in everyday life.
Privacy and Confidentiality: Your interview responses will be kept completely anonymous through the use of pseudonyms in the research report, any conference presentations, and any professional publications.

Voluntary Participation: Taking part in this research study is entirely up to you. You may choose not to participate or you may discontinue your participation at any time and no one will hold it against you.

Contact Information: If you have any questions or concerns about this research, you may contact Terri Hrina-Treharn at 330-676-0956/ thrinatr@kent.edu or Dr. Susan Iverson at 330-672-0653/ siverson@kent.edu. This project has been approved by the Kent State University Institutional Review Board. If you have any questions about your rights as a research participant or complaints about the research, you may call the IRB at 330-672-2704.

Sincerely,

Terri Hrina-Treharn

Consent Statement and Signature: Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

I have read this consent form and have had the opportunity to have my questions answered to my satisfaction. I voluntarily agree to participate in this study. I know what I will have to do and that I can stop at any time. I understand that a copy of this consent will be provided to me for future reference.

____________________________________________________________________________
Signature        Date
AUDIOTAPE/VIDEO CONSENT FORM

Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study

Terri Hrina-Treharn

I agree to participate in an audio-taped interview about mathematically gifted students’ attitudes toward writing in math as part of this project and for the purposes of data analysis. I agree that Terri Hrina-Treharn may audio-tape this interview. The date, time, and place of the interview will be mutually agreed upon.

____________________________________________________
Signature        Date

I have been told that I have the right to listen to the recording of the interview before it is used. I have decided that I:

_____ want to listen to the recording          _____ do not want to listen to the recording

Sign now below if you do not want to listen to the recording. If you want to listen to the recording, you will be asked to sign after listening to them.

Terri Hrina-Treharn may / may not (circle one) use the audio-tape made of me. The original tape or copies may be used for:

_____ this research project       _____ publication       _____ presentation at professional meetings

____________________________________________________
Signature        Date

Address:
APPENDIX D

PARENT JOURNAL DIRECTIONS
Appendix D

Parent Journal Directions

JOURNAL DIRECTIONS

As we already spoke verbally about the journals I am asking each of you to keep, I wanted to follow-up with a hard copy that you could refer back to as well. Remember I am asking you to keep a journal by making at least one entry every two weeks from September to January. I will follow-up with each of you at the end-of-the-year (May) to see if there is anything else that occurred during the second semester that you would like to share.

Since all of you chose to email me your journals I will be sending out email reminders to complete and send the journal on the weeks they are due (I have also included the schedule below). Please feel free to send them more often if you would like. Again, the information I am looking for in your journal entries are observations of your child’s experiences with writing in mathematics. I am seeking any comments your child may make during math homework that includes writing, experiences he or she may discuss relating to writing in math class, attitudes displayed, and/or behaviors when it comes to completing math assignments at home that involve writing, or anything else you deem would highlight this same sort of information.

Thank you again for your participation.
Terri Hrina-Treharn

Please send me something during each of the following weeks or more often if you choose.

Week of:
September 6th
September 20th
October 4th
October 18th
November 1st
November 15th
November 29th
December 13th
*Due to the holidays, you can send the last entry any time between December 27th and January 7th
Appendix E
Assent Statement/Script

ASSENT FROM CHILDREN
Mathematically Gifted Students’ Attitudes Toward Writing in the Math Classroom: A Case Study
Terri Hrina-Treharn

1. Hi, Johnny!

2. My name is Terri, and I am trying to learn more about your attitude towards writing in math class.

3. I would like you to answer some questions for me in a group with some of your other classmates and in an interview. I am going to audio tape these so I don’t miss anything you say. If you don’t mind, I’d like to collect and take a look at some of your math work samples too.

4. Do you want to do this?

5. Do you have any questions before we start?

6. If you want to stop at any time just tell me.
APPENDIX F

FOCUS GROUP PROTOCOL
Appendix F

Focus Group Protocol

*Warm-up: have students draw a “math student” and then share their pictures.

1. How do you feel about writing? (Students can draw a picture also)
2. Tell me something you like about math.
3. Tell me something you dislike about math.
4. What is the first word you think of when I say “math”?
   4a. What is the first word you think of when I say “writing in math class”?
   4b. Why do you think that came to mind?
5. How does writing in math help you learn?
   5a. In what ways does writing in math not help you?
6. What type(s) of writing have you done in previous math classes?
7. Tell me a story about the first time you were asked to write in math class.
8. Do you think there are different types of writing in math class? Can you describe
    those types of writing? Is there a certain type of writing that you enjoy more than
    another?
9. How do you feel when you are asked to explain your thinking in words (writing)
    after solving a challenging math problem? (Students can draw a picture also)
10. Is there anything else you would like to tell me that I haven’t asked you?
APPENDIX G

SAMPLE STUDENT INTERVIEW PROTOCOLS
Appendix G

Sample Student Interview Protocols

1st Student Interview Protocol

*Warm-up: Tell me about why you think your teacher is asking you to write in math this year.

1. Briefly tell your math autobiography you wrote about in your journal. (Students can refer back to their journal if they need to.)

2. Describe your attitude when you are asked to write in math class?

3. How would you describe your experience of writing in math to students at another school?

4. What was your experience in writing the Math Pledges?

5. Describe your attitude toward writing creatively in math class?

6. What is the difference between writing creatively in math and writing to explain how you solved a math problem?

7. In what ways did your teacher’s feedback in your journals impact your learning?

8. Do you think the writing you have done should be graded? Why or why not?

9. What else would you like to tell me about writing in math class?
2nd Student Interview Protocol

*Warm-up: Now that you’ve been doing this for awhile, tell me about why you think your teacher is having you write in math this year.

1. What is your experience with writing your Math Nursery Rhyme Book so far?

2. What do you think are the advantages to writing your Math Nursery Rhyme Book? Disadvantages?
   What do you think were the advantages for the Math Pledges? Disadvantages?

3. Do you think the writing (both creative -Pledges and Nursery Rhymes- and writing to explain -journals-) you have been asked to do has helped you learn math?
   If so, how?

4. Is there a type of writing you haven’t done that you would like to do in math? Tell me about this.

5. How would you describe your attitude towards writing in math now as compared to the beginning of the year?

6. Have you had any experiences at school or home that have influenced your attitude toward writing in math class? If so, explain.

7. Is there anyone (parent, teacher, friend, sibling, etc.) who has influenced your attitude toward writing in math? If so, who and how did they influence you?

8. What else would you like to tell me about writing in math class?
APPENDIX H

SAMPLE PARENT INTERVIEW PROTOCOLS
Appendix H

Sample Parent Interview Protocols

1st Parent Interview Protocol and Demographic Profile

* Please complete the following demographic profile. You may skip any items you do not wish to answer.

1. Pseudonym: ________________________________

2. _____ Male _____ Female

3. Age: ______

4. # of children: ______ Boys: ______ Girls: ______
   Grade Level: ______ Age: ______

5. Ethnicity: _______________________

6. Marital Status: ______________

7. Occupation: _______________

8. What is the highest level of education you have completed or the highest degree you received? _______________________

*Warm-up: Tell me about your child and math.

1. Tell me the first word you think of when I say “math”.

2. What do you think of when I say “writing in math class”? 

3. Describe your attitude towards writing in math class?

4. What experiences do you have with writing in mathematics?

5. What do you think your child’s attitude towards writing in math class is? Why do you think is it what you described?
6. Describe an evening at your house in which your child has had to do an assignment involving writing in mathematics.

7. Tell me some comments, behaviors, and/or attitudes your child has said/displayed when having to complete an assignment at home that involved writing in math.

*If applicable:
8. What experiences have your other children had with writing in math? What is their attitude towards it?

9. What else would you like to tell me about writing in math class?
2nd Parent Interview Protocol—Emerson

*Warm-up: You said you were curious to see how Jorge’s writing progresses this year as you stated you felt he suffers from “writer’s block.” Talk to me about what you have observed.

You talked a lot about having to prod to get things out of him in regards to his Math journal. How is he with completing his journal now?

1. You stated in our last interview that you didn’t think he understood WHY we were writing in math. What does he think now?

2. When we last spoke you categorized Jorge’s attitude towards writing in math as being neutral. How would you describe it now?

3. Describe an evening at your house in which your child has an assignment that involves writing in math.

4. Tell me the most recent comments, behaviors, and/or attitudes your child has said/displayed when it comes to writing in math (either completing an assignment at home and/or talking about what we are doing at school)?

5. At this point, what have your other children noticed or commented about your child writing in math?

6. What do you now think of when I say “writing in math”?

7. When we last spoke you categorized your attitude towards writing in math as being positive. How would you describe it now?

8. Describe what you have observed throughout the process.

9. Talk to me about any impacts you’ve noticed in your child’s learning as a result of having to write in math this year.

10. What else would you like to tell me about writing in math?
APPENDIX I

SAMPLE PRINCIPAL INTERVIEW PROTOCOL
Appendix I

Sample Principal Interview Protocol

**Principal Interview Protocol – Joe**

*Warm-up: Tell me the first word you think of when I say “math”? Can you describe some of your experiences with math?*

1. What do you think of when I say “writing in math class”?*

2. Is there a particular moment or point that stands out or was significant in shaping your attitudes about math?

   Describe your attitude towards writing in math? Has it always been positive (negative)?

3. What experiences do you have with writing in mathematics?

4. What do you think are your students’ attitudes towards writing in math? What makes you think this?

5. How would you respond to a parent who asked you why his or her child is being asked to write in math class?

6. How do you approach writing in mathematics with your teachers?

7. What have you observed when you have entered a classroom where students were writing in math?

8. Describe what you believe are the effects of writing in mathematics.

9. What else would you like to tell me about writing in math class?
APPENDIX J

FINAL JOURNAL PROJECT
Appendix J

Final Journal Project

Journal Project

The purpose of this assignment is to have a chance to look back on your journey in math this year as well as how far you have come. This project will consist of a title page, table of contents, introduction, chosen journals, and a conclusion. It will be due THURSDAY, May 26th.

TITLE PAGE: This page should include your first/last name, grade, class, your homeroom teacher’s name, and the date. This page should be illustrated as well. (8 pts.)

Ex. Madison Smith
5th grade math
Mrs. Treharn
May 26, 2011

TABLE of CONTENTS: This page should list each of your pages with titles and page numbers. EACH PAGE should include your writing AND a colored illustration. (9 pts.)

Table of Contents
Introduction .................................................................1
First thing I completely understood .........................2
Choice: Baking with grandma ....................................3
If math were a sound ....................................................4
Conclusion .................................................................5

INTRODUCTION: Your introduction should be written in paragraph form and answer the following questions:
How has writing in your journal this year affected your learning of mathematics?
How did you feel about journal writing this year in math class? (15 pts.)

CHOSEN JOURNALS: You need to pick 3-5 of your favorite journals. Make sure they are dated and have titles. Of your choices at least ONE has to be a “choice” entry and at least ONE has to be a “topic.” Think about what journals you felt helped you the most this year by writing them. Try to pick entries from different times throughout the year. (45 pts.)
CONCLUSION: Your conclusion should be written in paragraph form and answer the following questions:

What do you think are the benefits of writing in math?
How could journal writing be changed to be more effective? Or do you think it should stay the same and why? (15 pts.)

SPELLING/GRAMMAR: (8 pts.)

TOTAL = 100pts.

Name: _________________________      Class: _____________________

TITLE PAGE:  ________/8pts.
TABLE of CONTENTS:  ________/9pts.
INTRODUCTION:  ________/15pts.
CHosen JOURNALS:  ________/45pts.
CONCLUSION:  ________/15pts.
SPELLING/GRAMMAR:  ________/8pts.
TOTAL:  ________/100pts.

Comments:
APPENDIX K

SAMPLE JOURNAL PROMPTS
Appendix K

Sample Journal Prompts

Journal Prompts

1. Explain what you learned in math today.

2. Tell me your thoughts and feelings about the creative writing projects we’re doing this year.

3. Tell me what you know about perimeter and when you think you will need to use it in real-life.

4. Write a letter to a friend telling them what you know about equivalent decimals.

5. Explain the difference between an expression and an equation and provide examples.

6. Describe any discoveries you have made about mathematics or yourself doing mathematics.

7. How do you feel about what we are learning in this chapter?

8. If you could make one change to math class what would it be and why?

9. Explain the Addition Properties to your parents.

10. Write a letter to a friend explaining how to estimate quotients using compatible numbers.

11. Pick one of the problem-solving strategies and create and solve a problem for it. Then list at least three other problem-solving strategies we’ve discussed.

12. Explain how you rename when subtracting mixed numbers and give an example.

13. Explain to your parents how to add integers and give examples.
14. Tell me something you learned today or something that we did and you still have questions about.

15. What types of things can you do to “check” your work on tests before turning them in?
APPENDIX L

DATA COLLECTION MATRIX
Appendix L

Data Collection Matrix

Data Collection Matrix: Type of information by source and frequency

<table>
<thead>
<tr>
<th>Source</th>
<th>Type of data/Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Gr.</td>
</tr>
<tr>
<td>Students</td>
<td>X</td>
</tr>
<tr>
<td>Parents</td>
<td>X</td>
</tr>
<tr>
<td>Teacher</td>
<td>X</td>
</tr>
<tr>
<td>Administration</td>
<td>X</td>
</tr>
</tbody>
</table>

*Focus Gr. – occurred with students in September (audio recorded)*

*Interviews – occurred with students at the end of the first grading period (Nov.) and the end of the semester (Feb/March)*

- occurred with parents in Sept. and Jan.
- occurred with the current and former principal in early Dec.
*All interviews were audio recorded*

*Documents – Journals were collected from parents bi-weekly from Sept. to Jan.*

(*Parent all chose to email their journals - a final call occurred in May)*

Journals were collected from students in Oct. and Dec.

(*Final journal projects were collected in May)*

The teacher journal was collected in Jan.

Student poetic writing samples were collected throughout
Appendix M

Data Collection Timeline

- **September:**
  - FOCUS GROUP - Students
  - INTERVIEWS – Parents

- **October:**
  - DOCUMENTS (Journals) – collected from Students

- **November:**
  - INTERVIEWS – Students

- **December:**
  - INTERVIEWS – Principal
  - DOCUMENTS (Journals) – collected from Students

- **January:**
  - INTERVIEWS – Parents
  - DOCUMENTS (Journals) – collected from Teacher

- **February:**
  - INTERVIEWS – Students

- **March:**
  - INTERVIEWS – Finished up three students who were absent from the February interview

- **May:**
  - DOCUMENTS – final journal project from students and final call made to parents
  - DOCUMENTS (Journals) – collected from parents bi-weekly from September to January
  - Creative writing collected from students throughout
Appendix N

List of Codes

Color codes for themes:

Initial Challenges = Blue
One Hand Up, Maybe Two = +, N, -
Poetic Trumps Transactional/Expressive = Pink
Seeing the Light = Yellow
*Bare Minimum = Orange
*Need for Structure = Yellow/Pink

Note. * = These two themes were not used even though they emerged as they did not address either research question.

Codes for poster:

CAM I#1 = Cam’s 1st interview
CAM I#2 = Cam’s 2nd interview
CAM PI#1 = Cam’s 1st parent interview
CAM PI #2 = Cam’s 2nd parent interview
CAM J = Cam’s journal
CAM JP = Cam’s journal project
CAM PJ = Cam’s parent journal
CAM FG = Cam’s focus group

LUC I#1 = Lucas’s 1st interview
LUC I#2 = Lucas’s 2nd interview
LUC PI#1 = Lucas’s 1st parent interview
LUC PI #2 = Lucas’s 2nd parent interview
LUC J = Lucas’s journal
LUC JP = Lucas’s journal project
LUC PJ = Lucas’s parent journal
LUC FG = Lucas’s focus group

C I#1 = Collin’s 1st interview
C I#2 = Collin’s 2nd interview
C PI#1 = Collin’s 1st parent interview
C PI #2 = Collin’s 2nd parent interview
C J = Collin’s journal
C JP = Collin’s journal project
C PJ = Collin’s parent journal
C FG = Collin’s focus group
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