



5-12-2012

An Alternative Method: Using Novels in Mathematics to Teach the Concepts

Rachel Frances Colby
Butler University

Follow this and additional works at: <http://digitalcommons.butler.edu/ugtheses>

 Part of the [Curriculum and Instruction Commons](#), [Educational Methods Commons](#), and the [Science and Mathematics Education Commons](#)

Recommended Citation

Colby, Rachel Frances, "An Alternative Method: Using Novels in Mathematics to Teach the Concepts" (2012). *Undergraduate Honors Thesis Collection*. Paper 140.

This Thesis is brought to you for free and open access by the Undergraduate Scholarship at Digital Commons @ Butler University. It has been accepted for inclusion in Undergraduate Honors Thesis Collection by an authorized administrator of Digital Commons @ Butler University. For more information, please contact fgaede@butler.edu.

BUTLER UNIVERSITY HONORS PROGRAM

Honors Thesis Certification

Please type all information in this section:

Applicant Rachel Frances Colby
(Name as it is to appear on diploma)

Thesis title An Alternative Method: Using Novels in Mathematics to
Teach the Concepts

Intended date of commencement May 12, 2012

Read, approved, and signed by:

Thesis adviser(s) Jelly Furness 4/23/2012
Date

Reader(s) Kathe Freed 4/23/2012
Date

Certified by Judith Hayer Mord 11 July 2012
Date
Director, Honors Program

For Honors Program use:

Level of Honors conferred: University Summa Cum Laude
Departmental Middle/Secondary Education with High Honors
Mathematics with Honors
University Honors Program

**An Alternative Method:
Using Novels in Mathematics to Teach the Concepts**

A Thesis

Presented to the College of Education

and

The Honors Program

of

Butler University

In Partial Fulfillment

of the Requirements for Graduation Honors

Rachel Frances Colby

4 May 2012

Abstract

This paper explains a research project conducted exploring the effectiveness of using the novel, *The Number Devil*, to teach math concepts. The effectiveness was measured by if students met the standards, if students understood the concepts, and if students enjoyed the method of instruction. The reason for conducting this research was to look at new ways of teaching mathematics due to the thought that many students dislike and do not understand math. Using novels could prove to be an effective way to vary the instruction and teach difficult concepts. To complete this research, I taught a class the math concepts explored within the novel *The Number Devil*. Using the data gathered, I found that engagement leads to understanding, using context or relevancy are important to learning, fragmented learning fails, and no single method of instruction works for every student. Future research of this topic could be conducted in looking at *The Number Devil* in parts separated by math concept or in using a different book or novel in a math class to more effectively teach the concepts.

Keywords: Math methods, content literacy, math literacy

An Alternative Method:

Using Novels In Mathematics to Teach the Concepts

In the Fall 2010 semester, I enrolled in an education departmental honors course that focused on teaching literature. As a math major, this course seemed fairly irrelevant to my future aspirations, but, along with another student, we used the course as an independent study that focused on literature and math. For the course, I read countless books to do with math and created two resource guides for math novels, one being *The Number Devil* by Hans Magnus Enzensberger (1997). *The Number Devil* is a mathematical adventure novel about a boy, Robert, who does not like math at all. He begins to dream about the number devil who explains various math concepts to him. Throughout the novel, Robert gains a better understanding of math and grows to enjoy it. As my classmate and I made this resource guide, we realized the guide could actually be used in a classroom to teach math concepts in a different way.

The Math “Problem”

Math is a stereotypically disliked subject for various reasons, few of which make sense to me as a math enthusiast. Many find math to be boring, useless, and difficult to understand. People tend to not like what they don't understand so, naturally, if someone does not understand math then they will not enjoy it. This lack of understanding could possibly be due to the way in which math has traditionally been taught, in using a textbook and repeated practice of problems. Nonetheless, knowing how disliked math is by so many, I wanted to think of how to teach math in a way that is more enjoyable and more understandable.

What Teacher Education Tells Us: In many cases, it is difficult to learn math concepts only by reading the textbook. The teacher needs to use some other form of instruction other than the textbook to help the students understand the concepts. It is important for students to be taught at their appropriate developmental level. If students are taught above or below their developmental level, they will either be very confused or very bored, neither of which we want as a teacher (Powell, 2011). Vygotsky (1978) refers to this as the zone of proximal development or ZPD. McLeod (2010) defines the ZPD concept as, “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers” (Vygotsky, 1978, p. 86 as cited in McLeod, 2010). Students taught in their ZPD will be able to achieve the tasks they are given, will be more engaged, and will learn. Teaching a student in their ZPD will help them better understand difficult concepts while, on the other hand, students taught outside their ZPD will be less likely to understand and succeed.

Students are more likely to understand a new, difficult concept if it is presented or taught to them in a way that engages them. An engaging approach will keep their interest and attention. With the attention and interest of students, it is much easier to teach math concepts as well as challenge the students, helping them further deepen their understanding of those concepts. Many teachers simply teach from the textbook. Most textbooks are not very exciting and do not allow for much student engagement. This results in inattentive students who do not learn or do not fully understand concepts that are presented to them. I find it difficult to help students find content from a textbook

interesting or engaging when I, as the teacher, do not find it engaging or exciting myself. Teachers should try to incorporate different instructional methods to try to engage their students, helping them understand and enjoy the content they are learning.

My experiences have taught me that ideas read from a novel or in the form of a story are easier to understand and more interesting to learn. In several of my education classes, I have learned about the importance of making content relevant to the students at their developmental level. Stories help us see difficult and abstract ideas in a “real” context. Textbooks just have problem after problem for students to complete, but a story presents that same concept in a context that students may find useful or relevant to their own lives. Students continuously ask math teachers, “Why do we have to learn this?” and many teachers do not have an answer other than, “to graduate” or “to pass the test”. I think teachers need to give better reasons. Math and the skills learned through using math are used constantly in life. Using a story that presents concepts being used in some “real” way will help students see that they should learn because they can use math. If content is not relevant, meaningful, understandable, or connected then students will not be interested or engaged and there would be no point to teaching it. Using a story will help students see the use of math and also help them understand the concepts because they are presented in a more understandable way.

Maybe the Literature Class is Connected to Math: After reading so many young adult math related books as well as creating two resource guides for math novels, I started to see how literacy and English/Language Arts skills applied and could be used in math class. Knowing how many students dislike and do not understand math, I thought about how teachers need to try different methods of instruction to try to help students learn

math as well as enjoy it. As I was taking the literature course, I started to see more and more how important these literacy skills that are taught in English class are also necessary in order to understand math.

My education courses have made me aware of the importance of literacy in math and the components of literacy that are vital to understanding math, but not always taught. In one education class, we discussed in depth what content literacy means and how to incorporate literacy skills in class no matter the content. I researched what content literacy in math meant and developed my own definition. One definition I found states that literacy in math means being able to reason and solve problems in a real-world setting (Martin, 2007, p. 29). This supports the idea that using a book or a “real” context to teach math could help students become more mathematically literate. Being literate in math means knowing the specific vocabulary and structure that is involved in using math. It also means taking that mathematical knowledge and knowing how to use it in a practical setting as well as being able to explain how you used it. For all of this to happen, students have to understand math. Under the current traditional method of teaching math, many students are not understanding math and, therefore, not becoming literate in math. Continuing to use a method that is not very successful does not seem productive. Teachers need to try to use various methods to teach math concepts in a way that more students will understand and be successful. One of these methods could be using a novel.

The Research Question: My experiences, education classes, as well as research has led me to believe that using a novel to teach math concepts could be an effective instructional method. That belief has led me to pursue this research idea of using a novel to teach a

math class. Using a novel may be an effective way to make math concepts meaningful and to show the connectedness of math. Using a novel to teach a math class may be an effective means of teaching difficult concepts in a way that more students are able to understand them. It may also help students see math as a more enjoyable subject, or at least help them despise it less. This idea of using literature and writing in math has been researched and put into practice, but by very few. Several scholars believe incorporating literature in math classes helps students better understand different concepts and ideas leading me to believe the same and to believe that teaching math using a novel is an idea with potential.

Literacy and Math

What is Math Literacy: Teaching math is more than just giving notes, reading a textbook, and practicing problems. “Mathematics truly is a foreign language for most students: it is learned almost entirely at school and is not spoken at home” (Kennedy, 2005, p.3). Math is just like a foreign language with its own vocabulary, structure, and syntax that students need to learn and understand in order to be able to do math (Kester, Bardsley, Bach, & Gibb-Brown, 2009). If two math enthusiasts were talking about homomorphisms, isomorphisms, the pigeon-hole principle, or permutations, someone who is less adept in math or does not have a large repertoire of math vocabulary would be completely lost in that conversation. The vocabulary as well as other language components of math are important components of mathematics that need to be understood in order for one to understand mathematics itself. Therefore, if one is to become more fluent in the language of math, teachers must be purposeful in developing

math literacy. Math literacy can be defined in many ways. Martin (2007) defines math literacy as, “Mathematical literacy implies that a person is able to reason, analyze, formulate, and solve problems in a real-world setting” (Martin, 2007, p.29). After reading several scholars’ definitions and explanations of math literacy, I also developed my own definition: My definition of math literacy is the ability to understand mathematical vocabulary and structure in order to solve and explain math problems relating to the real world. This literacy component of math is rarely taught or included in the math curriculum. While there are many definitions of literacy in math that relate to a better understanding of math, another definition that is particularly accurate states, “an individual’s capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments, and to engage in mathematics in ways that meet the needs of that individual’s current and future life as a constructive, concerned and reflective citizen (OECD 1999).” This is what it takes to be literate in the language of math (DeLange, 2003, Introduction section, para. 5). Being literate in math is more than just being able to solve a problem or replicate a process, it is knowing the importance of math in the world and how to think critically in order to solve problems. It is important, as a teacher, to understand the need for math literacy and how helpful it is in being successful in math class as well as a competent thinker and problem solver in life. “Integrating mathematics and literacy creates opportunities to introduce new vocabulary, make connections among abstract concepts, and showcase ways that mathematics applies across curriculum” (Koellner, Wallace, & Swackhamer, 2009, p. 30). All of these help students better understand math and make it relevant to their lives. “Encouraging students to read in mathematics classrooms increases their comprehension of word

problems, their mathematical vocabulary, and their critical thinking skills” (Smyth & Waid, 2010, p. 113). Focusing on being literate in math helps teachers and students alike realize that understanding math is more than just being able to repeat a process from a textbook or fill out a worksheet. Being mathematically literate means being able to think critically and logically, being able to solve problems, and being able to see and understand how math is used in life.

Schults (2008) strongly believes that incorporating literacy components in content specific classes or outside of the language arts classroom is important and that it helps students gain a better understanding of the content.

Schults stated:

Read, write, and speak about math. Saving the most obvious for last, of course math students must learn to read and understand math problems. When algebra students are studying systems of equations, they must be taught to understand the pattern of the written scenarios for the real life application of this skill set.

Although most algebra books have abandoned the classic example, ‘when two trains leave the station,’ algebraic word problems are still massive brain breakers.

Great math teachers actively teach their students how to translate words to math symbols and math symbols back to words. They require their students to write in math journals narrations of the logical thought processes used to solve problems (Read, write, and speak about math section).

Schults (2008) believes that those teachers who incorporate reading, writing, and speaking in math are more successful and more effective teachers than those who neglect

to incorporate these literacy skills in math class. This added literacy component helps students become more successful in their content area classes.

Why is Math Literacy Important: Being literate allows students to be able to translate math to more common, spoken language and that spoken language to math. Knowing how to explain a math problem is a vital skill that students need to know how to do. It demonstrates that they understand the math concept and also shows that math is more than just strange symbols, but is actually something that they can use and talk about in their lives. “As teachers we have become more intentional about using reading, writing, and talking in math class and, as a result, we see increased understanding of math concepts and problem solving. Students rely on language skills to read, write, talk, and represent their mathematical thinking and problem solving” (Fogelberg, Skalinder, Satz, Bernstein, Hiller, & Vitantonio, 2008). Going through the motions of solving a math problem is not enough for students to understand it. They need to look at it from various perspectives, see how it is used, and be able to explain how to do it before really reaching an understanding of it. Teachers should incorporate writing and talking about math in their classes to help students better understand the concepts as well as see that math is more than just numbers and symbols from a textbook, but is actually something they can use.

Many students do not see the relevance of math when all they do with it is copy examples down and go home to repeat the exact same process that they learned in class (Shults, 2008). This method does not work for all students. It has little relevance or meaning begging the question, why is it still the primary method used to teach math? Students would benefit greatly from more varied math instruction. It is necessary to try

An Alternative Method

to differentiate instruction in order to teach each student and not just the ones who can learn in this traditional way.

Schults (2008) stated:

Today's teachers are visiting sites like TeacherTube or subscribing to online resources like United Streaming, downloading brief video clips (three to five minutes in length) on topics such as the peculiar properties of right angles, and inserting them into lessons on the Pythagorean Theorem. These kinds of lessons are rooted in literacy education because they help the learner access prior knowledge, increase motivation to learn, and create anticipation for new math knowledge. Math teachers are recognizing that today's students require active teaching strategies, infused with literacy practices that engage the learner and make learning relevant (Design lessons that integrate multiple resources section). Incorporating different instructional methods helps make content more accessible, more understandable, more interesting, and more relevant for many students especially those who struggle with the traditional math instructional method.

Instructional Approaches to Math: Varied instruction in math can be done in numerous ways. One way teachers have gone about varying instruction while also incorporating more literacy skills in math class is by bringing in novels that have math concepts within them. Koellner et al. (2009) believe that there are different complexity levels of mathematical novels, three being the highest, and at the higher level there are more opportunities to integrate the literature and increase mathematical understanding. *The Number Devil* is one of the books placed at complexity level three. The idea of incorporating literature in a math classroom is thought to be innovative, according to

Smyth & Waid (2010), but necessary to encourage reading across the curriculum as well as content literacy. The scholars, like Marilyn Burns, believe that it is important and helpful to a students' content comprehension to integrate literature in a mathematics classroom. "Combining math and literature in classroom activities is a way for teachers to invite children into the world of math," stated Burns. "Reading books that weave mathematical ideas into engaging stories helps dispel the myth that math is dry, unimaginative, and inaccessible" (Bafile, 2008, Math and Literature section, para. 3). Using a novel as opposed to a textbook or in addition to a textbook helps students approach math from a different perspective which may help increase understanding. Incorporating books into math class can help students see that math can be exciting, show that it relates to the world outside of the classroom, and lead to a better understanding of the concepts through a different medium. Using books, whether they be picture books or novels, in the math class can show students that math is used in contexts outside of a textbook. It can also help students see math as more enjoyable because it is woven into a story rather than just put in front of them as numbers and symbols.

Teachers that use literature in math classes have various ideas about how it can be used most effectively. Bafile (2008) uses a specific strategy to incorporate literature into the math classroom, "Read the story aloud to the class and discuss it as you would any other book. Then introduce an activity. As with all math lessons, keep the emphasis on children's reasoning, ask students to communicate their thinking and solutions, and encourage discussion among students" (How to begin? Dive right in! section, para.1). This strategy is more geared toward using math literature in elementary classes, but similar approaches can be used in a middle or secondary class. A teacher can still use a

picture book or other math book of sorts, read it aloud, and then have the students complete some sort of activity to explore the content presented in the book. The way the lesson is structured would just be catered more towards older students. A high school teacher, Sharon Powell, has had big successes in combining math and literature in her classroom using the book *The Crazy Horse Electric Game*, by Chris Crutcher (1987). "Basically, I looked for ways that math was used in the book and expanded on it. This can be done with any book," (Bafile, 2008). Either short picture books or novels can be used in this way, or even longer novels. To use a novel in this way, a teacher would just look at the parts of the novel that use the desired math skills and pull out excerpts for the students to read. "Books are stories about people and their lives, and these lives involve numbers," Powell continued. By keeping that in mind, she believes, any teacher can join math and literature activities. "My kids like this kind of work. They see it as real or fun, but either way, it is something they are willing to do. My own children actually think that math problems are harder when there is no story to go with them," (Bafile, 2008, Books get to the "meat" of mathematics section, para. 3). Just doing math problems out of context of any real situation not only makes math less enjoyable and seem less relevant, but also more difficult because it is as though there is no reason to solve the problem. With a story, there is a context as well as a reason to solve a problem making students more inclined to want to solve the problem and probably have a better understanding of how to go about solving the problem. "Picture books can also help students who love to read—but think math isn't their thing—experience the wonder of math in the same way they already enjoy the wonder of books." (Burns, 2010, para. 3). While not all students enjoy reading, I would say more enjoy reading than enjoy math. Incorporating literature

or reading in math classes can potentially help engage those students who dislike math, but enjoy reading. It could even possibly lead them to enjoy math more, or at least gain a better understanding of math concepts covered.

Other than using novels in math classes, teachers can add writing to their classes to incorporate literacy skills in math and to help students understand math concepts better. “Mathematics is beginning to be viewed less as a series of arithmetic calculations than as ‘the science of order, patterns, structure, and logical relationships (Devlin, 2000)’” (Kennedy, 2005, p. 26). Due to this changing view of math, people are starting to stress the importance of the understanding of math concepts by all students rather than just a few. This new goal has led some teachers to turn towards writing as a math class activity. While all students in a class cannot speak at the same time, they can all write at the same time. Writing encourages the students to think about the math they have learned while actively engaging them in the learning. “Written explanations in mathematics are about *what* is being done and *why* it works” (Kennedy, 2005, p.27). Students can reflect on what they have learned, write out how a problem should be solved, or simply write out the steps to follow to solve a problem. This helps the students themselves think about how to do math problems and can show the teacher whether or not the students understand what they are doing.

What Can Literate Students Do in Math: Using both literature and writing in math can help students better understand math concepts, enjoy math more, and see how math is related and relevant to the world. It is also important to teach math in a way that shows how connected it is and that it is not separated into different units, but that all of it builds on other ideas. If content is not relevant, meaningful, understandable, or connected then

An Alternative Method

students will not be interested or engaged and there would be no point to teaching it. Many of the chapters of *The Number Devil* build on each other showing that math is interconnected and that you need basic skills in order to do higher-level math. Students need to see that math is not separated pieces of information, but a whole, cohesive subject that is interconnected and woven together. It is necessary to have basic math skills before moving on to more advanced math, but it is also sometimes necessary to know geometry in order to be able to solve a calculus problem. Students should always be accessing prior knowledge when completing math problems rather than looking at each problem as something foreign and completely new to them. If students can learn how to do this and teachers teach this, then students may find math to be less daunting and gain a better understanding of it.

My Research Question: Scholars have found that incorporating literacy skills in math class through the use of literature and writing can greatly benefit students in helping them better understand and appreciate math. Making math more relevant to students' lives will help them better understand it and potentially lead them to enjoy it. Knowing this as well as discovering the novel *The Number Devil* led me to ask the question, why do more teachers not try using literature, writing, and other literacy skills in their math classes? If we know that the traditional method of teaching mathematics is not effective for all students, why do so many continue to use that method and only that method? I decided to use the novel *The Number Devil* and test out what these scholars found. The big questions I based my research around were: 1. Is using a novel to teach math an effective method? 2. Do students learn from it? and 3. Do students enjoy it?

to teach math in several different ways: if students met the standards, if students understood the concepts taught, and if students enjoyed this method of instruction, or what their opinion of this method of instruction was.

Data Sources: Data were collected in various ways which included 1) daily observations of the students I taught and writing notes over what I saw, 2) student written journals, 3) pre- and post- assessments over the various concepts covered in the novel, 4) interviews with some of the students, 5) a pre and post vocabulary rating chart, 6) a pre and post questionnaire, and 7) a final assessment. For examples of these assessments, please refer to the Appendices. My observation notes included notes made during class and impressions of how the class was going recorded after class. The student journals required the students to answer two questions over each chapter, what did they learn from the chapter and do they enjoy the book/this method of instruction so far. The pre- and post- assessments (see Appendix A) were the same in order to see what improvements were made throughout the course of the study. Interviews with individual students were videotaped and analyzed. The interviews asked the students what they thought about the novel itself as well as how they felt about this method of instruction in a math class. The pre- and post- vocabulary rating chart (see Appendix B) was a list of vocabulary words that the students had to rate on a scale of one to three, one being they had never heard the word before and three being they knew what the word was and how to use it. The pre- and post- questionnaire (see Appendix C) was a list of various concepts or words that the students had to write whether or not they knew what it was and if they did then write what it was. They were given the same vocabulary chart and questionnaire at the beginning and the end of the research period. The final assessment (see Appendix D)

The Number Devil Research Project:

Context of the Research: The research was conducted in a sixth grade science classroom at an urban public magnet school. This research was conducted in a science classroom rather than in a math classroom because the school did not want any students to lose their normal, daily math instruction. Instead, the school believed working in the science class on math content for a second class each day would serve as a math enrichment class for the students. Therefore, those two days a week, students would have their regular math class as well as this enrichment type class where they learned additional math skills using *The Number Devil*. The research lasted from the end of October until the middle of December 2011. The school serves approximately 500 students, 67% African American and 16% Hispanic. In terms of socioeconomic status, 88% of the students attending the school are eligible to receive free or reduced-price lunch. There were 15 sixth grade student participants in the research.

Research Design: With my question in mind and the knowledge taken from various scholars, I investigated the effectiveness of using reading and writing in a math classroom to teach mathematical concepts. The research was designed with an action research framework because of the effectiveness of that design for teacher use in the classroom (Johnson, 2009). Action research is an effective research design for teachers because it allows them to practically conduct research in their classroom in order to see what methods or techniques are effective at improving student learning. Action research can be altered or catered to the problem or question a teacher would like to research. This research design is very user-friendly and used in various ways. Using this flexible approach to conduct my research, I decided to measure the effectiveness of using novels

An Alternative Method

asked the students to write an additional chapter to the book in the same style as the author, but incorporating two new math concepts that were not covered in the book.

They worked on this in groups and then were asked to present their chapter as a skit.

Data Analysis: Data were analyzed by looking at and working with the whole data set (Hubbard & Power, MacLean & Mohr, 1999). During analysis, I catalogued my data sources, put them in order by type of source, looked at individual sources of data, looked across the data to see how different data sources pointed to the same idea, and then looked at the data as a whole to determine what the big picture was. Throughout this data analysis process, I constantly wrote down notes of ideas that stuck out or of implications of what the data was showing me. In cataloguing my data, I realized certain data sources were more showing than others. I found that the student journals as well as the student interviews were the most telling data sources. I looked at these two data sources first to see what they showed about my research. I looked at my other data sources individually to see what each one showed about my research. Different concepts or themes emerged from looking at my data sources individually so I looked for the themes that kept emerging from multiple data sources and compared those. I finally looked across the data as a whole to determine what the big picture was that my data sources were telling me as well as what, if any, parts of my data stuck out from the rest. To avoid bias and protect the privacy of my students, I assigned each student a number and in analyzing my data only referred to the numbers of each student rather than the names.

Research Findings

In analyzing my data, several big ideas were prevalent in multiple pieces of my data. From looking across my data sources at the student journals, the student interviews, my observation notes, as well as the pre-and post- assessments, the idea that the more engaged students are in what they are learning about, the better they will understand that content. My observation notes, the student journals, and the student interviews made me come to the conclusion that students learn content better, especially math content, if it is presented in a way that makes that content relevant to the students or if it is presented in some sort of real context. In reading the student journals and my observation notes, I concluded that content that is presented in a separated or fragmented way is more difficult to understand than content presented more cohesively. The other big idea that emerged from all my data sources was that one method of instruction will not work for all students or there is no one best method of instruction. All of these big ideas emerged from multiple data sources which led me to believe that these ideas were the important themes to look at more closely. Each of these big ideas emerged from the data sources individually first, then I noticed that those same ideas were emerging from other sources as well. I then compared what each source was saying in references to the big ideas and came to some conclusions about using novels to teach math as well as math instruction as a whole.

Engagement Leads to Understanding: Students that are engaged in what they are learning tend to understand the concept much better than if they are not engaged. One day in class, we learned about combinations and permutations by doing an activity like what the number devil did in the book. We had the students get in groups and figure out

how many different seating arrangements they could make for the number of people in their group. This activity taught the students about permutations and factorials, or vroom! as the number devil called it. Then in larger groups, the students had to figure out how many handshakes they had to have in order for each person in the group to shake everyone else's hand once. They started out doing this the same way as the seating arrangements, but after a little questioning realized it had to be solved in a different way. This second activity taught them about combinations.

From my observation notes about class this day, every student seemed to be actively involved in these activities and answered the questions at hand. Many of the students said that this day in class was one of their favorites. They were participating in an engaging activity that allowed them to learn about two difficult math concepts and gain a fairly good understanding of those concepts. From the post assessments, only three of fourteen students who took the post assessment did not correctly answer the question about factorial. Eight students correctly answered the question about handshakes and four correctly answered the question about seating arrangements. While I would have liked these numbers to be higher, both of these post assessment numbers were significantly higher than the pre-assessment numbers of three for the handshakes and zero for the seating arrangements. This goes to show that when students are actively engaged in an activity, especially one that they enjoy, they are more likely to understand the concept and learn from the activity.

Another activity that engaged students was journaling. While not all students put forth effort into the journaling assignment and not all students enjoyed journaling, those that did really benefited from it. Whenever we gave the students time to journal in class,

a majority of them took the time to write what they learned from the chapter and write their opinions of the book and the method of instruction being used. One student said, "I liked journaling because you could express yourself." Another few students also found journaling to be beneficial because they liked that they could look back to see what they read and what they learned which helped them understand what they read. "I liked getting to share my opinions about the story," said another student about journaling.

While these students all enjoyed journaling and benefited greatly from writing down what they learned as well as their opinions, several students had different opinions.

"Journaling was not exciting, it was hard to write a whole page, and it was not helpful," said one student. Another student said he did not like journaling because he is not good at writing and explaining. Students who do not like writing would not have benefited from having to write in a math class. Overall, I think most of the students benefited from writing about what they learned even if they did not enjoy it. It still gave them an opportunity to write down their opinions, share their thoughts, and see what they learned.

In addition to writing, reading the novel was also a more engaging activity for the students than just doing problems out of a textbook. Again, not all students like reading or like having to read a book about math, but some did and greatly benefited from this different means of math instruction. One student wrote in their journal, "I like this book as of right now. And I think Hans Enzensberger did good making this book to help kids understand and do better with math at school and at home." Another student wrote, "Learning from a book is new to me. I know you learn a lot just from reading and it's easier from just doing worksheets. I hope they give this book to other kids because you can really learn a lot." Reading a story can be a very engaging activity for those students

who like to read or if the story is particularly interesting. It depends on the student as to whether they will be engaged in reading a mathematical novel, but from my observation notes at least half of the students in our class seemed to enjoy the book as a whole or certain chapters. One student wrote in their journal, "The first chapter, I like it, it was fun. I really enjoy it." Then later about a different chapter the same student wrote, "I didn't like this one because it wasn't as fun like the other ones that we have read about." This student did not like every chapter of the book, but even just liking a few chapters helped this student engage more in what they were learning which in turn helped increase understanding. It is evident that this student had an increased understanding of math concepts because their post assessment score was two points higher than their pre assessment score. Another student wrote, "I enjoyed chapter one and the few pages of the book I have read. I can't wait to read chapter two." Several other students wrote in their journals that they really enjoyed certain chapters, but found some chapters more confusing or less exciting. Those chapters that students enjoyed and were engaged in had concepts in them that the students understood and enjoyed learning about. Many of the students wrote in their journal or said in their interview that they enjoyed chapter one which was all about infinity and the importance of the number one. The students enjoyed this chapter because it kept their attention and engaged them. We also did an activity in class to expand on the concepts introduced to help the students understand. We used examples that the number devil used to try to present the idea of infinity in some sort of context rather than as an abstract idea. The fact that this chapter and activity were engaging along with the fact that the concepts were presented in a context at the students level helped them understand and enjoy learning.

Importance of Context or Relevancy to Learning: Reading a novel to learn math concepts seemed to help many students understand the math concepts, even those that were more challenging for the level of the students. One student noted, “This book was more interesting than a math book because it has characters. You can learn faster because it is interesting.” Another student said, “I liked this book because the characters had good personalities.” This student also said that although he had seen a lot of these math concepts before, the book helped him understand them a lot better because it was more relatable and more descriptive. Both of the statements made by these students show that using a novel to learn math concepts can prove to be beneficial because of the way in which the concepts are presented. Learning math, something that is frequently considered dry or boring, through a story that has a plot and interesting characters can really help students learn. The novel helps add a context to the math that is being learned and makes it more relevant since it is being used in a story rather than just in a problem out of a textbook.

In the novel, the number devil used an example of rabbit reproduction cycles to explain Fibonacci numbers. Many of the students said that this was their favorite part of the book in the interviews. While many could not remember what exactly Fibonacci numbers were, they were able to recall that they had something to do with rabbits. On a post-questionnaire, one student wrote, “Yes, they are like counting rabbit cycles,” under the question about Fibonacci numbers. Giving an explanation of what Fibonacci numbers are by using a real life example of rabbits greatly helped the students understand a rather difficult concept. We did not use Fibonacci numbers too extensively with the class which probably adds to the reason why many did not remember exactly what the

numbers were. However, the fact that so many students remembered that they had to do with rabbit cycles was better than not remembering anything about them at all.

Another difficult concept that the number devil explained well was permutations and combinations. Students in college math classes have difficulties using these ideas to perform simple problems and yet our sixth grade students were able to complete simple permutation and combination problems. The number devil used seating arrangements and handshakes to show how these ideas work. As I said, we did these same activities in class as the number devil demonstrated in the book and most, if not all, of the students really seemed to understand how combinations and permutations worked. Just asking a sixth grade student to follow a formula to solve a combination or permutation problem would have been difficult and I would guess that few students would have really understood how those types of problems work. Setting a context of how many ways a number of students can sit in that number of seats or how many handshakes a group of people must exchange in order for each person to shake everyone else's hand really made these problems easy to understand. The students not only understood how to solve these problems, but also seemed to enjoy solving them, as several said in their interviews that the day we did seating arrangements and handshakes in class was their favorite class day.

Reading this novel as a means of teaching math concepts showed me how important it is to teach concepts in a way that makes them relevant to students or to teach problems that have context. Students are more likely to understand how certain math concepts work if they are presented in a relevant manner. They are more likely to remember what the concept is if it is presented with some relevance or context rather than just as an isolated formula or idea unrelated to anything in life. Students do not believe

that they use math or math concepts in their lives which was made evident in the interviews we did. Several students said they only use math to do their homework. A few came up with some practical uses like counting or using money, shopping, cooking, and playing games. While these are all ways students do use math, students really struggled to even come up with these basic uses of math in their lives. They have not been taught how math relates to their life and how they use it in their life which makes it seem irrelevant to them.

I believe students will understand math better and have a better appreciation for it if it is made relevant to them or presented in a way that gives math context. Using *The Number Devil* to teach math concepts made this very apparent. The students understood and mostly remembered those concepts that were presented in a relevant way or put in a context that sixth graders could understand. It is evident that using a novel with context to teach the math concepts helped students understand these concepts because of the increase from their pre-assessment to post-assessment scores. Of the 15 students in the study, only one student had a decrease from pre- to post- assessment. One student stayed the same and one student did not take a post-assessment. The following scores are of each student who took both the pre- and post-assessments and are listed in that order, pre then post. The scores were: 12, 15; 14, 16; 14, 12; 8, 14; 9, 17; 14, 16; 14, 14; 9, 19; 14, 19; 11, 12; 7, 19; 17, 19; 6, 13; and 4, 10. While not all students had a greatly increased post-assessment score, most students did improve showing that using a novel to learn various math concepts does help them understand those concepts. The result of using a novel to learn math by some students was more positive feelings toward math and a

better understanding of difficult concepts. "You made math fun. Now its one of my favorite subjects." "I didn't like math before. I like it more now, we had fun."

Fragmented Learning Fails: In *The Number Devil*, several math concepts build off previously learned concepts, but it also covers a lot of different concepts in a rather short book. Each of the twelve chapters basically talks about a new idea or a new group of ideas. In later chapters of the novel, there are references to some simpler concepts covered in earlier chapters, but only briefly and only if the earlier concept helps increase understanding of the later concept. While these connections that are made between the different concepts in the book are beneficial to helping students understand the concepts, not enough connections are made to create a cohesiveness I believe is necessary to ensure understanding. This novel was too fragmented to allow the students to really learn to their fullest ability all of the math concepts that were presented.

In an interview with one of the students, he said, "I kind of liked this book. I didn't like it because it jumped around a lot and I couldn't get the whole lesson." Each new chapter basically introduced a new idea which made an interesting story, but also made it more difficult for the students to follow everything that was being presented and really understand what they were reading. Math naturally builds on itself and is usually taught in a way where you learn the simple concepts first, then the next concept uses and expands on the first concept and so on. *The Number Devil* did that to some extent, but there was still too much fragmentation to the math being presented. The fragmentation of the learning that took place made it difficult for students to remember all that they learned. While most of them understood the concepts the day they learned it and possibly a day or two later, by the end of the novel they had forgotten most of what they had read

about in the beginning of the novel. The post-questionnaires the students filled out made this very evident. Over half the students wrote that they had heard of the concepts like triangle numbers, Fibonacci numbers, or rutabaga (square roots), but forgot what they were. While that math may be a little advanced for a sixth grade class, the number devil presented these concepts in a simplistic way that would have allowed for younger students to understand. During the time when the class was reading the chapters concerning those concepts and doing activities involving those concepts, they understood what the concepts were. However, without revisiting them or continuing to use the concepts, they quickly forgot what they were and how to use them.

This idea was very apparent in looking back at some of the more difficult concepts presented in the novel. I think students struggled to see the connection between Fibonacci numbers, triangle numbers, and the rest of the concepts they were learning about or any math concepts that they had learned previously. They were unable to access prior knowledge so after they learned these new ideas, they had nothing really to connect it to. Even Fibonacci numbers, which was presented by using a story or context, was not remembered by a majority of the students. They initially understood Fibonacci numbers and could see what they were, but without repeated exposure and continuous use, they quickly forgot what the concept was.

Students are not always shown how connected math is and that they are constantly needing to use previous math knowledge in order to solve more advanced problems. Teachers need to be more deliberate in showing students how new concepts that they are learning are related to what students already know. Math continuously builds on simpler ideas and if students are shown this more explicitly then they may find

math to be easier, less daunting, or more enjoyable. The number devil was somewhat successful in doing this, but since the novel covered so many different concepts in a short amount of time, it was difficult to constantly refer back to previous knowledge and help the students connect new information to what they already know. Using this novel could have been more successful with this age of students if more time was taken to really explore the different math concepts presented rather than just grazing the surface of each of concepts within the wide range of ideas.

No Single Method of Instruction Works for Everyone: As Shults (2008) pointed out, the traditional style of teaching math does not work for every student. Not everyone can really learn and understand math by simply seeing a demonstration of how to solve a problem and then repeating that process. Many students need to be more involved in the learning process or see how problems are solved in a different way than just an example on the board. Granted students do learn and succeed from this method of instruction, but it should not be the sole method of instruction used when there are students who struggle to learn from it. Using writing or reading in a math class is one way to vary instruction and reach those students who struggle with math, but may excel in or prefer English. Of the twelve students interviewed, eight said that they liked the book while the other four thought it was just okay. Nine students said they would want to read a novel in a math class again. Their reasons for this include because it was more fun, you can learn more, and it helps you understand better. Several students did say they would never want to read a novel in a math class again. One student's reasoning was because it was not that fun and he did not enjoy *The Number Devil* since it jumped around a lot. Another student's reason was because he does not like reading. There were students who both

liked and disliked using a novel in a math class just like there are students who both like and dislike doing problems from a textbook or worksheet. Enough students liked using the novel in class and seemed to learn from it that it is a good option to use when trying to vary instruction. Granted it depends on the students, the subject matter, and the novel selected for how effective using a novel would be in a mathematics classroom. None of the students had ever read a novel in a math class before so it was a completely new experience for all of them. As a whole, they seemed to enjoy the experience and many benefited from it in terms of learning different math concepts better.

Many of the students enjoyed using the novel or at least enjoyed several chapters from the novel. Others disliked the entire book. "I don't like this book because it's talking about nothing but stuff that we already know and I don't like learning stuff over because it's irritating," wrote a student in his journal. While this student did not like this book or this way of learning, he still improved quite a bit (by eight points) from his pre-assessment to his post-assessment. He may not have enjoyed learning in this way, but his improvement showed that he did in fact learn. Another student wrote, "I think this book is lame. I think this is because I don't like books about math. I don't really like math." Not every student is going to enjoy the way a class is taught, but that just makes varying instruction even more important. If a teacher varies instruction and incorporates things like reading or writing rather than only ever lecturing, giving notes, assigning worksheets, and using the textbook, then more students and learning styles could be reached allowing more students to learn and enjoy math.

Conclusion

This study has made various ideas about teaching and teaching math very apparent. If students are actively engaged in learning and the learning process then they are more likely to understand the concepts better, students understand math better if it is presented in some context or in a way that is relevant to their lives, it is difficult to learn concepts when they are fragmented or presented in separated pieces, and no single method of instruction works for all students. Using literacy components, like reading and writing, in a math class helped reach those students who disliked math or always struggled to understand math because of how it had been presented to them. While not every student benefited from using reading and writing to learn math, many did and even enjoyed the experience. Changing up the math instruction helped students look at math from a different perspective and see more clearly different ways that it can be used in real life problems.

The novel *The Number Devil* was a book that presented many different, and some difficult, math concepts. This caused some confusion on the part of the students because not enough time was spent on each concept for the students to fully understand and appreciate the math being taught. A different way this could be approached using this novel could be to split the book up based on concepts covered and use only the parts of the book that are relevant to what is being taught in class. The excerpts or chapters could be used as a supplement to a class textbook or could still be used as a primary text for presenting the information. Doing this may help increase student comprehension of different concepts without the confusion of so many new topics being presented to them in a short period of time. Another option for using this same novel could be to use it over a

greater period of time so each chapter could be looked at more deeply and the students could gain a better understanding of the concepts.

Other ways to try incorporating literature into math classes could be to use picture books that are math based as supplementary texts to a class textbook. Many picture books present concepts in fairly simple ways and just cover the basics of those concepts. Picture books could therefore be used as an introduction to a new concept or during a unit to help further the understanding of a topic. Another idea would be to use a different novel in a math class, one that has a single topic of focus rather than a wide range like *The Number Devil*. One such book is *A Gebra Named Al* by Wendy Isdell (1993) which is all about the order of operations. A novel like this could be used to introduce a class to the order of operations or could even be used with a class that just needs to review the order of operations. Using a novel that has a single focus could work better because it would give the students the opportunity to really look at that one topic and only that topic.

Incorporating more writing in math class is another idea to try. Having students keep a math journal where they write out their thoughts about math or how they solve certain problems could greatly help them increase their understanding of different topics. Being able to explain how to solve a problem is always helpful in increasing understanding and I am sure it is the same with being able to write out the steps for how to solve a problem.

Using more reading and writing in math classes as a way to vary instruction while also focusing on improving math literacy skills are goals I think teachers should strive for. While not all students will benefit from these methods of instruction, there are

definite pros to incorporating these literacy skills in math classes. Many students do not like math so changing up how it is presented to them and incorporating different ways of instruction may help them find it more enjoyable and more understandable.

In my future math classroom, I plan to incorporate more literacy skills through the use of reading and writing. I want to help all students learn and in completing this research believe that incorporating reading and writing in math could help more students understand and enjoy math. Using a novel, like *The Number Devil*, may not be a feasible option for all math classes or all grade levels, but some sort of literature could be incorporated into any level math class. While I know not every student will benefit from these different instructional strategies, it is worth trying since not every student benefits from the current instructional strategies in place. Math is an interesting, exciting, and useful subject that too many students struggle with or just flat out dislike. From this research, I have seen the benefits of incorporating literacy skills in the mathematics classroom. I plan to use reading and writing in my own classes and hope other teachers will strive to do the same.

References

- Bafle, C. (2008). Math and Literature: A Math Made in the Classroom. *EducationWorld*. Retrieved from http://www.educationworld.com/a_curr/curr249.shtml.
- Burns, M. (2010). As Easy as Pi: Picture Books are Perfect for Teaching Math. *School Library Journal*. Retrieved from http://www.schoollibraryjournal.com/slj/printissuecurrentissue/884762-427/as_easy_as_pi_picture.html.csp.
- Crutcher, C. (1987). *The Crazy Horse Electric Game*. New York, NY: HarperCollins Children's Books.
- DeLange, J. (2003). Mathematics for Literacy. *Mathematics Association of America*. Retrieved from http://www.maa.org/ql/pgs75_89.pdf.
- Devlin, K. (2000). *The Math Gene*. New York: Basic Books.
- Enzensberger, H.M. (1997). *The Number Devil*. New York, NY: Picador.
- Fogelberg, E., Skalinder, C., Satz, P., Bernstein, L., Hiller, B., & Vitantonio, S. (2008). *Integrating Literacy and Math: Strategies for K-6 Teachers*. New York, NY: Guilford Press.
- Isdell, W. (1993). *A Gebra Named Al*. Minneapolis, MN: Free Spirit Publishing Inc.
- Kennedy, J. (2005). *Literacy Strategies for Improving Mathematics Instruction*. Alexandria, VA: ASCD.
- Kester Phillips, D.C., Bardsley, M., Bach, T., & Gibb-Brown, K. (2009). But I Teach Math! The Journey of Middle School Mathematics Teachers and Literacy Coaches Learning to Integrate Literacy Strategies into the Math Instruction. *Education*, 129(3), 467-472. Retrieved from EBSCOhost.
- Koellner, K., Wallace, F.H., and Swackhamer, L. (2009). Integrating Literature to Support Mathematics Learning in Middle School. *Middle School Journal* 41(2), 30-39.
- Johnson, A. P. (2009). *What Every Teacher Should Know About Action Research*. Boston, MA: Pearson Education.
- Maclean, M. & Mohr, M. (1991). A teacher research process: Beginning: What do you need? In *Teacher researchers at work* (pp. 1-18). Berkley, California: National Writing Project.
- Martin, H. (2007). Mathematical Literacy. *Principal Leadership*, 7(5), 28-31.

McLeod, S. (2010). Zone of Proximal Development. Retrieved from <http://www.simplypsychology.org/Zone-of-Proximal-Development.html>.

Organization for Economic Cooperation and Development (OECD). (1999). *Measuring Student Knowledge and Skills. A New Framework for Assessment*. Paris: OECD.

Powell, S.D. (2011). *Introduction to Middle School*. (2nd ed). Indianapolis, IN: Pearson Education, Inc.

Schults, D. (2008). Content Area Literacy: Beyond the Language Arts Classroom. *Visual Thesaurus*. Retrieved from <http://www.visualthesaurus.com/cm/teachersatwork/1305/>.

Shagoury-Hubbard, R. & Miller-Power, B. (2003). *The art of classroom inquiry: A handbook for teacher-researchers*. Portsmouth, New Hampshire: Heinemann.

Smyth, T.S., and Waid, B. (2010). Integrating Literature: A Novel Idea! *Mathematics Teacher* 104(2), 113-119.

Vygotsky, L. (1978). *Mind in Society: The Development of Higher Psychological Processes*. (p. 26). Cambridge, Massachusetts: Harvard University Press.

Appendix A

Pre/Post Assessment of *The Number Devil* Concepts

Name: _____ Date: _____

Directions: Read each question carefully and answer each question completely to the best of your knowledge. Be sure to show all of your work.

Number Sense:

1. Write the next two numbers of the following sets of numbers:

a. Prime numbers: 1, 3, 5, 7, 11, _____

b. Perfect squares: 1, 4, 9, _____

c. Even numbers: 2, 4, 6, _____

d. Odd numbers: 3, 5, 7, _____

2. Use the following number to answer the questions below: 147.369

a. What number is in the tenths place? _____

b. What number is in the hundreds place? _____

c. What is the value of the number 7? _____

d. What is the value of the number 6? _____

Algebra:

Solving the following:

1. $2^2 =$ _____

2. $3^1 =$ _____

3. $12 \div 4 =$ _____

4. $125 \div 5 =$ _____

5. $3! =$ _____

6. $\sqrt{16} =$ _____

Geometry:1. What is pi (π) approximately equal to?

2. Identify four different types of shapes?

1. _____

2. _____

3. _____

4. _____

Problem Solving:

1. When leaving a birthday party, everyone shakes everyone else's hand while saying goodbye. If there were 5 people at the party, how many handshakes were made?

2. If a class had 4 students and the 4 students sat in one row of desks. How many different seating arrangements could the teacher make so that no two seating arrangements were the same?

3. Write the next three terms in the following pattern:

a. $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}, \dots$

b. $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \dots$

Appendix B**Vocabulary Knowledge Rating Chart**

Please rate the following terms based on your current level of understanding. There is no right or wrong answer, so please answer honestly. This will help us plan appropriately for future lessons based on your background knowledge. Use the following rating system:

- **1** if you have never heard of the term before
- **2** if you have heard of the term before but are not exactly sure how it correctly applies to mathematics
- **3** if you can define the term or identify the particular type of number and you understand the meaning of the term

1. The number 1 _____
2. The number 0 _____
3. Roman numerals _____
4. Place value _____
5. Palindrome _____
6. Prime numbers _____
7. Composite numbers _____
8. Irrational numbers _____
9. Perfect squares _____
10. Triangle numbers _____
11. Fibonacci numbers _____
12. Even numbers _____
13. Odd numbers _____
14. Imaginary numbers _____
15. Exponents _____
16. Division _____
17. Fractions _____
18. Square roots _____
19. Factorials _____
20. Series _____
21. Pythagoras _____
22. Pi _____
23. Combinations _____

Appendix C

Pre ad Post Questionnaire

NAME: _____

1. Do you remember ever reading a book that had math concepts in it?

Before: _____

After: _____

2. Do you know the importance of the number one in math?

Before: _____

After: _____

3. What do you think a “hopping” number is?

Before: _____

After: _____

4. Have you ever heard of triangle numbers? If so, what are they?

Before: _____

After: _____

5. Have you ever heard of Fibonacci numbers? If so, what are they?

Before: _____

After: _____

6. If you were told to take the “rutabaga” of a number, what do you think you would have to do?

Before: _____

After: _____

Appendix D

The 13th Chapter of *The Number Devil* (Final Assessment)

Assignment: With your group, you are to write a 13th night to *The Number Devil* in which the number devil teaches Robert about at least two chosen topics. Creativity is encouraged just as it was seen used throughout *The Number Devil*. Be sure to include all aspects of your topics to demonstrate your understanding of the topics. You must also include a few, at least 2, examples of real world applications of the topic you are explaining. You also must be creative. Remember this is the 13th chapter to the book. Therefore, there should be some similarities in the creativity the author used and in the creativity you used. Ask for help if you need help in making your chapter more creative. You must have at least a legible hand-written copy of your chapter and if time allows you may type it.

After writing your chapter, you will decide how you can act out your chapter. All groups will present their chapter on Monday, December 12th. Finally, your chapter will be turned in to be grade. Also, your presentation of your chapter will factor into your grade. This grade will go towards the points you will be receiving for partaking in this unit of study involving *The Number Devil* and the points will go towards your science grade.

See the rubric for specific guidelines and elements to include.

If you type the chapter, it is to be typed using 12 point Times New Roman font and should be double-spaced. Margins should be standard 1 inch all the way around.

Due Date: Monday, December 12th (You will have all of class on Monday, December 5th and Wednesday, December 7th to work on it.)

Concepts to be covered: Choose at least 2 concepts to incorporate into your chapter. You do not have to go into great detail; however, you must show that you have a solid understanding of the concepts. This can be done through showing examples and explaining the concepts. Look back at the chapters with read for examples how to possibly do this.