2011

Exploring Literacy Across the Curriculum: Writing in the Mathematics Classroom

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EXPLORING LITERACY ACROSS THE CURRICULUM: WRITING IN THE MATHEMATICS CLASSROOM

A Thesis Submitted

in Partial Fulfillment

of the Requirements for the Designation

University Honors

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May 2011

EXPLORING LITERACY ACROSS THE CURRICULUM

This Study by: Sarah Heddinger

Entitled: Exploring Literacy Across the Curriculum: Writing in the Mathematics Classroom

has been approved as meeting the thesis or project requirement for the Designation

University Honors

4/29/11
Date

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5/6/11
Date

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Introduction

The purpose of my Honors thesis is to find evidence that writing in mathematics benefits both students and teachers. To research this claim, I viewed how writing takes place in mathematics within a specific elementary classroom. I hoped to view mathematics lessons in which literacy, specifically writing, was involved as an integral part of every lesson.

I became interested in the topic of writing in mathematics through my courses as a literacy minor and mathematics minor. In my literacy classes, the idea of writing across multiple subject areas was commonly discussed, but mathematics always seemed to be left behind. Discussions about writing occurred occasionally in my mathematics courses. However, the concept of journaling in mathematics was rarely discussed in great detail. The limited introductions that I had to mathematics journaling are what sparked my curiosity to look at the possible significance that they might have for both teacher and student growth.

Literature Review

Literacy and mathematics are two subjects that most people would not consider to be closely related. However, after devoting significant parts of my college career to both, I realize the importance of connecting the two subjects. Mathematics and literacy are both extremely important in their own rights, but they are also connected to one another. This literature review will explore what content area literacy is, how writing in mathematics has been shown to benefit both students and teachers, and findings on how mathematics journaling has been proven beneficial for students.

Content Area Literacy

Reading and writing in mathematics goes far beyond just a simple story problem. It is true that story problems in mathematics do include literacy. The student must read the problem

and write the answer. However, this is not really connecting literacy across the curriculum, or "content area literacy." Interest in and research about content area literacy began in the early 20th century and has grown and expanded until the present time (Lapp, Flood, & Farnan, 1996). In more recent years, educators have become focused on:

> creating educational environments in which students are challenged to analyze, reflect, communicate, and create. In such environments, effective strategies for reading, writing, speaking, listening, and thinking are more likely to develop more naturally and easily than when these are addressed as isolated elements (Manzo, Manzo, & Thomas, 2005, p. 13).

Society has come to recognize that the ability to communicate, problem solve, and evaluate information is much more critical than remembering large amounts of information (Manzo et al., 2005). For this reason, applying literacy strategies in content areas in the classroom is important in preparing students for life outside of school.

Writing in Mathematics

The goal of this thesis is to look specifically at writing in the mathematics classroom. Writing in mathematics refers to students writing about their thoughts, reasoning, and connections, not simply writing the answer to a problem. Writing can take place in many forms in mathematics, and it has also been found to have many benefits, both for teachers and for students (Fogelberg, Skalinder, Satz, Hiller, Bernstein, & Vitantonio, 2008). When students write about what they are doing in mathematics, they "think more deeply and clearly about mathematics" and "organize, clarify, and reflect on their ideas" (Burns, 2004, p. 30). Writing in mathematics also provides "a way for students to reflect on their own learning and to explore, extend, and cement the ideas about the mathematics they study" (Burns, 2004, p. 30).

Teachers have found that having students write about their thinking in mathematics can be useful as a type of formative assessment. Marilyn Burns (2004) explained that reading her students' writing about mathematics allowed her to assess their learning and better understand their thinking about mathematical concepts. Using writing in the mathematics classroom also provides evidence for teachers to discover that students learn mathematics in different ways (Brandenburg, 2002). Students may also feel uncomfortable expressing their confusion with mathematical concepts during class time. By allowing students to write about their misconceptions in private, teachers get a better view of which areas students need the most assistance (Miller, 1992). Viewing a student's writing about mathematics can be both a clarification of the student's thinking and an evaluation tool for the teacher.

Benefits of Mathematics Journaling for Students

Studies and articles written by teachers and researchers suggest that there are many different reasons why using mathematics journals benefit student learning. Some of these ideas are that journaling allows students to track their changing conceptualization and to clarify their thoughts over time, gives them a purpose to explain their reasoning of mathematical concepts, assists them in connecting mathematics to their everyday lives, and helps them become more comfortable with mathematics.

Progression of thinking.

Learning new concepts in mathematics is not something that just happens automatically; it takes building on ideas over time. For example, a child cannot be taught multiplication without first understanding addition. It takes years of practicing addition and understanding repeated addition before multiplication can be introduced. Sometimes, students need ways of connecting with concepts in other ways than through drill and practice. By writing about a subject, students

are able to connect with the topic and understand it (Zinsser, 1988). "Writing about new concepts gives students an opportunity to clarify and extend their thinking (Burns, 2004).

After introducing mathematics journals into her second grade classroom, Susan Carter wrote that journaling "helped students monitor their own mathematical progress and see how their thinking changed over time" (2009, p. 607) and "extended [her] students' thinking about the strategies they use to problem solve in math class" (2009, p. 610). One author suggests that students are not often reflective of their thought process until they must put those thoughts into words and make them clear in writing (Miller, 1992). If a student wrote about a mathematical concept on multiple occasions over a period of time, it is likely that a progression of his or her thinking could be seen in the writing.

Reasoning.

The National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics* (2000) is a widely used resource for mathematics teachers. Two of the ten standards described by NCTM are "Reasoning and Proof" and "Communication." The reasoning and proof standard explains that in order for a person to fully understand mathematics, they must have the ability to reason, and to do so throughout multiple contexts (NCTM, 2000). Through reasoning, students justify why they did something a certain way or how they came up with a specific answer. If students are not expected to reason, they are not held fully accountable for their work.

NCTM's communication standard states that "written communication should be nurtured" and that mathematics curriculum "should enable all students to organize and consolidate their mathematical thinking through communication" (2000, p. 60). It is important that students justify their reasoning in mathematics, and a way that this can be done is through

writing. After having students keep journals in mathematics class, Brandenburg (2002) explained that she "saw a tremendous increase in students' comprehension and their ability to explain what they knew" (p. 67). Through combining the two process standards of reasoning and proof and communication, mathematics journaling can help students analyze mathematical concepts by stating their logic in writing.

Meaningful connections.

Teachers are constantly striving to make learning meaningful for students, and this can often be done by connecting lessons to everyday life. If students can see how mathematics can be used in their lives outside of school, learning mathematics becomes much more important (Albert & Antos, 2000). As a result of their "Daily Math Journal Project," Albert and Antos (2000) saw that "thinking and writing about how mathematics is used in daily life helped students make connections between classroom learning and real-world situations and gave them different ways to express their mathematical knowledge" (p. 528). By writing, students can also make connections between mathematics and other school subjects, and between different mathematical concepts.

Comfort with mathematics.

Oftentimes, students feel extremely confident in certain subjects but lack that confidence in other subject areas. Susan Carter explains that "students with strong writing skills should be able to apply writing skills in other contexts" (2009, p. 606). This allows students to mix the subject that they are comfortable with, writing, with other areas of education that they may struggle in.

Students who generally have a strong ability in writing may feel more comfortable with mathematics when journals are used in the mathematics classroom (Albert & Antos, 2000).

Albert and Antos (2000) found that with the use of mathematics journals, "the students who struggle with mathematics are able to convey their mathematical knowledge successfully" and that "a certain level of understanding is revealed through each piece of writing" (p. 531). If the areas where a student is comfortable can be connected across the curriculum, he or she may come to find their understanding of the subjects to come more naturally or with ease, rather than a struggle.

Methodology

The main research question to be answered in this thesis was: How is the use of writing in mathematics beneficial for both students and teachers? Sub-questions that I originally formed included: Is writing about a particular concept both before and after a lesson more beneficial than writing only after a lesson? Does allowing students to choose their writing topic prove to be more beneficial than having the teacher provide a guiding question or subject? Due to the qualitative research methodology of the thesis, these questions were not necessarily answered, but other sub-questions arose. They included: Do certain types of questions or prompts provide more in-depth answers? Does a student's motivation affect the quality of his or her writing?

The research collected for this study was done in Mr. Evans' fourth grade classroom at an elementary school in Waterloo, Iowa (an alias is used for this paper). During mathematics class, there are a total of 21 students in the classroom, comprised of 11 boys and 10 girls. The class is made up of 12 African American students, 2 Hispanic students, and 7 white non-Hispanic students.

Participant Selection

For this study, both parent and student permission was needed. My participant selection methods were designed to prevent coercion and protect confidentiality to the greatest degree

possible. The University of Northern Iowa's guidelines in the protection of human research participants were followed, and the Institutional Review Board approved my study before I began doing any research.

For student consent, I explained the purpose of my research and how to fill out the permission forms by reading a script aloud to the class. The script can be found in the Appendix (see Appendix A). Students were given permission forms, and they filled them out as explained in the script.

For parental consent, permission forms were sent home with all students in the class. These forms asked if parents would allow their child to take part in my study, as long as the student complied as well. Return envelopes were attached to the permission slips, and the parents sent the forms back to the teacher, who gave them to me. Both the student and parent permission slips can be found in the Appendix (see Appendix B and Appendix C).

Due to the time constraints on my research, it was not feasible to view all of the student journals available to me. However, I wanted to collect data from students who range in ability. In order to fairly choose which students' journals I would view, I asked the teacher to compile three lists of his students: those who are high-achieving in mathematics, those who are low-achieving in mathematics, and those in-between. Those three lists were then edited to only include the students from whom I had both student consent and parental consent. My thesis advisor then randomly chose two students from each of the three lists, and those students' journals were used for the basis of my research.

The two students selected from the high-achieving list were an African-American female and an African-American male. The two students selected from the in-between list were two African-American females. The two students selected from the low-achieving list were a

Hispanic female and a Caucasian male. For the basis of explaining my results, each student was identified by a letter, A through F, which will be explained further in the Results section.

Data Sources

I collected data by conducting an interview with the classroom teacher, viewing mathematics lessons in the classroom that included writing, and reviewing a select number of student participant's mathematics journals. The teacher interview allowed me to gain insight to the teacher's view of using writing in the mathematics curriculum. Viewing mathematics lessons was directly linked to viewing the mathematics journals. I needed to know what happened during class in order to fully analyze students' writing. I observed not only the teacher but also the students whose journals I used for my study during mathematics lessons. Finally, viewing the students' actual mathematics journals allowed me to look at their writing.

While observing in the classroom, I would sit in the back of the classroom, at a table located behind all of the students' desks. I took notes over student interactions, comments made by the teacher and students, and the general environment of the classroom. I usually stayed in the back of the classroom while taking notes so that the students would not feel nervous about my observations. I also tried to provide students privacy as they wrote in their journals, to avoid any skewing of data.

Data collection took place for five weeks, during the fifth through ninth weeks of the spring semester of 2011. Collection took place on Mondays, Wednesdays, and Fridays. The teacher interview took place during the eighth week of the spring semester of 2011, and was audio recorded with permission.

Data Analysis

When analyzing the data found in the math journals, my focus was on the categories explained in the "Benefits of Mathematics Journaling for Students" section of the Literature Review. Those categories are: (1) progression of thinking, (2) reasoning, (3) meaningful connections, and (4) comfort with mathematics. Since this research was subjective, it was up to me as the researcher to determine whether a student showed gains in any of the areas listed, but I focused on evidence found in the Literature Review when deciding this.

Results

Data Collection

When collecting data, I arrived in Mr. Evans' classroom at the beginning of the math block, which took place from 12:45 p.m. to 1:55 p.m. daily. The students would return from recess at 12:40 and use the restrooms on their way to the classroom, and oftentimes they would not even enter the classroom until 12:50. Generally, the first few minutes back in the classroom were spent with the teacher trying to resolve issues that occurred during recess, and it was a common occurrence that the math class did not actually begin until at least 12:55.

Upon arriving at the classroom, students were expected to immediately begin working on their "Meaningful Math Distributed Practice", or MMDP, notebook. According to Mr. Evans, the MMDP notebook contains daily practice problems of math concepts that will be taught in the future, so that when the students arrive to that concept in instruction, they already have some experience with it. There was a section for explanation after every day's MMDP problems, and Mr. Evans explained how that could even be considered a journal, as the students are expected to explain their reasoning. However, most students who do not understand the material do not write about it.

The routine for the rest of the mathematics class period was not very consistent. Once the students had worked on their MMDP for ten to fifteen minutes, the teacher would either go over the answers and concepts of the MMDP, present the students with their math journal question, or begin teaching the math lesson. Mr. Evans would not always go over the answers of the MMDP, but he always included a journal prompt and a main lesson in the mathematics period. If the journal prompt was not presented before the lesson, it was presented following the lesson and was usually directly tied to the lesson.

Journal time was usually allotted five minutes or less during the math period. Mr. Evans would type a question or prompt onto the Promethean Board at the front of the room, and the students would have a few minutes to respond. At the beginning of my research he asked them to write in their math notebooks, but most students would open to a random page and write, without putting the date at the top of the page. This made it very difficult for me to find each entry in the students' journals.

I did not ask Mr. Evans to change the method of students journaling in their notebook, but after a few entries he began passing out a quarter of a sheet of notebook paper to every student for the daily journal. Each student wrote his or her journal for the day on that small piece of paper, which I would then gather. So that the class did not know whose journals I was looking at for my research, I collected every journal each time, but only looked at the six which had been chosen for the basis of my research.

In order for me to collect my data without taking the journals with me, I would make copies of each of the six journals at the school, and then return them to Mr. Evans before leaving. After handing journals back to the teacher, I am not sure what was done with them. I never saw that the quarter sheets of paper were bound together in any way to create a sort of "complete

journal." This is a factor that will be covered later in my "Discussion" section. In an email, I asked Mr. Evans how often he read the students journal writings, and whether or not he wrote responses to the students. He replied, "I usually read their journals after every entry. I have not written comments back when returning them to students, but it is a very good idea." This is another factor that will be discussed further.

When asked about how he chooses journal prompts, Mr. Evans explained:

> I usually just look at what we did that day. Sometimes I change it depending on how the day went and how far we went in the lesson, and so it's kind of a spur of the moment thing sometimes. I might think, "Oh, they seemed to be struggling with that; I want them to think deeper about that certain thing." Otherwise sometimes I have them planned in the lesson plan.

Appendix D shows the prompts that were given to the class each day that I was present to collect research. They are numbered by entry in order to easily refer to them when explaining my results. For all direct quotations from Mr. Evans, see the transcribed teacher interview in Appendix E.

As I went through the data from each student, I looked for examples of the categories discussed before: (1) progression of thinking, (2) reasoning, (3) meaningful connections, and (4) comfort with mathematics. I also noticed that a new category could be included for journals which included information that was not applicable to or did not answer the prompt, (5) irrelevant. In order to discuss each student's data when addressing each of these categories, I have identified each student with a letter (see Appendix F). When analyzing student journal responses in the following sections, the students' writing and grammar have been modified when necessary to allow the reader to understand more easily. For example, the students' writing,

"You mite yos it sum day" will be written as, "You might use it someday" within the paper. All of the student writing mentioned in the paper can be found in Appendix G. The following sections give examples of student writing from each of the five categories listed above, where available.

Progression of Thinking

Due to the prompts used by the teacher in this study, there were no identifiers of progression of thinking in the students' mathematics journals. This idea will be explained in further detail in the Discussion section.

Reasoning

When answering Prompt 8, Student D wrote, "I think it is division because repeated addition is multiplication and repeated subtraction is division." The class had been talking about how multiplication and division "undo" one another, so essentially division is the opposite of multiplication. The class also had discussed that multiplication is a form of repeated addition. When given Prompt 8, Student D was able to put these two ideas together to reason that repeated subtraction must be the same thing as division. Her ability to do this and explain it in terms of repeated subtraction is seen in her writing for this specific prompt.

After looking at many of the journal entries, I realized that not only does writing reveal correct reasoning, but incorrect reasoning can also be revealed, which can benefit a teacher's assessment and decision-making. An example of this can be seen in Student E's journal for Prompt 2. He wrote, "Five times six equals thirty. Thirty times twenty equals sixty." This shows the teacher that the student understood that he should multiply the two smaller numbers first, and then multiply the answer with the remaining number. However, in this case the student did not

multiply correctly, as thirty multiplied by twenty does not equal sixty. The teacher is able to see that the reasoning is there, even though the computation is not correct.

Meaningful Connections

An example of a meaningful connection made by Student B was found in her response to Prompt 3, "Because if you do a division problem, you have to multiply." The student was beginning to learn long division in her mathematics class and recognized that in order to complete long division problems, she needed to know how to correctly multiply. This connection was meaningful because the student was able to express her understanding of the relationship between different areas of mathematics.

Comfort with Mathematics

Due to the nature of this study, there was no way to identify students' comfort with mathematics. This concept will be explained in further detail in the Discussion section of the thesis paper.

Irrelevant

Unfortunately, I found that many journals I collected over the course of my study contained data that was considered irrelevant. In these journals, the writing had nothing to do with what the prompt asked or suggested, or the student just did not give the writing his or her best effort. For example, Student D's response to Prompt 7 was "Idk," standing for, "I don't know." On occasion, students would not even attempt to write their journal for the day, leaving their paper blank.

Another example of an irrelevant journal writing was Student A's response to Prompt 1. He wrote, "I would say follow the steps on the board." This answer refers to a poster about multiplication hanging on the whiteboard. After giving the prompt to the class, Mr. Evans

noticed that many students were writing responses similar to this one, which do not give an answer to the question, but rather direct the reader to another resource. After seeing some answers that were written, Mr. Evans said aloud to the class, "'Look at the wall,' and 'Use your resources,' are not good enough answers. Pretend you are in a room with no resources." However, Student A did not add to his journal or change his answer, so this journal writing does not give the reader any information about what the student knows about multiplication.

Discussion

Before conducting my research, I anticipated finding mathematics journals to be beneficial for both students and teachers, in accordance with the research cited in the Literature Review. I believed it would be most probable that students would show a progression of thinking and improved reasoning when using mathematics journals, but I hoped to find evidence that meaningful connections and greater comfort with mathematics were also present. The following is a discussion of why I believe I found the results that I did and suggestions for how I think writing in mathematics could work to benefit teachers and students more fully in the classroom.

Progression of Thinking

I believe that in order to see a progression of thinking in a student's writing, one would need to have a study on a larger scale than I was able to do for this thesis. A longer period of time would be needed to see if progress is made, and the teacher would also need to have prompts that relate to one another over time. For example, if a teacher had a student write about his or her conceptual understanding of fractions once every two weeks, they might be able to see how the student's thinking about that topic changed over time after a unit or semester. Due to the fact that I did not have any input regarding the prompts that were used for this study, I could not

structure the prompts to see if this progression of thinking would happen over time. I also had a very limited time to collect data, so this hindered my ability to look more fully into this category.

Reasoning

If students are justifying their answers in mathematics, they are thinking more deeply about the concepts with which they are dealing. Even if their answers are incorrect, they are working through the process of how they came to an answer, and from there a teacher can help guide them through misconceptions that they may have to help them find a correct solution. Reasoning can be seen in Student D's writing because she worked through the process of finding a definition for "division" by using previous knowledge. When writing about her finding, she explained her thought process, showing reasoning. By simply writing the word "division" on her paper, she would have correctly finished Prompt 8. However, by writing her reasoning, her teacher can see how she came to that conclusion.

Mr. Evans can see how Student E came to a conclusion in a different way because the student explained his reasoning. Student E's writing for Prompt 2 shows that he knows an efficient process for completing the multiplication task because he wrote out his thinking. Without the information of his reasoning, Mr. Evans could have assumed that Student E didn't know what he was doing. If he had asked the students to simply solve the problem "5 x 6 x 20" and Student E had written "60" for his answer, the teacher would have assessed it as simply wrong, and moved on. However, because the student recorded his steps, the teacher can see that the student does know the process; he just did the calculation incorrectly.

Meaningful Connections

In my literature review on meaningful connections, I mainly focused on students connecting mathematics to their everyday life. While I didn't see this in the journals that I read, I

did find it interesting that Student B was able to make a connection between two topics in mathematics, multiplication and division. This is just as important of an observation as connecting mathematics to their life, as it was extremely insightful and brought the child's thinking to a new level.

I believe the reason that students did not connect their writing to their lives is because the prompts they were given did not give them the opportunity to do so. If prompts probed students for more, the children would most likely write more and put more thought into it. For example, Prompt 11 is, "What is the difference between repeated subtraction and sharing?" Most students could answer that question in one sentence and be finished. If the prompt included, "What are some situations in which you see 'repeated subtraction?' What are some situations in which you see 'sharing?'" the students would be required to put more thought into their response. They would most likely dig deeper for a more critical answer, which would probably lead them to sharing life connections in their writing.

Comfort with Mathematics

I believe that, like progression of thinking, a change in a student's comfort with mathematics cannot be seen in this particular study. My hope was to view a student who generally felt uneasiness when it came to mathematics, but really enjoyed writing. From the information I discussed in the literature review, I predicted that a student of that nature would gain more comfort with mathematics by experiencing it through a subject that they really like: writing.

Due to the nature of this study, I was not able to get to know the students of Mr. Evans' classroom very well, and especially beyond the subject of mathematics. There was no way for me to know exactly how each student felt about mathematics, or how much they did or did not

enjoy writing. The study was also done with a limited number of students. I think that researching the effect that mathematics journaling could have on students' comfort with the subject is something that can be done, and I hope that it is a relationship that I can investigate in the future with my own classroom of students.

Irrelevant

When looking at the fourth grade students' journals, finding examples that show a lot of reasoning and meaningful connections was not an easy task. However, seeing irrelevancy and lack of effort was not difficult at all. I believe that there are many reasons for this, and many could be prevented if different actions were taken in the classroom, as explained for each factor.

First, I think that the time of day during which the students wrote for mathematics was a huge factor. Since they were coming straight from recess, the fourth graders did not have the concentration necessary for sitting still and writing about math right away. If changing the time of day that mathematics is taught is not an option, using the journal at the end of the class period could prove to show better results, as students have settled back into the school day routine. Otherwise, using an energizer to re-focus the class may be an effective way to get students ready to write.

Mr. Evans said that he had never given his students any instruction on writing in the mathematics classroom, and I believe that this is a second cause for students' lack of writing and overall effort. With guidance and examples that model mathematics journaling given to them at the beginning of the school year, the class would most likely have a better idea of how to write a journal entry. I believe that consistency with journal writing over the course of the year would also give them more practice and keep them in the routine of writing in mathematics.

An observation that came to mind after Mr. Evans began using quarter pieces of paper is that the students no longer were using "journals," in a sense, they were just writing on a piece of paper that was not connected to any other writing they had done in the past for mathematics. I think that having a consistent place for the students to write, separate from their math spiral notebook, is important in order to keep their journal entries together chronologically and organized. This would not only give the students a sense of accomplishment when they see how much they have written in a journal at the end of the school year, but it will also better serve the teacher for assessment purposes. Having all entries together can help the educator track progress over time, and it could even serve as a mini-portfolio for parent-teacher conferences.

Finally, I believe the biggest factor that caused students to put forth minimal effort is that they had absolutely no motivation to write entries in a mathematics journal. They did not have a purposeful audience. The fourth graders would turn in their work, never receive feedback about it, and never see the journal entry again. If the teacher would take the time to write back to the students in their journal, just a sentence or a small comment, it would be much more motivating to the children. Even a smiley face or a simple, "Great thought!" would show the student that the teacher at least looked at their journal. This seems like a lot of extra work for the teacher, but I believe that it is well worth it in order to make the most of what could be a really great learning tool in the classroom, the mathematics journal.

Teacher Benefits

Although I did not see as much evidence of student benefits as I had hoped, Mr. Evans still believes that using the mathematics journals in his classroom is helpful for him as a teacher. He explained, "It helps me see which kids are making connections and thinking deeper, versus the ones who are just kind of staying on the surface. And what I've noticed is that the ones who

are able to journal about it a lot are the ones who are understanding and being proficient on the tests." This shows that the teacher is using the journals as a form of assessment in his mathematics class.

Mr. Evans also admitted that he knows the journals could be of more use than they currently are. Speaking of himself and the other fourth grade teachers at his school, who are also in their first year of teaching, Mr. Evans said, "This is a real introduction right now; I think it could go a lot farther than we're taking it." He hopes to use journals in mathematics again in the next school year, but would like to start them right away to get students into the routine and used to the idea of writing in the mathematics classroom. He also had considered letting his class journal in pairs of students, with one child who excels in mathematics journaling paired with another who does not. Overall, Mr. Evans believes that what he is doing with mathematics journals in his fourth grade classroom is beneficial to him, but could be helpful to an even greater degree with some changes put into practice in the future.

Conclusion

In reflecting on the discussion of my study, I would recommend that teachers who wish to use mathematics journals give their students instruction in the area of journal writing and model the procedures involved. I would also suggest designing prompts that promote reflection as well as ones that allow the possibility for observing student progression and change throughout a school year. In addition, prompts should be written with a purpose and audience in mind, so that students are motivated to complete the writing. Feedback from the teacher is vital for increased student motivation as well. My final recommendation for educators is to keep in mind that students should be assessed in a variety of ways, and writing about mathematics is just one way to do so. Though many students might show growth and increased thoughts through

their writing, not every single child will. For this reason, assessing in many different manners is necessary.

This study is significant for current teachers and pre-service teachers who are or will be responsible for teaching mathematics to elementary students. Ruiz, Thornton, and Cuero (2010) claimed that it is important "to prepare mathematics teachers to integrate mathematics and literacy in a way that not only promotes students' understandings and appreciation of reading and writing but also deepens mathematical conceptualization" (p. 236). My hope is that my findings can be an example for teachers of, with the proper implementation, the magnitude of importance writing could hold in the mathematics classroom.

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Appendix A

Script for Class Permission:

Hello, my name is Miss Heddinger and I am a student at UNI. I am studying to become a teacher, and I am very interested in both math and writing. I am doing a study for one of my classes that involves looking at math journals. In order for me to do this study, I need actual student math journals to read. Mr. Evans has allowed me to ask you if you would let me collect and read your journals every once in a while. In order for me to do this, I need both your permission and your parents' permission.

You can choose to either check yes or no on the permission form that you will sign. "Yes" means that you will allow me to collect your journal and take a look at it after some math classes, and "no" means that you would rather not let me do that. Either way is fine, and Mr. Evans will not know whether you said "yes" or "no." You will not be receiving a grade from me; I will just be looking at journals to help me learn how to be a better teacher.

I will pass out the forms and then leave the room while you fill them out. Please fold the form in half when you are done and place them in the yellow folder on the back table. Thank you!

Appendix B

Student Permission Slip:

Name: (printed)

_____

_____ Yes, I will allow Miss Heddinger to read my math journal.

_____ No, I will not allow Miss Heddinger to read my math journal.

Signed:

_____

Today's Date:

_____

Appendix C

Parent Permission Slip:
Dear Parent or Guardian:

My name is Sarah Heddinger and I am a senior Elementary Education major at UNI this year. As a student in the University Honors Program, I am writing my Honors thesis this semester. I have decided to connect writing and math as the topic of study in my thesis. I am especially interested in journaling in mathematics, and would like study whether or not writing about math helps students learn.

In order for me to research this area, I need to view student math journals. Your student writes in a math journal as part of their class at [Elementary School]. Mr. Evans and the principal have given me permission to collect and read your student's math journal, as long as I have your permission and your child's permission. ***Your child's involvement in the study is voluntary, and they may withdraw or choose not to continue with the study at any time. There are no risks or benefits involved with your child's involvement in the study. All of the information collected for the study will be kept strictly confidential and only used for the purposes of the study.*** I have asked your student to sign a permission form similar to the one attached after explaining to them the purpose of my viewing their journal. I will only view journals for which I have the permission of both the child and the parent.

Please fill out the permission form below, indicating whether or not you will allow your student to be part of the study. In order to keep confidentiality, please seal the form in the enclosed envelope. If you have any questions about the study, please feel free to call me at (515) 250-5707 or email me at heddings@uni.edu. You can also contact Mr. Evans at [email address] or my advisor Dr. Rick Traw at rick.traw@uni.edu. You can also contact the office of the IRB Administrator, University of Northern Iowa, at 319-273-6148, for answers to questions about rights of research participants and the participant review process.

Thank you for your cooperation.
Sincerely,

Sarah Heddinger

PERMISSION FORM
Please sign and return in a sealed envelope to Mr. Evans by _____. Thank you!

____ I **allow** my child's writing to be collected and read as a part of this study.

____ I **do not allow** my child's writing to be collected and read as a part of this study.

My Child's Name: _____

Parent(s)/Guardian(s) Signature(s):_____

Today's Date: _____

Appendix D

Prompts for Student Journals:

Entry	Date	Prompt
1	2-9	If you were teaching someone to solve the following problem, 143 x 51, what would you say? Write out the words you would say to teach them to solve the problem. Addition to the original prompt: What is multiplication?
2	2-10	Explain the best way to solve the following problem: 5 x 6 x 20
3	2-14	Explain why it is important to know how to multiply.
4	2-16	Explain what the partial products are in 57 x 23
5	2-18	I will do (well/ok/not good) on my checkpoint today because I…
6	2-21	I am ready for my multiplication post test because I understand… OR I am not ready for my multiplication post test because I do not understand…
7	2-23	Division is…
8	2-25	Repeated subtraction is… Try to give an example.
9	2-28	Explain the words and give an example: Dividend: Divisor: Quotient:
10	3-4	Explain how to use sharing when you do not have enough 100s for everyone. Explain what to do.
11	3-7	What is the difference between repeated subtraction and sharing?
12	3-9	How can finding the missing factor help you solve a division problem?

Appendix E

Teacher Interview:

Researcher (R): "Do they journal in any other area, or is it just math? What have you done with journals?"

Teacher (T): "So, one of the things it is, we try to have them journal in reading too. We usually use it more of a reflection of what they did that day or previously or just trying to get them thinking deeper about connections between things. There's not a lot a lot of extensive use of the journals. I would like to use it more, but, for academic reasons, it's more of just like a reflection thing."

R: "Is it something you do often, or every once in a while?"

T: "In reading, it's kind of an every once in a while thing. We're trying to do it more, but they really fight us on it every step of the way."

R: "What about creative writing?"

T: "We have a writing time, and so we have specific focuses, so there's some creative writing. Every now and then we do a free write, where they can just write about any thing they want. I tell them no one has to read it unless they want someone to read it so they like that sometimes."

R: "Do they usually tend to write a lot during the time?"

T: "There's three or four of them that will write two to three pages, and some of them will write two to three sentences."

R: "I was just wondering, before I came and basically forced you to do the journals every Monday, Wednesday, Friday, how often did you do the journals?"

T: "We try to do it every two to three times a week, it wasn't always necessarily writing it down, maybe it's just a reflective question. Sometimes that's the same process, it's just maybe not necessarily the writing part of it."

R: "Did you start doing the journaling for math at the beginning of the school year?"

T: "We tried to, and we introduced it very slowly just because we've recognized with this group of fourth grade students that writing is something that they struggle with and writing stamina is just so low, and so we kind of just started it and as they're working in their spiral I'd ask them a question and say write down the question, so we didn't necessarily call it a journal or anything, but they would be writing."

R: "And did you ever do basic instruction on how to write in math, or was it more of a just, 'here you go?'"

T: "It was more of a 'here you go' type thing. It was kind of 'here's a question, what do you think the answer might be? Write down your response.'"

R: "But I've noticed that when you do the journals you kind of have think-aloud things where you're kind of trying to prompt them through it at the same time. So how do you choose your prompts?"

T: "I usually just look at what did we do that day. Sometimes I change it depending on how the day went and how far we went in the lesson, and so it's kind of a spur of the moment thing sometimes, I'm like, 'Oh, they seemed to be struggling with that; I want them to think deeper about that certain thing' otherwise sometimes I have them planned in the lesson plan."

R: "I've noticed that sometimes you use really open-ended prompts and sometimes they are really closed, and I'm definitely seeing a different type of writing, depending on those. Do you think about that before you do the prompts?"

T: "I do. If it's something that I really want them to think about, I leave it a little more open-ended. If it's something that I want to boost their confidence or something that I really need an exact answer from, I'll close it down a little bit, just to see like, did they actually get it?"

R: "Have you ever tried journaling unprompted?"

T: "I haven't, and it scares me. I really have no idea what they'd come up with and I have a feeling that some of them would sit there and just write 'I don't like math' and then that's all I would get from some of them. Or some of them would just write, 'I like math.' And with the writing they don't tend to go very deep with it."

R: "Yah, do you find that they generally have that dislike toward math?"

T: "Most of my kids, and actually it kind of surprised me, we had conferences this week and most of the kids said that math was their favorite. I don't know if it's because we're trying to do more hands-on things and our reading is more direct instruction, but I think it's kind of in the approach. They've never had an approach like this before. It's been, 'we're doing this lesson in the textbook and then were going to go the next lesson in the textbook.' When I was in college, we switched it up and did more like inquiry based things and trying to make them think their own way and I think they like that better. The thing I really like about [connecting to "The Doorbell Rang" is the connection]. I feel like with our math curriculum right now there is no real life connections or applications. The teacher says this is how you do it, they try it with you, and then they do it on their own. And they don't really understand what they're doing, they just know how to do it."

R: "So how does the math curriculum work with the Waterloo district?"

T: "They have a recommended scope and sequence. We're behind on that because we're going a

lot deeper with it than they do. I mainly do the whole math plans for the 4th grade, and I'm all over in the teacher's guide, going from chapter 3 to chapter 8, and so on."

R: "As a teacher, are you seeing benefits from reading the journals? How does it help you?"

T: "It helps me see which kids are making connections and thinking deeper, versus the ones who are just kind of staying on the surface. And what I've noticed is that the ones who are able to journal about it a lot are the ones who are understanding and being proficient on the tests."

R: "For those who don't understand it, do you think it helps them at all?"

T: "I think it does. I think something I'd like to do is kind of share with each other, if I could pair up the ones who have really good journal entries and pair them up with the ones that don't. I've thought about doing a paired journal, instead of just one person writing, have them work together. The only downfall to that is then I don't necessarily know individual thinking, it's just more of a paired thing."

R: "Have you thought about changing the way that you present journaling?"

T: "I would like to start it right at the beginning of the year, hardcore. This year we are all first year teachers in the whole pod, so we started off kind of not really knowing anything. So if we could go back to the beginning of the year, there are some things I would do differently, and I think that's something I would start the first day and just get them into that routine, because it's really hard to introduce it after you haven't been doing it. If you didn't do it a lot and then all of the sudden you say, 'Hey, we're going to start writing about it.' Then they're going to fight you like crazy. That is definitely something I would do different, start it right away."

R: "I've noticed that it takes a really long time to get everyone in and settled…"

T: "…Calmed down. Especially coming right off of recess. It's very frustrating, and I think it does hinder a lot of what we try to do in here. It's a very high-energy class, and trying to get them to focus for even two minutes to just sit there and journal, it's just crazy."

R: "What does the MMDP stand for?"

T: "Meaningful Math Distributed Practice. The whole district is trying to get into it. It's almost like a preview of what's coming up. They recommend 5-10 minutes but we generally do 15-20. They are kind of introduced to what's coming so when you get there they are already introduced to it. We've found it very beneficial. We really hit multiplication concepts really hard before we got to it and we had 45% of students pass the pre-test. Especially with ITBS coming up, we've been previewing a lot. In the booklet we really stress them to explain what they did, so that's kind of like a journal."

R: "Do you find that they actually write a lot in those, or no?"

T: "I've found that the ones that do write a lot understand it. And I've been blunt with a lot of the kids and said, 'Well, you're explanation's blank, and that's why you don't understand it.'"

T: (talking about expanding the concept of mathematics journaling in the future) "This is a real introduction right now; I think it could go a lot farther than we're taking it."

Appendix F

Student Indentification:

Student	Classification
A	High achieving, male, African-American
B	High achieving, female, African-American
C	In between, female, African-American
D	In between, female, African-American
E	Low achieving, male, Caucasian
F	Low achieving, female, Hispanic

Appendix G

Samples of Student Writing:

Student D, Prompt 8:

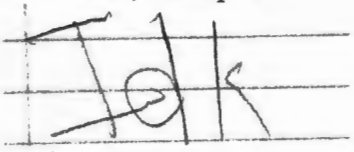
I think it is divison because repet addtion is Mutiped and repet Satison is divSon

Student E, Prompt 2:

Student B, Prompt 3:

Because if you Do A divison Problem you have to Multiply.

Student D, Prompt 7:



Student A, Prompt 1:

I would Say follow the Steps on the board