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An Integrated Approach: Incorporating Literature and Writing into Middle School Mathematics Instruction

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Abstract

Integrated curriculum, including integrated mathematics curriculum, is becoming more common in classrooms as teachers look for ways to improve students' understanding and performance across the board. Specifically, the presented thesis explores and reflects on the implementation of meaningful integration of literature and writing into mathematics instruction to promote students' mathematical literacy. Through carrying out an action research project involving teaching an integrated mathematics enrichment unit with the novel *The Number Devil: A Mathematical Adventure* by Hans Magnus Enzensberger and constantly reflecting and analyzing the lessons conclusions were drawn. Cross-curricular mathematics instruction can work if carried out effectively and it can provide ways in which to differentiate instruction and to teach skills in application in order to help all students become mathematically literate.
Introduction

The First Part: "You Need One Thing and One Thing Only."

Reading, writing, and arithmetic, or the three R’s, have been a commonly used and often transformed catchphrase for numerous years now. These original three R’s were frequently referred to as the essential skills. Many still believe students must master the basics of these three skills in order to move to higher order thinking. However, these crucial proficiencies have repeatedly been taught in isolation, especially arithmetic. I rarely encountered writing in my arithmetic courses and reading generally only came in the form of the dreaded story problems. When I learned a Secondary Mathematics education major had to take a course about literacy, I wondered why in the world a mathematics teacher needed to learn about reading. I began the course, and my undergraduate career, with the mentality that I was never going to be teaching reading in math and I finished the semester with a drastically different, more integrated outlook on literacy, on my future profession, and on how teaching mathematics should be approached.

Mathematical Literacy

During the first few weeks of my education course about content area literacy, I was challenged to define mathematical literacy. I understood literacy as a lens through which social and cultural contexts are understood, but I was clueless about what mathematical literacy meant, until I started researching. After reading several sources, I began to see a whole new side of mathematics and mathematical thinking. I began to see and understand the three separate, but equally important, types of mathematical
knowledge: declarative, procedural, and conceptual. Declarative knowledge encompasses terminology and some of the first mathematics taught: the easily recalled math facts, which provide the basis for procedural knowledge. Procedural knowledge includes all the rules, algorithms, and procedures used to solve mathematical tasks as well as knowing how each of these rules and algorithms are utilized. The last and most important area of mathematical knowledge is conceptual knowledge, which involves understanding and creating relationships among the various components in mathematics. Conceptual knowledge enables students to solve problems, reason, and take charge of their own learning. Yet, this is the area of mathematics frequently overlooked or under taught by many teachers, as it is not found in many of the academic standards. The academic standards merely serve as goals and meeting them is not enough because “students (still) lack the conceptual knowledge that enables them to apply their knowledge in problem solving situations” (Goldman & Hasselbring, 1997, p. 201).

These three areas of mathematical knowledge must be addressed, as “mathematical literacy requires the development of interactive relationships among declarative, procedural, and conceptual knowledge” (Goldman & Hasselbring, 1997, p. 200).

After spending time researching and learning about how others view mathematical literacy, I knew how to craft my own definition of mathematical literacy. Mathematical literacy requires having a wealth of understanding of the various concepts and components of mathematics and their relationships to one another so that students can appropriately apply these ideals in real-life experiences. Becoming mathematically literate is an intricate and complex endeavor and learning the language of mathematics is similar to that of learning a foreign language and becoming literate in it. After being
challenged to define mathematical literacy, I had a new outlook on mathematics and I began to understand the importance reading and writing play in mathematics. Students need to establish relationships between all of the mathematical knowledge they learn. Writing and literature can help students foster and reinforce the relationships of many of the areas of mathematical knowledge, especially with the critical development of conceptual knowledge, as well as reinforce the relationship across different disciplines. The incorporation of reading and writing into mathematics also helps build students' language literacy, as students are using their prior skills in reading and writing and developing them further with additions such as new vocabulary and new ways of thinking, explaining, or justifying their work.

Integrated Mathematics Instruction

After my eyes were opened to the incorporation of content area literacy in my future mathematics classroom and my views about teaching mathematics were altered, I completed an independent study course on young adolescent literature and strategies for teaching it. Throughout the course, I explored countless connections between literature and mathematics. An article titled "Integrating Literature to Support Mathematics Learning in Middle School" by Karen Koellner, Faith Wallace, and Lyn Swackhamer became the framework for the course. One of the pieces of literature discovered from the article and explored in the course was The Number Devil: A Mathematical Adventure by Hans Magnus Enzensberger. After reading and enjoying this young adolescent novel filled with an abundance of mathematical concepts including factorials, square roots, prime and composite numbers, and even Fibonacci numbers, a fellow undergrad and I
drafted a unit of study utilizing this book as the primary teaching text, opposed to a mathematics textbook. Our unit integrated a new and creative approach into teaching mathematical concepts and addressed various areas of mathematical knowledge. We incorporated reading of the novel and journaling throughout our unit. We also incorporated vocabulary and reading strategies often found in an English classroom, as the mathematical computations were not the only essential mathematical elements in the text. The vocabulary used throughout the text, part of declarative knowledge, is just as important as the computations, part of procedural knowledge. This unit integrated the key elements to achieving mathematical literacy.

After drafting my first integrated mathematics unit of study, I began looking for more research on integrating literature and writing into mathematics instruction. While researching, I discovered there is not an abundance of scholarly research on the integration of literature, writing, and mathematics, but there is some. One such scholar includes Marilyn Burns, a veteran mathematics teacher and the author of *Writing in Math Class: A resource for grades 2-8*. Burns is also the author of many articles including “3 Lessons by Marilyn Burns: Using storybooks to teach math” in which she notes “When I visit classrooms, I find that connecting math to literature can boost the confidence of those who love books but are ‘math-wary’” (Burns, 2005, p. 27). The integration of writing across the curriculum is a new and upcoming idea as schools are searching for ways to improve students’ understanding and performance, especially in mathematics. With the push for student improvement, I envision more scholarly works will be produced in the next few years about the possible advantages and ways in which literature and writing can be integrated into mathematics instruction.
As a student, I survived, and even thrived, in my mathematics classes. However, I do recall much of my mathematics instruction coming in the form of direct instruction or present-and-explain followed by a series of repetitive homework problems. This approach to teaching mathematics worked for my learning style and my abilities; yet, there are many more students for whom this approach to mathematics instruction and understanding does not work. Many students would benefit from a more integrated approach to teaching mathematics.

The meaningful integration of literature and writing into mathematics classes can only enhance mathematics and can help some students continue to develop their mathematical literacy. Specifically, the incorporation of reading into a mathematics classroom enables students to explore mathematical concepts in applicable situations making the mathematics more relatable while fostering students’ conceptual mathematical knowledge. Over the course of my action research, I will investigate and reinforce my philosophy toward teaching mathematics, especially integrating literature and writing to help students further develop their mathematical literacy. The following questions will provide the foundation for my action research: (1) Can an innovative cross-curricular approach to teaching mathematics contribute to the positive development of students’ mathematical literacy? (2) Can the incorporation of literature and writing into mathematics instruction ignite enthusiasm about mathematics in students?

**Mathematics Instruction Today and In the Future**

In our world today, we hear of students failing or falling behind in mathematics. Perhaps the skills-in-isolation way in which mathematics is taught in a plethora of
classrooms in the United States may be contributing to the lack of sound mathematical thinking and understanding by students today. Students deserve to have the opportunity to succeed in mathematics and I, as a mathematics teacher, want to find ways to provide this opportunity to my future, diverse classrooms full of students. The integration of reading and writing into mathematics could help open this opportunity for mathematical success for many students. Therefore, now is the time to create and discover new and innovative ways to adapt mathematics instruction in an effort to develop a more cross-curricular approach to teaching.
Literature Review

The Second Part: “You’re Just Trying to Win Me Over.”

I’m really excited about the possibilities of using literature to teach math in my class. And yet, I’d be less than honest if I didn’t say that the idea makes me feel a little uncomfortable. After all, I’m a math teacher. I haven’t had any training or experience in this area, so I don’t really know what literature is out there to teach math and where to find it (Moore & Bintz, 2002, p. 78).

This thought process describes the dilemma many mathematics teachers face; they know their content and are comfortable teaching mathematical concepts, but they want to try something new. Many teachers, including mathematics teachers, are unsure of trying something new for fear that failing would result in the loss of valuable time in the curriculum scope and sequence. Therefore, they do not incorporate a variety of teaching devices, such as literature and writing, into their classrooms. They have little to no experience with these teaching devices and often do not even know where to start. Luckily, some support does exist for current teachers who want to bring literature and writing into their mathematics classrooms. However, this support is not necessarily found in a nearby colleague. The needed support resides in journal articles and other scholarly sources. These sources combined represent our distant teachers and colleagues who have often already found some of the answers for us. Many teachers have succeeded in incorporating various elements often found in a language arts classroom into their mathematics classrooms. Some of these elements include writing, children’s books, folk and fairy tales, poetry, and even the Harry Potter series (Sherard, 2005). If distant teachers have found success, who is to say more teachers cannot find success too and who is to say teachers are approaching mathematics instruction in the best possible way?
The Beauty of the Language of Mathematics

Many mathematics related sources claim mathematics is like a language, if not claiming mathematics as a language. One of the numerous definitions of language in the Merriam-Webster Dictionary is “a formal system of signs and symbols including rules for the formation and transformation of admissible expressions.” Given this definition of language, mathematics appears to be a language and mathematics shares many attributes of language:

- Abstractions are used to communicate.
- Symbols and rules are uniform and consistent.
- Expressions are linear and serial.
- Understanding increases with practice.
- Success requires memorization of symbols and rules.
- Translations and interpretations are required for novice learners.
- Meaning is influenced by symbol order.
- Communication requires encoding and decoding.
- Intuition, insightfulness, and ‘speaking without thinking’ accompany fluency.
- Experiences from childhood supply the foundation for future development.
- The possibilities for expressions are infinite. (Wakefield, 2000, p. 272-273)

These attributes are one in the same for learning a language and for learning mathematics. Thus, the inclusion of ways in which people acquire a language into mathematics classes can enhance the mathematics instruction. These necessary characteristics of mathematics instruction will allow students to “become immersed and experience the mystical ‘fluency without thought’ phenomenon in a second language” while moving “to a level unexplainable to those who have not experienced it” (Wakefield, 2000, p. 275).

“The finite instances of math instruction fail to explain the infinite applications and adaptations humans exhibit” (Chomsky, 1999 as cited in Wakefield, 2000, p. 273).
Mathematics cannot be taught alone with little to no connections to other areas of mathematics and with little to no applications to students’ lives. Mathematics must be taught collectively and not in a restricted manner. Students must acquire the knowledge of the mathematical concepts and then also learn the language through which to communicate their knowledge (Burns, 2006). Mathematics education must allow students to go all in and immerse themselves within it to discover how to navigate through it. Mathematics must be spoken before it can be written and it involves continual practice and intuitive thinking. Lastly, mathematics lessons must be taught in meaningful contexts (Wakefield, 2000). When mathematics “focuses on detailed facts and procedures while neglecting the fundamental nature and value of the field” (Kleiman, 1991, p. 48), students learn an impoverished mathematics. Students deserve to learn the beauty of the language.

Unfortunately, many mathematics teachers struggle to convey the rich language appropriately to their students in order for them to see the connections it has to their own world. Many teachers and a few other select people understand the language of mathematics “provides a means for understanding, analyzing, and communicating across the curriculum and throughout students’ lives” (Kleiman, 1991, p. 51). However, this is not the view of most students. To most students and to most people “mathematics is its own world, accessible to only a select few, and, except for basic computation, of little relevance or use for most people” (Kleiman, 1991, p. 48). Therefore, teachers must find ways to alter many of their students’ viewpoints. “E=mc² is a wonderful and insightful idea if you speak the language” (Wakefield, 2000, p. 278). Thus, students must speak the language to understand the concepts, equations, and theorems expressed in the language.
Learning the Language of Mathematics through Literature

In Wakefield’s article “Math as a Second Language” (2000), the idea of teaching mathematics as if it were a second language is explored. From Wakefield’s (2000) study of teaching mathematics as a second language, she concluded, “As we begin to conceive of math as a living, breathing language with a culture of ideas expressed in numbers, we also see that math cannot be regulated to a narrow time slot in the curriculum” (p. 278). Once students become fluent in this second language of mathematics, they will understand mathematics in new ways and become stronger problem solvers and thinkers. Students will be able to share in the beauty of the language, along with other mathematicians, upon fluency. Hence, mathematics teachers do not only bear the task of teaching mathematics, but they must help their students reach fluency in the language.

“The task of teaching...the language of math should be a comprehensive endeavor rather than an isolated foray into a theoretical land of abstractions” (Wakefield, 2000, p. 278). Incorporating literature into mathematics instruction is one of many ways to help create the study of the language of mathematics a comprehensive endeavor. Literature can make mathematics more enjoyable, interesting, and relevant for students (Sherard, 2005). Connecting mathematical concepts to literature, or visa-versa, represents an innovative approach to teaching mathematics and helps capture students’ attention and interest. In addition, “the use of literature with mathematics can help reduce the anxiety felt by mathephobes” (Zambo, 2005, p. 395). These connections between mathematics and literature are rooted in the understanding of mathematics as a language and lead students to a better appreciation of the subject matter. Making and showing the mathematical connections found in literature, enables students to more easily discover the
usefulness of various mathematical concepts as they are presented in context (McShea, Vogel, & Yarnevich, 2005).

**Where Mathematics Can Be Found in Literature**

There are many existing pieces of literature out there including children’s books, poems, and novels waiting to be brought into a mathematics classroom. “Man listened to narratives long before he learned how to read and write. As humans, we are predisposed to listening to stories and using them to explain things to ourselves” (Zambo, 2005, p. 395). Hence, stories such as *A Grain of Rice* (Pitman, 1986), *The Toothpaste Millionaire* (Merrill, 1972), and *A Gebra Named Al* (Isdell, 1993) can guide us in mathematical explanations as they “present interesting problems and illustrate how other children solve them” (Wilburne & Napoli, 2007, p. 139). Specifically, the plot of *A Gebra Named Al* follows a young girl who is struggling in Algebra and dreams of an adventure in math and science land. Not only does this piece of literature connect to mathematics in numerous places, it also integrates science into the reading experience (Koellner, Wallace, & Swackhamer, 2009).

Additionally, the popular Harry Potter series by J.K. Rowling can be incorporated into a mathematics classroom, especially since Harry Potter, himself, is nothing short of a problem solver. In *Harry Potter and the Sorcerer’s Stone* (Rowling, 1997), Harry must quickly understand the wizard monetary system, which can be incorporated into a mathematics lesson involving “expressing measurements in equivalent forms” (McShea, Vogel, & Yarnevich, 2005, p. 409).
Griphook unlocked the door. A lot of green smoke came billowing out, and as it cleared, Harry gasped. Inside were mounds of gold coins. Columns of silver. Heaps of little bronze Knuts.

"All yours," smiled Hagrid...

Hagrid helped Harry pile some of it into a bag.

"The gold ones are Galleons," he explained. "Seventeen silver Sickles to a Galleon and twenty-nine Knuts to a Sickle, it's easy enough" (Rowling, 1997, p. 75).

Also, the concept of functions can be introduced using an example from *Harry Potter and the Sorcerer’s Stone* (Rowling, 1997). This scene takes place on Harry’s train ride to Hogwarts School of Witchcraft and Wizardry and it is one of his first experiences free from the Dursleys:

He had never had any money for candy with the Dursleys, and now that he had pockets rattling with gold and silver he was ready to buy as many Mars Bars as he could carry—but the woman didn’t have Mars Bars. What she did have were Bertie Bott’s Every Flavor Beans, Drooble’s Best Blowing Gum, Chocolate Frogs, Pumpkin Pasties, Cauldron Cakes, Licorice Wands, and a number of strange things Harry had never seen in his life (Rowling, 1997, p. 101).

After reading this excerpt, the following problem can be posed to students: “Assume that Harry bought Chocolate Frogs, which cost 11 bronze Knuts per bag, and Bertie Bott’s Every Flavor Beans, which cost 17 bronze Knuts per bag. How many bags of each candy did Harry buy if his purchase totaled 11 silver Sickles and 7 bronze Knuts?” (McShea, Vogel, & Yarnevich, 2005, p. 409). These are two examples of how mathematics teachers have used literature, specifically *Harry Potter and the Sorcerer’s Stone* (Rowling, 1997), to explore mathematical concepts, including conversions and functions and linear modeling in the above problem. Using mathematics connected to literature allows students to connect and apply the mathematics they are computing to the story. “While studying the mathematics of Harry’s world, [students] are able to share in the adventures and identify with characters” (McShea, Vogel, & Yarnevich, 2005, p. 413).
In addition to children’s books and novels, poetry provides another tool for engaging students in mathematics. Particularly, many of the works by Shel Silverstein have mathematics written within them. “Imbedded in many of his poems and prose are opportunities to do mathematics in ways that will get students’ minds ‘flickerin’” (Bay-Williams, 2005). One example of mathematics in poetry can be found in Shel Silverstein’s poem “Band-Aids” in *Where the Sidewalk Ends* (Silverstein, 1974). The mathematical opportunity involves “counting the number of Band-Aids in the poem and figuring out the area that they cover” (Bay-Williams, 2005, p. 392). Also in *Where the Sidewalk Ends* (Silverstein, 2074), “Eighteen Flavors” can challenge students to discover the height of the ice cream cone before it fell to the ground. This task invites many different approaches to the problem and the use of algebra in a different context. Additionally, in *Falling Up* (Silverstein, 1996) more mathematics can be explored. For example, the poem “Closet Full of Shoes” offers opportunities to explore conditional probability along with other elements of statistics. These are just a few of the many poems with potential to create a more engaging mathematics lesson in which students explore different contexts to make sense of the complex language of mathematics (Bay-Williams, 2005).

**Using Journals to Explore the Language of Mathematics**

Another avenue in which to explore the complexities of the language of mathematics is writing. Writing is another key component to learning a language, but as mentioned earlier the spoken language comes first. After giving students time for discussion and verbal exploration of a concept, it is important to challenge them to write
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about it (Darvin, 2007). Vygotsky views “the relationship between language and thought as a dialectic one, where language and thought are both transformed in the act of representation” (Borasi & Rose, 1989, p. 348). Writing engages all students in structuring meaning, accommodates the speed of all learners as they can move at their own speed, and allows the writer personal feedback as one can immediately read their own thoughts now put on paper (Borasi & Rose, 1989). However, in order for writing to complement reading, it must be a “meaning-making process that involves the learner in actively building connections between what she’s learning and what is already known” (Borasi & Rose, 1989). Journal writing is one valuable type of writing that fits this category of writing to learn (Borasi & Rose, 1989).

Marilyn Burns, who once compared math and writing to water and oil, dramatically changed her views about writing in mathematics instruction while studying at the City University of New York in a language, literacy, and culture in education course (Darvin, 2007). “Not only did I see how writing helped students think more deeply and clearly about mathematics, but I also discovered that students’ writing was an invaluable tool for me to assess their learning. Writing in math class supports learning because it requires students to organize, clarify, and reflect on their own ideas—all useful processes for making sense of mathematics” (Burns, 2004, p. 30). Students’ writings allow the teacher to see the thinking behind their responses. Did the students arrive at the correct answer through the correct thought process? Often this question is left unanswered, but writing allows teachers to truly see the thought process and know if the students understand the process accurately.
Writing also allows students to explore their own thoughts and question what they are being taught. "Mathematics was born from people’s need to question the world around them and set out to prove or disprove theories they had about how it functions" (Darvin, 2007, p. 248). Questioning is what led Archimedes, Einstein, Descartes, and other mathematicians to their discoveries and contributions to the field of mathematics. Thus, it is fitting for students to likewise question and explore the subject matter (Darvin, 2007). The language of mathematics would not be where it is today without exploration and trial and error by many individuals. Students, too, must not accept everything they are told or taught. Students should see and understand the connections and reasons why they are computing certain ways to solve particular problems. Journaling is one such way for students to think out loud in order to more clearly see and understand the connections and explanations to the concepts which have been introduced to them.

**Integrating Creative Writing into Mathematics**

One specific way for students to combine writing and mathematics and continue the exploration of mathematical thinking other than through the use of journal prompts is to incorporate mathematics into creative writing. Cara Halpern, a Geometry and Algebra teacher at Lexington High School in Lexington, Massachusetts, utilizes literature and creative writing “to enhance the understanding and enjoyment that her students experience in their study of mathematics” (Halpern & Halpern, 2005/2006, p. 226). Halpern provides her students with numerous opportunities to succeed in her mathematics classes and to use their language skills combined with the language of mathematics to demonstrate their knowledge. Halpern “assigned a project in which the
students were either to modify a story or a fairy tale they knew or to create one of their own. They were also required to incorporate some of the mathematics they had learned in class” (Halpern & Halpern, 2005/2006, p. 226). She then assessed the project on mathematical language, creativity, and mathematical accuracy (Halpern & Halpern, 2005/2006). Through the students’ products, including plays, revamped fairy tales, love stories, and even stories of war, they expressed a variety of mathematics in everyday life and the students saw the importance of the mathematical language. “They (the students) came to realize that mathematics contains history as well as culture” (Halpern & Halpern, 2005/2006, p. 230).

Additionally, creative writing can be integrated into a mathematics unit on graphing. While students are studying graphs, they can create realistic graphs of their day or week. After creating their graphs, students can then write about and explain their particular graph and why there are certain changes in their graph (Maus, 2005). John Maus, a seventh-grade mathematics teacher came up with this idea while reading Kurt Vonnegut’s autobiographical work Palm Sunday. In Palm Sunday, Vonnegut says, “stories have shapes that can be drawn on graph paper, and ... the shapes of a given society’s stories are at least as interesting as the shape of its pots and spearheads” (Maus, 2005, p. 375). “Their (the seventh-grade students’) determination to defend their interpretations of the stories in their graphs lead to fruitful arguments that laid the groundwork for our work with linear functions and beyond” (Maus, 2005, p. 379). This is just another example of integration of literature into mathematics and how this integration can not only provide a means to explore mathematical concepts, but also can provide a connection by joining the concept to part of the students’ lives.
Incorporating Literature and Writing into Mathematics Instruction

Mathematics can be omnipresent in one’s thoughts and views of the world. Teachers can help restore this developing phenomenon of mathematical thinking by incorporating literature and writing into their instructional strategies. Teachers can also approach mathematics from more of a linguistic perspective to engage their students in more meaningful and thought-provoking ways along their discovery of and fluency in the language of mathematics. The integration of literature and writing into mathematics can help foster students’ imaginations and investigations as they begin to see the numerous occurrences of mathematics in their lives and in the world in which they live.
Methodology

The Third Part: “I Am the Number Devil.”

Can an innovative cross-curricular approach to teaching mathematics contribute to the positive development of students’ mathematical literacy? Can the incorporation of literature and writing into mathematics instruction ignite enthusiasm about mathematics in students? In an effort to discover answers to these questions, my co-researcher, Rachel Colby, a fellow undergrad, and I designed and carried out an action research project and we utilized the work *The Art of Classroom Inquiry: A Handbook for Teacher-Researchers* by Hubbard and Power to guide our research endeavor (Hubbard & Power, 2003).

Creating the Plan

To find answers to these questions, we brainstormed our options. We knew we needed an opportunity to teach a cross-curricular mathematics unit to gather data and explore possibilities (Hubbard & Power, 2003). Therefore, we created a unit around the novel *The Number Devil: A Mathematical Adventure* by Hans Magnus Enzensberger. We chose to incorporate this novel because it creates an engaging, contextualized, and fun way to learn about challenging concepts in mathematics. Students alongside the main character Robert can explore practical and relatable applications of concepts, such as algebra, problem solving, geometry, and numbers and operations. Robert is a twelve-year-old who does not like mathematics and is not very good at it either. In the first chapter titled “The First Night,” Robert is visited by an elderly math whiz the size of a grasshopper, also known as the Number Devil, in his dream. Over the course of several
subsequent nights, the Number Devil visits Robert and shows him new approaches and insights into the world of numbers and mathematics including making numbers hop (exponents), hopping backward (taking the square root), and vroom! (factorials). Based on the main character Robert in *The Number Devil* and the mathematics explored in it, we decided our target grade level for instruction would be sixth or seventh grade.

**Finalizing the Plan**

With a unit plan created, we next needed to find out where and with whom we could utilize it (Hubbard & Power, 2003). We considered teaching our unit as an extra-curricular activity, but thought our data would be more valuable for future classroom applications if we taught our cross-curricular approach to mathematics in a classroom during the school day. With the goal of teaching our unit in a classroom setting, we thought about the school in which we wanted to work. While we considered our potential options in a few different middle schools, our first choice was to carry out our research at a local school partnering with a local university. Our involvement at the school would help to continue fostering the relationship between the school and university. Additionally, my co-researcher and I both had previously worked with teachers at this school for some of our coursework. In particular, my previous cooperating mentor teacher at the school was a sixth grade mathematics teacher. While observing her instruction and even teaching a few lessons of my own in her classroom, she and I developed a strong, positive relationship. This positive experience led me to think there would be a possibility that my co-researcher and I would be able to work with her to carry out our action research project.
After we received IRB approval to carry out our project, we worked with some of the school officials to determine when and how we could execute it. We were graciously provided the opportunity to teach a mathematics enrichment unit to one of my previous cooperating mentor teacher’s sixth grade classes. We typically worked with the class on Mondays for forty-five minutes and Wednesdays for eighty minutes throughout much of the school year’s second quarter from the 24th of October through the 14th of December.

The Research Questions

Before beginning to teach and collect data, we developed two specific questions or criteria to evaluate the effectiveness of our cross-curricular approach with the incorporation of literature and writing in mathematics instruction: (1) Can an innovative cross-curricular approach to teaching mathematics contribute to the positive development of students’ mathematical literacy? (2) Can the incorporation of literature and writing into mathematics instruction ignite enthusiasm about mathematics in students? These specific questions served as the foundation and purpose behind our data collection (Hubbard & Power, 2003).

Data Collection

After the development of the criteria, we created a plan for data collection. We determined what type of data was needed, as well as addressed the issues of when, how, and how often we were going to collect the data during our enrichment unit incorporating The Number Devil. Each day of instruction had a detailed plan including the concepts
and standards being addressed and the data, if any, to be collected and was co-taught by my co-researcher and I.

In order to address whether or not students exhibited improvement and if students’ levels of mathematical literacy increased, we administered a pre assessment on the first day of the unit and a post assessment on the last day of teaching in the unit. In addition to the data from the pre and post assessments (See Appendix A.), we also collected data from the final project (See Appendix B.), a pre and post questionnaire (See Appendix C.), and a vocabulary knowledge-rating chart (See Appendix D.) to measure students’ levels of mathematical literacy (Hubbard & Power, 2003). This collection of data helped answer the first two criteria for our data collection.

The pre and post assessments contained questions drawn from what my co-researcher and I perceived as the most important concepts discussed in the novel relative to sixth grade mathematics state standards, including numbers, operations, geometry, and problem solving. The students’ pre and post assessment scores were compared question by question to show patterns of where student improvement occurred and did not occur. The questionnaire involved questions about students’ interests and knowledge of particular mathematics concepts. The purpose of the questionnaire was to see if students’ answers developed from the beginning to the end of the unit. The vocabulary knowledge-rating chart contained mathematical vocabulary taken from The Number Devil and students were asked to rank their understanding of each term given. The students’ pre and post rankings were compared and analyzed for patterns and themes (Hubbard & Power, 2003).
The final project involved students working in assigned groups to explore two mathematical concepts not discussed in the novel. As a group, students wrote their own thirteenth chapter for the novel in which they incorporated the two concepts they explored with their group. After completing their chapter, students acted out their chapter in order to present it to their classmates. This idea for students to act out their chapter stemmed from the hook of this unit of study in which students watched a video (Hans Magnus Enzensberger's "The Number Devil") of much of the first chapter of the book before we began reading it. The final project provided a close to the cross-curricular approach and incorporated more writing into mathematics. While students were working on their final project, my co-researcher and I worked with the groups and took many field notes from our observations (Hubbard & Power, 2003). Our field notes during this time contributed not only to data addressing the first two criteria in showing students' improvement in mathematical literacy, but also the last criteria about students' enthusiasm toward mathematics.

The last criteria for our data collection, which questioned whether or not students developed or displayed an enthusiasm toward mathematics during the unit involving literature and writing, proved to be the most difficult evidence to collect. Throughout the unit, the students were assigned almost daily journal entries. After each chapter was read and discussed, students were asked to journal about it. Students were asked to explain the mathematical concepts in such a way that someone who had not read the chapter, such as a friend in a different class, a sibling, or a parent, would understand the concepts. Students were also asked to write about their feelings toward the chapter, toward the activities in relation to the chapter, and toward this approach to learning mathematics.
Also, after each class period, my co-researcher and I individually wrote extensive field notes in our own research journals about the particular class period and what we saw, heard, and felt. We paid special attention to students’ body language and attitudes while teaching and noted these observations in our journals. Observing students’ body language and attitudes helped to gauge both their understanding and enthusiasm, which play important roles in learning (Hubbard & Power, 2003). In addition to journal entries, several students were interviewed two days after the conclusion of our unit. We videotaped the interviews in order to review students’ responses to the questions in addition to their body language and facial expressions (Hubbard & Power, 2003). The journals and interviews were collected in hope to analyze students’ enthusiasm toward mathematics with the added elements of literature and writing to mathematics instruction.

Starting to Analyze

While continuing to collect data and upon wrapping up instruction, the information gathered was organized and analyzed. While analyzing the data, I looked for themes and patterns to develop (Hubbard & Power, 2003). The students’ pre and post assessments were compared, as well as the pre and post questionnaires and the vocabulary knowledge-rating charts given both at the beginning and end of the unit. The journals were also read and analyzed periodically. In the journals, I looked for commonalities, opinions, and reactions to two different things: (1) students’ explanations and understandings of the concepts and (2) students’ reactions and thoughts about the cross-curricular approach used to teach and reinforce mathematics (Hubbard & Power, 2003). The analysis of the journals contributed to the findings of whether or not the
integration of literature and writing improves students’ levels of mathematical literacy and creates enthusiasm in students toward mathematics. In addition to the analysis from the journals, the post-unit interviews were also reviewed for themes and patterns in students’ responses, body language, and facial expressions throughout the interview.

**Framing the Results and Drawing Conclusions**

All of the commonalities, reactions, themes, and patterns were utilized in the analysis of the criteria and how the action research project helped to find answers to the overarching research questions (Hubbard & Power, 2003). From the action research project and the analysis of the data, results were drawn. Also, potential modifications to be made to the unit utilizing *The Number Devil* as the primary source of text based on the findings after the first implementation of the unit were noted. In addition to the results found, the applications of these results were discussed and suggestions for mathematics instruction were made based on the analysis of this particular action research project. Finally, a conclusion wrapped up the action research project and future questions were asked (Hubbard & Power, 2003).
Analysis

The Fourth Part: “And Here We Are Again.”

Mathematical literacy requires having a wealth of understanding of the various concepts and components of mathematics and their relationships to one another so that students can appropriately apply these ideals in real-life experiences. Did a cross-curricular approach to teaching mathematics contribute to the positive development of students’ mathematical literacy? Did the students develop an enthusiasm toward mathematics with the added elements of literature and writing? These are the two questions addressed in the data from the research my co-researcher and I carried out in our enrichment unit.

Development of Students’ Mathematical Literacy: Procedural Knowledge

The collection and analysis of data has led to a variety of conclusions in answering the questions raised throughout this process. Can an innovative cross-curricular approach to teaching mathematics contribute to the positive development of students’ mathematical literacy? Multiple sources from students’ journals, interviews with students, and my field notes point to the overarching conclusion that a cross-curricular approach to teaching mathematics with the inclusion of writing and literature can work. The students built a stronger foundation, in regards to procedural knowledge, of the mathematical concepts that they already knew in the novel The Number Devil. As for the concepts they had not seen before reading this novel, students were able to show progress in application of the mathematical concepts from their pre assessment to their post assessment.
Eleven of the fifteen students from which data was collected improved their scores by an average of 4.4 points out of 22 total points, which was an 18.67% increase. The majority of students who showed improvement in their overall assessment scores, showed an increase in understanding of the problem solving questions involving applicable scenarios, including the number of different seating arrangements and the number of possible handshakes while reinforcing the mathematical concept of combinations without repetition. This concept of combinations is discussed in great detail in “The Eighth Night” in The Number Devil. Two of the students scored the same on the pre assessment and the post assessment; however, they did not answer all of the same questions correctly on the pre and post assessments. The fifteenth student’s score went down 2 points from 14 out of 22 to 12 out of 22; nevertheless, the student did not answer all of the same questions correctly on both assessments. A number of factors could have contributed to this particular student, as well as other students, answering different questions correctly on the pre and post assessments, including how the student was feeling the day of the assessment, luck, and the overall energy of the student at the time they were asked to take the assessments. Yet, the pre to post assessment scores demonstrate students gained knowledge and understanding of concepts discussed in the enrichment unit utilizing The Number Devil.

Another measurable indicator of students’ mathematical literacy is evident in the fact that throughout the entire unit using The Number Devil sixth grade Indiana state standards were met and evidence supporting this claim was found in students’ journals as well their post assessments. (See Appendix E.) Students multiplied and divided positive and negative integers (MA.6.2.2 2000). Students expressed solutions clearly and
logically by using the appropriate mathematical terms and notation and students supported their solutions with evidence in both verbal and symbolic work (MA.6.7.5 2000). Students also solved problems involving addition, subtraction, multiplication, and division of positive fractions and explained why a particular operation was used for a given situation (MA.6.2.5 2000).

In addition to meeting mathematics standards for sixth graders in Indiana, several National Council of Teachers of Mathematics (NCTM) standards were also met. Students explored numbers in a variety of forms and understood numbers, ways of representing numbers, relationships among numbers, and number systems (Numbers and Operations Standards grades 6-8, NCTM) through our exploration of even and odd numbers, prime and composite numbers, triangle numbers, Fibonacci numbers, exponents, square roots, and Roman Numerals and the importance of zero. Students also developed an understanding of some patterns, relations, and functions (Algebra Standard for grades 6-8, NCTM) through the study of combinations and permutations. In addition, students built new mathematical knowledge through problem solving and students were able to apply and adapt a variety of strategies to solve problems (Problem Solving Standards grades 6-8, NCTM). A variety of these NCTM standards were assessed through the pre and post assessments, as students were asked questions in relation to many of the standards including finding the next two numbers in sequences of numbers, computing operations, and solving story problems involving combinations and permutations.

Nevertheless, another question must be addressed: would the students' scores have improved using a method of instruction in which the students' mathematics classes
have been taught in the past? In other words, would the same outcome be achieved without a cross-curricular approach? From experience and education the answer would tend toward a yes while discussing the students’ procedural knowledge development through this enrichment unit. The same students would have more than likely produced a similar outcome in regards to mathematical procedural knowledge without the cross-curricular approach. Yet, a cross-curricular approach can lead to more than simply development of mathematical procedural knowledge. Students were not only required to utilize and develop their mathematical skills; students had the opportunity to enhance their reading, writing, and vocabulary skills as well through reading the novel and writing journal entries.

**Development of Students’ Mathematical Literacy: Conceptual Knowledge**

While the assessment scores point to an improvement in students’ mathematics understanding, or procedural knowledge, and ability level on particular mathematical concepts, the answers given in the journals, and the interviews reflect varying results toward students’ conceptual knowledge. When students were asked to explain the new concepts we discussed in the unit in the interview or in their journals, many students’ explanations were incomprehensible for someone with a minimal background in mathematics.

When one student was asked to explain his favorite day of instruction while interviewing him, he described the day we talked about “handshakes.” I followed up his response with a question about how we can find out how many handshakes it would take for everyone in a group to shake hands once. In his response he said, “If we have like 5
people, you have to shake hands with everybody and once you shake hands with everyone you will know how many we have” (#18). In his response he could not articulate exactly what he really wanted to say, but from an activity in the previous class where we literally found the number of handshakes for five people, he was able to arrive at the answer. Thus, while some students could answer questions requiring them to apply their understanding, like those on the assessment, they could not explain nor demonstrate their understanding and thinking through words. Therefore, their mathematical literacy as a whole was not developed as much as it potentially could have been and needs to be. Students’ declarative knowledge and conceptual knowledge were not greatly improved upon over the course of the enrichment unit.

In addition to the interviews and journals providing this evidence, the students’ responses to the vocabulary-knowledge-rating chart supports this claim as most students’ rankings on understanding of the mathematical terms stayed the same from the beginning to the end of the unit. In particular students had the same strong understanding of division, fractions, prime numbers, and place value. However, on the knowledge-rating-chart student’s claimed to have an increased understanding of triangle numbers and Fibonacci numbers, but the increase demonstrates that they can now acknowledge that they have seen the word and have heard about it, not that they have a sound understanding of the particular concept yet. This was sustained in the students’ interviews when some students tried to explain these concepts in their interviews; their descriptions lacked sound logic and coherent mathematical explanations.

The questionnaires and journals provide several examples of the absence of sound mathematical literacy of some of the particular concepts covered. One student’s response
on the questionnaire to “taking the *rutabaga*”, or square root, included: “you get a number that can go in even with that number” (#3). Some other examples from students’ journals include: “the explanation mark means to multiply the numbers before the number for example, 5!=5x4x3x2x1” (#7); “Greater (fractions) are actually smaller pieces and smaller fractions are bigger pieces!” (#7).

Students’ apprehension toward answering some questions involving explanations shown in some class discussions and through the interviews demonstrates the existing disconnect in their mathematical literacy, which may be linked back to deficiencies in developing a strong understanding of the vocabulary. While the students may think they have an increased understanding of the particular concepts, their ability to translate their understanding was weak and even obsolete for some students, as several students simply drew pictures or wrote an example of a computation in their journal instead of explaining their thoughts in words. Having students write about their mathematical thinking is important as it challenges them by requiring students to organize, clarify, and reflect on their own ideas. This process helps students to develop their mathematical literacy as a whole. However, in this unit of study, we as pre service novice teachers were not able to achieve the status of organization, clarity, and reflection from our students. Many factors could have contributed to this missed opportunity, including the role the students’ journals played in instruction and learning.

Almost all of the students had little experience with journaling in mathematics and the combination of their lack of journaling experience with the new mathematical concepts they were being asked to write about created many mediocre journal entries. In the future, I will show students the expectations for each journal entry and how they can
write a successful and beneficial entry in order to complete the journal exercise. In
hindsight, we should have taught a mini lesson on effective journaling at the beginning of
our unit. Another improvement to the journal exercises would have been to modify the
journal entry questions, including making some questions more specific to guide the
students more clearly on what they should write and how to organize their thoughts
around the mathematical concepts.

A Glimpse Inside Students’ Journals

While the journaling exercises were not the most effective in expressing
mathematical knowledge for the majority of the students, several students did express
their reactions to this approach of learning mathematics and more specifically their
reactions to certain chapters and mathematical concepts. There was a wide range of
journal comments, including some at both extremes.

In one student’s journal, his opinion in regards to the book fluctuated from the
beginning to the end of the enrichment unit. After reading and discussing “The First
Night” in his journal he noted that the book appeared boring based on the title, but then
later in that same entry wrote “the book seems very interesting” (#14). It is unknown if
this comment is from the actual text in the book or how we introduced the book to the
class. After passing out the books and before beginning to read any of it, students
watched a video clip based on the first half of the first chapter (Hans Magnus
Enzensberger’s “The Number Devil”). This helped to get some of the students excited
about what we were reading and it may have led to the comment about the book seeming
interesting. In this same student’s journal he later wrote, “So far I think this book is
boring. I think this because it’s about math. I don’t really like math” (#14). This was found in the entry written after “The Fifth Night.” However, by “The Eighth Night,” he wrote, “I really enjoyed the things we did today. But I really didn’t understand when we first started” (#14). Thus, while this student may not have enjoyed the book, he did enjoy some of the activities completed in response to some of the chapters in the novel. This particular day may have been enjoyable because students were grouped then given challenges to complete with their group about permutations without repetition, or seating arrangements, and combinations without repetition, or handshakes.

Another student (#10) who had a very thorough journal and reflective entries expressed his thoughts toward each of the chapters and even explained some of the mathematical concepts we studied as the students were asked to do. After reading “The First Night,” the student wrote, “I enjoyed chapter one and the few pages of the book I have read. I can’t wait to read chapter 2” (#10). Later on in “The Second Night” journal entry the student wrote, “I liked this because it is very mathematical, humorous, and acknowledgeable” (#10). By “The Third Night,” the student even began to explain some of the new mathematical concepts clearly. “Prime numbers are numbers that are only divisible by one (and itself)” (#10). However, in “The Fourth Night” the student expressed that the mathematical concepts were confusing and thus the student did not like the chapter very much. This chapter involved taking the rutabaga or square roots. In the student’s journal entry for “The Fifth Night” it said, “This night was comical and very challenging… I find this method very usable (referring to exponents)” (#10). The student went on to say how he loved chapter six, but chapter nine was boring and bland (#10). The journal entries from this student provide insight into what parts of the book were
more enjoyable and more easily understood. Where the student expressed frustration and dislike due to the confusing concepts, it was expected to see some confusion or frustration as some of the mathematical concepts discussed in the book are beyond the sixth grade level, especially some of the more abstract concepts, as sixth graders are generally not able to think completely abstract and still rely on very concrete thinking and ideas.

From other students’ journal entries it is apparent several students enjoyed many of the chapters and the cross-curricular approach to the mathematics instruction. “The first chapter I like it. I really enjoy it” (#3). “I really like reading the book in this class. I hope we can do stuff like this in our (math) class” (#3). “My opinion is still the same. I love this book. I like how it teaches you in fun ways” (#4). “I like this book. It helps me learn new things that I didn’t know before. I really enjoy the book a lot. It has a lot of humor” (#18.) “I do like what we are reading because I usually have trouble with math and it’s helping me a lot” (#7).

Yet, a few students did not like this approach to learning mathematics and it was very clear in some of their journal entries. One particular student (#11) continually expressed dislike and frustration toward the mathematics and the novel. After “The First Night” he wrote, “I don’t like it because there was too much math. I get frustrated with math because I don’t like it” (#11). Following “The Fourth Night,” he wrote, “I did not like this chapter because it was confusing” (#11). In “The Fifth Night,” this student did not like how the problems were solved in the book, which may have contributed to more frustration with the book and the mathematics. In the last chapter we covered, “The Ninth Night,” the student wrote, “I did not like it because it almost made me fall asleep”
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(#11). In his final journal entry, his reflection on the enrichment unit, the student shared, “I don’t like this way of learning because it is hard for me to learn a particular way like I have to be taught myself or I will get distracted” (#11). While this entire statement does not make much sense, it is apparent through reading the complete journal that this student did not like this approach to instruction and it did not positively affect his attitude toward mathematics.

Development of Students’ Enthusiasm toward Mathematics Enrichment

Can the incorporation of literature and writing into mathematics instruction ignite enthusiasm about mathematics in students? From the majority of the interviews conducted, the students were in agreement that if they liked mathematics before partaking in this enrichment unit of study, then they still liked mathematics and if they did not like it before, then they still did not like it. A few students said they liked it a little after completing the unit. One student in particular wrote in his journal “I like this book as of right now (“The Eighth Night”). The stuff he (the Number Devil) is teaching now is harder than what I do in school” (#17). Some other students expressed similar thoughts in their journals as well, although a few students did not like the fact that the mathematics was more difficult than what they were learning in their sixth grade mathematics class.

In regards to students developing more enthusiasm toward mathematics, most students enjoyed completing “The 13th Night” project other than some slight issues that were raised in some of the groups, as the sixth graders were not used to completing projects in groups. Even so, once the students determined the mathematical concepts they were going to incorporate into their chapters, they enjoyed creating their own ending
to *The Number Devil*. A few groups’ final chapters incorporated the mathematics clearly and their chapter was cohesive, while other groups did not do this. A few students fully immersed themselves into the project and enjoyed writing their script and having the opportunity to act it out, even though it was centered on mathematical concepts. One student wrote in her journal, “It was easy to write. I loved it. My group cooperated great” (#11). Another student wrote, “My group worked hard on the script. It was funny and well done (#16). Also, one student (#8) even commented, “I learned more about mean, median, and mode” (#18), as that was one of two additional concepts they focused on in their chapter.

Yet, just as people do not always agree, all of the students did not have a positive experience with the project. One student wrote “I think our presentation was not successful, because we didn’t do a good job...we kept laughing, messing up...we didn’t use good details to make our presentation interesting” (#7). Thus, as it is in working with any group of students, some will enjoy an activity and others may not depending on their learning styles and personalities. Regardless, overall the project taught all the students something, even if they did not enjoy it and it did not necessarily challenge and enhance their mathematical literacy.

**Variables in the Research and Results**

Like all research there are many variables and factors contributing to the results discovered and, therefore, these exact results could not be repeated even if the methods were repeated. This was the first entire unit either one of us taught. In previous coursework we have taught a few lessons, but never an entire unit with complete control
over all class activities, assignments, and expectations. As a reflective educator, I continually wrote in my field notes journal about modifications I would make to our lessons after we taught them and I saw how some methods and strategies we used worked and some did not work so well. One such example of this came from day two. In my journal entry, I wrote, “after giving the students the challenge of completing the multiplication problem that the Number Devil did not try in “The First Night” with the extra class time, it became apparent the students did not recall multiplication with two and three digit numbers, which led to confusion when multiplying two eleven digit numbers.” In response to the outcome of this activity, I more clearly see the importance for teachers to understand their students’ prior knowledge, as my co-researcher and I were not aware our students did not recall how to multiply two and three digit numbers before challenging them with two eleven digit numbers. Additional modifications are noted in the next section.

Other contributing factors and variables also played a role in our instruction and data collection. While our research was performed during the school day, students did not receive a grade for their effort, so there was no grade motivating them to strive for success. Also, our class only had fifteen students and if this project was repeated with a larger class, the results could and would be very different as fifteen students provided a small classroom experience and about an 8:1 student-to-teacher ratio since my co-researcher and I were co-teaching the unit. If this unit was taught to a larger class and if students were given grades for some of the work, then the results would differ. Additionally, while my co-researcher and I were teaching our unit there was some turbulence in the school resulting in the dismissal of some personnel. This added issue
may have impacted the results we were able to achieve as some students were distracted and affected by this situation, although many of the sixth grade students did not seem as affected as the older students at the school.

Thus, while the results from our unit with the integration of writing and literature in mathematics instruction point in a positive direction, there were many contributing factors creating this particular research and data non-replicable. Additionally, if my co-researcher or I were to teach this unit again we would not repeat all of the same procedures, so we, too, would achieve varying results.
Results

The Fifth Part: “You’ve Hit the Nail on the Head.”

I have asked questions: (1) Can an innovative cross-curricular approach to teaching mathematics contribute to the positive development of students’ mathematical literacy? (2) Can the incorporation of literature and writing into mathematics instruction ignite enthusiasm about mathematics in students? I have researched and explored cross-curricular instruction and mathematical literacy. I have carried out a mathematics enrichment unit and I have collected data along the way. Finally, I have analyzed my data. Yet, my action research is not complete without finding ways to use and apply what I, as a future educator, have learned throughout the entire process from the very beginning and especially from carrying out a cross-curricular mathematics enrichment unit with a class of sixth grade students. Where do I as an educator go from here?

Reflection on Reflective Teaching

While teaching this enrichment unit, I was constantly thinking how things could be better, more efficient, and more effective throughout all of my lessons. One such example would be from our lesson involving prima donnas, or prime numbers, and the garden variety, or composite numbers. As we were asking students to identify which numbers were prime and composite, it dawned on me that it would have been ideal to review the divisibility rules before going into our discussion about prime and composite numbers. If we had done that, students would have been reminded how they could be certain if a number was prime or composite by simply thinking back to the divisibility rules instead of trying to divide it by every other number less than itself. This is simply
one of the many small changes I would consider making before teaching this unit and even this lesson again. This is one such way how me being a reflective educator impacts myself and will impact my future students, as I reflect on and strive to create stronger and academically richer lessons.

In addition to expanding on the divisibility rules, I also noticed some mathematical concepts were discussed in isolation in *The Number Devil* and thus this isolation in the novel led to isolation in instruction. As a result, at some points throughout the unit, I noted where I should have found and crafted more continuity between the varied concepts in the consecutive nights of dreams. Furthermore, I would provide supplementary explanations and examples for some of the more difficult concepts brought up in the novel if I taught this unit again. I would also work with students more on their mathematical vocabulary, as this is one contributing factor to developing mathematical literacy, particularly declarative knowledge. Students need to be able to speak the language in order to understand the concepts, equations, and theorems expressed in the mathematics. Students also need to be able to speak the language in order to explain what they are doing and answer mathematical questions intellectually and in such a way that others can follow their explanations and learn from them. The necessary sound mathematical vocabulary background was not evident in many of my students while discussing the unit in the interviews we conducted following the unit. Therefore, changes would need to be made if I used this unit again to improve this outcome for students’ declarative knowledge in pursuit of their full development of mathematical literacy.
Additionally, in reflecting in my own journal, I expressed the need to make changes in order to improve the effectiveness of the inclusion of writing and literature in mathematics instruction and the effect its use has on students’ mathematical literacy. Every student deserves to learn mathematics and the incorporation of literature and writing into mathematics instruction can help provide that opportunity to more students. However, it can only help and enhance learning if both the literature and writing are being effectively and purposefully utilized. While I thought the purpose of the journals was clear at the beginning of the unit, the journal assignments were not made clear enough to the students and thus the results of the journal entries did not meet the objective of using them and did not produce the desired outcome.

These areas of reflection from our enrichment unit have further impacted my own opinion toward reflection and being a reflective teacher. Had I not been keeping a journal and writing down my thoughts to the lessons on semi-daily basis I would not remember all of the changes I thought about at the time I was teaching this unit if I were to look back at the unit to teach it again next year or even in any future years. Day five was one of the shorter class periods and we primarily worked on solving two pretzel problems as a class. One of the pretzel problems was the following:

If \( \frac{1}{3} \) of 33 bakers can make 89 pretzels in \( 2\frac{1}{2} \) hours, then how many pretzels can \( 5\frac{3}{4} \) bakers make in \( 1\frac{1}{2} \) hours? (Enzensberger, 1998, p. 69)

After day five’s lesson, I made the following note in my journal: “If I was going to revisit the pretzel problems again, I would start with a simpler problem and work the students up to the more complex problems found in the novel. The more simplistic problems would build the students’ confidence and understanding and then the more complex problems
would not seem as daunting.” If I were to teach this unit again or even just a few of the
lessons, my teaching would be more effective and my lessons would be stronger and even
better for my students, because I took the time to reflect and note changes on each of
these lessons. Without this reflection process my lessons and methods of instruction
would not be enhanced or improved. Even if I were to write down a few sentences or
even words after each of my lessons, my future lessons would be greatly enhanced when
I would need to teach the same concept again. This is one particular philosophy of
teaching that has been significantly reinforced from this action research project and the
teaching of an enrichment unit that will impact me as a future educator.

**Effects on Me as an Educator**

Over the course of teaching the enrichment unit and the entire action research
process, I, as an educator, have grown in multiple ways. I have new goals for myself in
my future teaching endeavors and I have new and modified ideas to try. I have come to
more clearly see the necessity of being a reflective teacher and documenting ones
reflections whether in a journal or simple notes made on each lesson I teach.

I have also come to see the importance of not teaching material and concepts in
isolation. I reflected briefly on this earlier and through this enrichment unit I saw the
negative effects of instruction of particular concepts in isolation. While I cannot change
the nature of the novel *The Number Devil*, I could have changed the instructional
methods tied to the particular concepts discussed in the novel. The majority of the
students did not grasp the concepts discussed in isolation in the novel and thus discussed
in isolation in instruction. Wakefield even mentions the flaw of teaching in isolation in
his article "Math as a Second Language." "The task of teaching...the language should be a comprehensive endeavor rather than an isolated foray into a theoretical land of abstractions" (Wakefield, 2000, p. 278). And honestly, thinking back I do not even know why I thought the students would thoroughly understand the concept taught in isolation, but often it takes making a few mistakes like this before I can see how I should have done something or more so how I cannot do certain things and expect a positive outcome. This is where the reflection process ties in again as I need to reflect on all of the instructional methods I use and how they have worked for the study of certain concepts.

In addition to seeing the importance of not teaching concepts in isolation, I have seen the importance and impact of not teaching one particular mathematical concept in isolation. Throughout the enrichment unit we used a cross-curricular approach. We integrated literature and writing into mathematics to help support the students' development of mathematical literacy as the article "Integrating Literature to Support Mathematics Learning in Middle School" by Karen Koellner, Faith Wallace, and Lyn Swackhamer suggests. For many students the approach incorporating the use of literature was different, but effective in much of the same ways it would have been had we taught the concepts in a more traditional manner. If this approach to instruction can have the same effect and maybe even a greater effect if certain areas of reflection were addressed before teaching this particular unit again, why not incorporate a few units like this one into future lessons. Maybe then more students will be able to see the beauty of the language of mathematics on their journey to becoming mathematically literate.

Incorporating a variety of styles of units and instructional methods into a semester is one great way to differentiate learning and help to meet the surplus of students' needs
and learning styles brought into every class. After trying this new idea in an enrichment unit, I feel more comfortable trying units similar to this one in my future classrooms. I have incorporated literature and writing once into instruction and I feel as though I can do it again. This attempt to incorporate literature and writing is one that many teachers need to try as many distant teachers have found success in doing so and now I, too, have found success in doing so. While I did not find success in everything, as the journals did not fully serve their purpose, I now have ideas on how to alter the journal activities for the future and how they could potentially be used more effectively and purposefully.

However, it is important to note that using literature and writing every day may also not be the most effective, but using literature and writing in addition to other methods including collaborative learning, project-based learning, and direct instruction will create a more cross-curricular, integrated, and differentiated class to better meet the variety of needs and learning styles of my students.

In order to ensure effective use of a variety of instructional strategies, it will be important for me to frequently and consistently monitor and check students’ progress. If my co-researcher and I had been continuously analyzing our students’ work in our enrichment unit, then we would have been able to see the somewhat ineffective role the journals were playing early on in the unit and we could have made changes to make them more beneficial to the students’ learning. After going through this experience, I have come to see the importance of continuously analyzing students’ work to ensure the objective of each particular task is effectively met by all students. Just as it is important for me as a teacher to reflect daily on my instructional methods, I also must be reflecting daily on the tasks I am asking my students to complete. I must respect their time as
students and I must provide them with worthwhile and beneficial assignments helping them to develop a stronger mathematical literacy.

**Effects on My Future Classroom**

Similar to reflecting on instruction and assignments given to students, it is important for me to reflect on the young adolescents or adolescents I will be working with daily in my future classroom. I must take into consideration their learning styles and developmental needs. Some of my future students will benefit from direct instruction, some will benefit from journal exercises, and some will benefit from the incorporation of literature. In my future classroom I intend to incorporate multiple stories whether they are found in children’s books such as *Math Curse* by Jon Scieszka + Lane Smith or *G is for Googol* by David M. Schwartz or novels such as *The Number Devil* by Hans Magnus Enzensberger or *The Parrot’s Theorem* by Denis Guedj and translated by Frank Wynne, or one of the many other books that contain mathematical concepts. (See Appendix F.) The incorporation of literature differentiates instruction and integrates another content into mathematics, including the integration of the application of some mathematical concepts.

Incorporating literature will help to build students’ mathematical literacy, as the use of literature will help to reinforce the second language of mathematics, as some refer to it. Literature helps students to see mathematics as a “living, breathing language with a culture of ideas expressed in numbers” (Wakefield, 2000, p. 278). Students are exposed to a different side of mathematics through literature and students can be exposed to another dimension of the language of mathematics with the integration of writing in
mathematics. Throughout this enrichment unit, my co-researcher and I attempted to effectively utilize journals to promote the use of mathematical vocabulary and to challenge students to express their mathematical concepts in their own words and on paper. These tasks were not effectively met in all of the students' journals entries, but I still think they can be with a more effective use of journals. I plan to find more effective and beneficial ways for students to complete journal entries in my future classroom, as writing in a particular language is one such way to become more fluent in that language (mathematics).

The future students that I teach through a variety of levels of mathematics will be challenged to become more mathematically literate and will be challenged to continue to develop toward fluency in mathematics. From my previous experiences and the completion of this action research project, I already have several goals for my students and myself in my future classroom. Students will build on their declarative knowledge, which should be in solid formation by middle grades and especially high school, to expand their procedural knowledge and improve their conceptual knowledge. I will take many measures to promote these areas of necessary growth in my students. In my future classroom, a word wall will be in place so students are constantly reminded of the key concepts and terminology utilized in mathematics, specifically the mathematics courses they are taking. Students will constantly be asked questions, especially the question "WHY?", and students will be able to express themselves using the appropriate terminology using logical reasoning. Students' work will be constantly analyzed in order for me to gauge their understanding and to ensure the proper and effective use of students' time in their individual development of mathematical literacy. Finally,
instruction will be differentiated to meet a variety of learning styles and students’ needs. One such method of differentiation will be through the incorporation of children’s books and even novels where seen fit and worthwhile.
Conclusion

The Sixth Part: “All Right Then. I’ll Be on My Way.”

Mathematics is a culture of its own and as students become mathematically literate and fluent they are able to see the world through a different lens, as they recognize and appreciate the power and beauty of mathematics. It is my goal as a teacher to help students see the world through the lens that is mathematics. This action research project in combination with my undergraduate studies and my experiences in the classroom has solidified this goal of mine as a future teacher.

A cross-curricular method of mathematics instruction can work. I have researched and read about the teachers who have already tried these approaches and have found success. Now, I, too, can share my successes with the approach as well as the changes to the methods I took that I would make if I were to teach this unit again. Throughout this entire process, I have become more willing to try new ways of instruction as I have seen the positive impact from this particular method on students’ mathematical knowledge. Some students did not like this approach, but some really liked it. The same outcome is reached with almost any method of instruction: some like it and some do not like it. Therefore, this is one such method that may excite different students and this method can be incorporated into a semester of study to differentiate instruction and appeal to a different audience of learners for a unit or part of a unit.

New Questions

As I found out in my action research project and as distant teachers have been saying, literature and writing can be effectively integrated into mathematics instruction
with the necessary planning and considerations taken into account. The integration of literature and writing plays an important role in students' development of a second language, the language of mathematics. While I know a cross-curricular approach to mathematics can work, additional questions have come to mind throughout this action research process. How would a classroom with continuous integration of literature and writing look? How would adolescents respond to the integration of literature, novels, and children's books into a mathematics classroom? Are there multiple novels that address many of the same mathematical concepts in such a way that these novels could be incorporated into different groups of students reading different novels but still studying the same mathematical concepts? What additional methods of writing can be integrated into a mathematics classroom? How should writing be graded if completed for a mathematics class? What is the best way to assess students after completing a mathematics unit using a novel? What would a novel encompassing an entire chapter of Algebra be like?

**Closing Remarks**

In closing, I will leave one final remark from one of our sixth grade student's journal entries: "Learning from a book is new to me. I know you can learn a lot from just reading. I really didn't know you could learn math reading. It's easier from just doing worksheets. I like the activity they gave us. It helps us understand what is going on. Hopefully they give this book to other kids because you can really learn a lot" (#6).
References


Appendix A

Pre/Post Assessment of *The Number Devil* Concepts

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! = $ __________
3. $12 \div 4 = $ __________
4. $125 \div 5 = $ __________
5. $3! = $ __________
6. $\sqrt{16} = $ __________
Geometry:

1. What is $\pi$ 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. $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{1}{5}, \ldots$
   b. $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \ldots$
Appendix B

The 13\textsuperscript{th} Chapter of \textit{The Number Devil}

\textbf{Assignment:} With your group, you are to write a 13\textsuperscript{th} night to \textit{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 \textit{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 13\textsuperscript{th} 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 12\textsuperscript{th}.

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.

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

\textbf{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.
<table>
<thead>
<tr>
<th>The 13th Chapter</th>
<th>16-20 Points Excellent</th>
<th>11-15 Points Good</th>
<th>6-10 Points Needs Improvement</th>
<th>0-5 Points Incomplete</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demonstrates an understanding of the topic explored</strong></td>
<td>The assigned mathematical topic is explored thoroughly and clearly. A few real world applications are discussed in the chapter.</td>
<td>The assigned mathematical topic is explored thoroughly and clearly. One real world application is discussed in the chapter.</td>
<td>The assigned mathematical topic is not explored as thoroughly and completely as possible. Some questions remain unanswered. No real world application is discussed in the chapter.</td>
<td>The assigned mathematical topic is not explored thoroughly or clearly. Many questions remain unanswered or arise from the unclear explanation. No real world application is discussed in the chapter.</td>
</tr>
<tr>
<td><strong>Math calculations are correct and accurate</strong></td>
<td>All calculations and statements are correct and free of mathematical errors.</td>
<td>There are a few (&lt;5) errors in mathematical calculations and statements made throughout the chapter.</td>
<td>There are many (&gt;5) errors in mathematical calculations and statements made throughout the chapter.</td>
<td>The mathematical errors and inaccurate statements make the chapter hard to follow and make the topic hard to understand.</td>
</tr>
<tr>
<td><strong>Writing and Grammar</strong></td>
<td>The chapter is 3 pages long and contains few (&lt;5) grammatical errors. Sentences are thorough and complete. Paragraphs flow from one to the next.</td>
<td>The chapter is 3 pages long and contains grammatical errors, but the errors do not make it hard to read or understand. Sentences are thorough and complete. Paragraphs have a general flow.</td>
<td>The chapter does not meet the length requirement and contains many grammatical errors that make parts of the chapter difficult to understand. Sentences are short and are not thorough. The paragraphs have little flow.</td>
<td>The chapter does not meet the length requirement and contains numerous grammatical errors making it difficult to read and understand. Sentences are short and are not complete. The paragraphs have little to no flow.</td>
</tr>
<tr>
<td><strong>Presentation</strong></td>
<td>Speaks clearly and loud enough for the whole class to hear. Speaks at a comfortable pace allowing the chapter to be comprehended by the listeners.</td>
<td>Does not speak clearly or does not speak loud enough for the whole class to hear or does not speak at a pace for which the chapter can be comprehended by the listeners.</td>
<td>Does not speak clearly or loud enough for the whole class to hear and does not speak at a pace for which the chapter can be comprehended by the listeners.</td>
<td>Does not speak clearly. Does not speak loud enough for the whole class to hear. Does not speak at a pace for which the chapter can be comprehended by the listeners.</td>
</tr>
<tr>
<td><strong>Creativity</strong></td>
<td>Explored some element of creativity that resembles that of the author throughout the entire chapter. Takes a creative approach to explain the assigned mathematical topic.</td>
<td>Explored some element of creativity that resembled that of the author in parts of the chapter. The explanation of the mathematical approach lacks creativity.</td>
<td>Little creativity that resembles the author is explored. The explanation of the mathematical approach lacks creativity.</td>
<td>No creativity is evident throughout the chapter. No creative explanation of the mathematical approach is evident.</td>
</tr>
</tbody>
</table>
Appendix C

Pre/Post Questionnaire
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

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 E

The following are samples of student work. These are copies of students’ post-assessments. From these assessments, it can be seen that some of both the Indiana State standards and the National Council for Teachers of Mathematics Standards were met including:

- **MA6.2.2** Multiply and divide positive and negative integers.
- **MA.6.2.5** Solve problems involving addition, subtraction, multiplication, and division of positive fractions and explain why a particular operation was used for a given situation.
- **NCTM Numbers and Operations**: Explore numbers in a variety of forms and understand numbers, ways of representing numbers, relationships among numbers, and number systems.
- **NCTM Problem Solving**: Apply and adapt a variety of strategies to solve problems.

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, 13, 17, 19
   b. Perfect squares: 1, 4, 9, 16, 25
   c. Even numbers: 2, 4, 6, 8, 10
   d. Odd numbers: 3, 5, 7, 9

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. \(12 + 4 = \) __________
4. \(125 + 5 = \) __________
5. \(3! = \) __________
6. \(\sqrt{16} = \) __________
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?

\[ \frac{5 \times (5-1)}{2} = \frac{5 \times 4}{2} = 10 \]

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?

   A: ABCD  \quad L_0 \times 4 = 24
   B: ACBD  \quad l_0 \times 4 = 24
   C: ADBC  \quad l_0 \times 4 = 24
   D: ACDB  \quad l_0 \times 4 = 24

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

   a. \[ \frac{1}{2} \cdot \frac{1}{3} \cdot \frac{1}{4} \cdot \frac{1}{5} \cdot \frac{1}{6} \cdot \frac{1}{7} \cdot \frac{1}{8} \]
   b. \[ \frac{1}{2} \cdot \frac{1}{4} \cdot \frac{1}{8} \cdot \frac{1}{16} \cdot \frac{1}{32} \cdot \frac{1}{64} \cdot \frac{1}{128} \]
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#### Appendix F

**Annotated Bibliography of Books to Integrate Literature into Mathematics**

<table>
<thead>
<tr>
<th>Title: <em>A Gebrä Named Al</em></th>
<th>Author: Wendy Isdell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Level: 4-8</td>
<td></td>
</tr>
<tr>
<td>Description: The story begins with Julie working on a simple math problem, (-5 + 3). As she struggles to reach an answer, she gives up in frustration and is soon awakened by an Imaginary Number. In time, she follows the Imaginary Number and enters into a strange place. The first person she meets is Al, a gebrä. Al, along with other Periodics, helps Julie return home. On this journey they travel through the Land of Mathematics and the Orders of Operations. They must travel through all of the Orders of Operations, parenthesis, exponents, multiplication and division, and addition and subtraction, to reach the Mathematician’s Castle, who knows how Julie can return home. While traveling through the operations, Julie learns more about each operation, especially from the environment of each operation. Julie eventually returns home, where she has only been sleeping for an hour, although it felt like she had spent several days in the Land of Mathematics.</td>
<td></td>
</tr>
</tbody>
</table>

**Classroom Notes and Uses:** This book could be utilized in a beginning chemistry course or in mathematics courses that deal with the orders of operations, which is generally taught in middle school. While explaining each order of operation, this book could be used as a supplemental tool and each environment of each order can be shared. For instance, “Parenthesis is a network of circular caves, each containing a smaller cave inside. They are connected by doors which open only when you solve the problem inside each one (p. 45).” This is a creative and vivid description of the parenthesis part in the orders of operation. Additionally, prime and composite numbers are discussed (p. 75) as prime and composite plains in the addition environment and the “distance=rate x time” formula is referenced as well (p. 83). |

<table>
<thead>
<tr>
<th>Title: <em>A Very Improbable Story</em></th>
<th>Author: Edward Einhorn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Level: 1-3</td>
<td></td>
</tr>
<tr>
<td>Description: What is the probability of waking up with a cat, and not your cat if you have one, on your head? Ethan woke up on the morning before his big soccer match with a cat named Odds on his head. Odds told Ethan that he would not get off of his head until he won a game of probability. At first they played a game of probability with picking two socks out of his drawer. Then, Ethan played with marbles. Finally, while eating breakfast, Ethan played Odds game of probability with his cereal. Ethan successfully picked two of the same pieces of cereal to beat the game of Odds. Since, Ethan won the game, Odds climbed off of his head and Ethan went on to play his soccer game.</td>
<td></td>
</tr>
</tbody>
</table>

**Classroom Notes and Uses:** This book can be used during the introduction of probability. The games of probability that Ethan plays throughout the book can be discussed and explained to help students learn about probability and odds. The book provides applications of probability and also has visuals demonstrating Ethan’s odds. |
Title: *Albert's Halloween: The Case of the Stolen Pumpkins*

Author: Leslie Tryon

Grade Level: K-3

Description: Pumpkins have gone missing from Patsy’s Pumpkin Patch and Chief Inspector Albert and his three detectives begin a search to find the twenty stolen pumpkins. During their search, they find a note that leads them to discovering the first missing pumpkin. Then, they find another note that gives them clues to finding another pumpkin. As their search continues, they continue to find two more clues that lead to two more pumpkins. When they find their final note, it states, “This is the spot where my game ends”. There are no more notes, but they must put together previous notes to find the rest of the missing pumpkins.

Classroom Notes and Uses: While the reading level of this book is K-3, the problem solving found in this book could provide a story problem for sixth or seventh graders to work through around Halloween. The mathematical concept found in this book is simple addition, but the method and application of the addition give meaning and justification for using this book in a middle school classroom. The students can each work on solving where the missing pumpkins are on their own as the story is read with the appropriate materials provided to them. Using this book in a mathematics classroom would provide a good element of diversity in classroom routine and instruction.

Title: *Chasing Vermeer*

Author: Blue Balliett

Grade Level: 5-8

Description: The mystery begins when three people in Chicago receive mysterious letters in which they are invited to help solve a century-old crime. In these letters, the author tells the readers to show it to no one, especially not the authorities. Strange things begin to happen at the beginning of the novel that bring Petra Andalee and Calder Pillay, two sixth grade students in Ms. Hussey’s class, together. Together Petra and Calder begin visiting an old woman who wants their company. Also, during this time a famous Vermeer painting, *A Lady Writing*, disappears before it is supposed to be put on display at the Art Institute in Chicago. Petra and Calder get caught up in the middle of the hunt for the missing Vermeer painting. While more strange events and occurrences are happening, Petra and Calder are forced to put their problem solving skills to work with the knowledge they know about Vermeer and the knowledge they have gained from the mysterious letters and happenings. As time is running out, Petra and Calder are able to solve the mystery and find the missing painting, but not without a fight.

Classroom Notes and Uses: Throughout Calder and Petra’s hunt for the missing painting, Calder continually has a set of twelve pentominos in his pocket. With these twelve pentominos a code is created that he and his friend, who moved away, use when writing letters to each other. Also, these twelve pentominos can be put together to create a perfect rectangle. These are two elements of mathematics that can be explored while reading this novel. This novel and the mathematical concepts in it would probably be most useful in a sixth or seventh grade classroom. Patterns and codes can be explored as they come across in the novel and then they can be explored further to align with the standards.
Title: *G is for Googol: A Math Alphabet Book*

Author: David M. Schwartz

Grade Level: 4-8, but good for both children and adults

Description: Like any other alphabet book, this math alphabet book has at least one topic for every letter of the alphabet that is explained in great length with some humor. There are additional mathematical concepts for each letter that are defined in the glossary at the back of the book. Through Schwartz's writing style and practical examples, this book keeps the reader intrigued and wanting to find out more about the concepts he discusses. The topics he explores range in varying levels of difficulty from "B is for Binary" to "P is for Probability" to "W is for 'When are we ever gonna use this stuff, anyway?'".

Classroom Notes and Uses: This book can be utilized in multiple mathematics classrooms from sixth grade all the way through twelfth grade. For example, during a geometry class, the letters E, O, R, S, and T discuss applicable concepts learned in geometry. In a pre-algebra or algebra course, the letters E, F, X, and Y would be applicable. When one approach is not working, the teacher can turn to this book to find another explanation, or perhaps the same explanation using different wording. There are not only explanations of mathematical topics and concepts, but also there is a lot of history about where things came from and why things are the way they are today. There are also numerous practical applications of some of the concepts explored.

---

Title: *Hannah Divided*

Author: Adele Griffin

Grade Level: 4-6

Description: Hannah May Bennett, a thirteen-year-old living with her family on a dairy farm in Chads Ford, is illiterate, but extremely talented with numbers and mathematics. Hannah's grandfather always worked on her mathematics skills with her and had high expectations for Hannah and believed that math could take her places, as she could count and calculate faster than she could run. On the farm Hannah takes care of all the invoicing and in school Hannah helps the younger students in mathematics. When a visitor, Mrs. Sweet, from Philadelphia comes to her school one day, she recognizes Hannah's talent and offers her an opportunity to study in Philadelphia for a special scholarship opportunity. This was rare for a girl living out in the country in 1934. Her parents were not on board with sending their daughter to the city, but with support from her grandfather, Hannah heads to Philadelphia. Life in the big city is harder than Hannah could have ever imagined. Hannah does not fit in with the rich, snobby girls that go to her all girls school. Hannah has no friends other than another student, Joe, staying with Mrs. Sweet who is also competing for a scholarship, and at first he was not the nicest person to her. While in the city, Hannah's grandfather passed away and she returns home for the funeral service. While at home, Hannah struggles to decide whether to stay home or go back to the rough life in the city where she is enjoying studying mathematics. With the help of her brother, Hannah returns to Philadelphia and continues her studies in hope of scoring high enough on the exams to get a scholarship. However, Hannah does not pass the scholarship exam and the book leaves her out in a tree waiting for Joe before heading back to Mrs. Sweet's house. Hannah then decides she is going to somehow find a way to continue studying mathematics.
Classroom Notes and Uses: This book has few and far between direct references to mathematical concepts. However, the overarching message from this book is something that Hannah discovers throughout the course of the book: “Math is everywhere, and it has always belonged to me if I wanted it” (p. 262). A few concepts that could be discussed in conjunction with reading this book would be the Pythagorean theorem, division, and properties of numbers. Everywhere that Hannah goes, she is always counting things and coming up with more and more numbers. Hannah’s favorite number is 32 and she discovers more and more significant facts related to the number 32. A good story problem is found in this book on page 66, “If Hannah May Bennett opens her math book and finds that the sum of the facing pages was two hundred and forty-one, what pages did she open to?”

<table>
<thead>
<tr>
<th>Title: <strong>Holes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Author: Louis Sachar</td>
</tr>
<tr>
<td>Grade Level: 4-8</td>
</tr>
<tr>
<td>Description: The novel follows Stanley Yelnats as he is punished for apparently stealing Clyde Livingston’s shoes, which were donated to a homeless shelter. Stanley claims the shoes fell on him as he was walking under an overpass. Stanley can go to prison or to Camp Green Lake. His parents chose for him to go to the camp. After a long bus ride, Stanley arrives at the camp and realizes it is nothing like an ordinary camp. All of the people at the camp must dig a hole 5 feet by 5 feet each day they are there in the hot, dry sun. Many years ago, there was a lake where the holes were being dug and the purpose of digging these holes was for the Warden to find the <strong>buried treasure</strong> worth a few million. After several days of digging, Stanley befriends Zero, another boy from his group. Stanley and Zero make a deal where Zero will help Stanley dig his holes in return for Stanley teaching Zero how to read and write. After awhile, one of the other boys turns Stanley and Zero in and Zero runs away from the camp. A few days later, Stanley also runs away from camp. Nobody went after either of them because Camp Green Lake is in the middle of nowhere and nobody thought anyone could survive out there for more than a few days. As the novel continues we learn how Zero and Stanley survive and how the camp becomes closed.</td>
</tr>
</tbody>
</table>

Classroom Notes and Uses: While there is no mathematics that is essential to the plot of *Holes*, there are two applications of mathematics that can be found connected to the novel. The first mathematical reference in the novel is on page 13 when they are discussing the size of the holes that have to be dug. With each hole being 5 feet wide and 5 feet tall, the teacher could then ask the students the volume of each hole, what shape the hole would be if the measuring device was the shovel, and what the perimeter of each hole would be? This example can be used in a lesson on perimeter or volume as a practical application. The other mathematical reference in the novel occurs when Zero and Stanley are arranging their plan for Stanley to teach Zero how to read in exchange for Zero digging part of his hole everyday. “‘You can teach me ten letters a day,’ suggested Zero. ‘Five capitals and five smalls. After five days I’ll know them all. Except on the last day I’ll have to do twelve. Six capitals and six smalls’” (p. 98). This is a very practical application of mathematics that Zero uses to determine how long it will take him to learn all the letters in the alphabet. This reference can be used to reinforce the importance of knowing simple mathematical computation and problem solving skills.
<table>
<thead>
<tr>
<th>Title: <strong>How Much is a Million?</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Author: David M. Schwartz</td>
<td></td>
</tr>
<tr>
<td>Grade Level: 3-8</td>
<td></td>
</tr>
<tr>
<td>Description: This book tries to quantify a million through the use of different examples, such as “If one million kids climbed onto one another’s shoulders, they would be... taller than the tallest building, higher than the highest mountains, and farther up than airplanes can fly.” After giving several examples to quantify the magnitude of a million, the author follows with quantifying a billion and a trillion. At the end of the book, Schwartz explains how he made his calculations to make the statements he made throughout the book.</td>
<td></td>
</tr>
<tr>
<td>Classroom Notes and Uses: The calculations at the end of this story can be discussed in a math class and they provide story problems to solve. Some of these calculations are advanced and could most certainly be relevant in a pre-algebra or algebra classroom. Grasping the quantity and magnitude of a number can sometimes be challenging for students and with the examples Schwartz uses and his explanations of how he figured out his statements this challenging task can be overcome for some students.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Title: <strong>If You Hopped Like a Frog</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Author: David M. Schwartz</td>
<td></td>
</tr>
<tr>
<td>Grade Level: K-4</td>
<td></td>
</tr>
<tr>
<td>Description: This book is short and to the point. This book has several statements that follow the form: If you _______ like a _________... you could __________. A few examples include, “If you were as strong as an ANT... you could lift a car!”, “If you had the brain of a BRACHIOSAURUS...your brain would be smaller than a pea!”, “If you high-jumped like a FLEA...you could land on Lady Liberty’s torch!”. At the conclusion of the book, the author has explained how to go about solving the problems related to the statements made throughout the book. If you hopped like a frog, how far could you go?</td>
<td></td>
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<td>Classroom Notes and Uses: This book provides fun real world math examples and story problems to be solved. These story problems could be used throughout middle school to help students further develop their problem solving skills by figuring out how to calculate the answers to the questions being asked. Students would think about: “well if I hopped like a frog, how far could I really hop?”</td>
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<table>
<thead>
<tr>
<th>Title: <strong>Lawn Boy</strong></th>
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<td>Author: Gary Paulsen</td>
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<td>Grade Level: 4-8</td>
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<td>Description: A boy (unnamed) is twelve years old and broke. But when his grandmother gives him his grandfather’s old riding lawn mower for his twelfth birthday everything changes. He starts out mowing only a few yards for his neighbors, but quickly he has more clients than he can handle and his business begins. One of his clients, Arnold, is a stockbroker who invests the money he owes him in the stock market. As the text unfolds, his business and cash multiply. In a short matter of time, he becomes the sponsor of a prizefighter, Joey Pow. However, when he runs into some trouble, his prizefighter ends up helping in more ways than just winning his paid fights.</td>
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Classroom Notes and Uses: This text explores many concepts in economics and seemingly simple mathematical operations as he develops his business. Many of the mathematical operations he performs are not explained well and occur rather fast. Thus, in a fifth or sixth grade mathematics class, a situation where he utilizes his mathematics abilities could be discussed and explored further to ensure students understand the operations that he is performing. This text is a quick enough read for the teacher to read a portion of a chapter that deals with performing mathematical operations and then the teacher could base the lesson for the day off of that short excerpt read aloud in class. For instance on page 15, he is trying to figure out how often he needs to work and how much money that will translate into him earning. This would create a perfect story problem that connects to practical experiences for students.

Title: Lawn Boy Returns
Author: Gary Paulsen
Grade Level: 4-8
Description: The twelve year’s old company continues to grow and expand as Lawn Boy Returns picks up where Lawn Boy ends with the second half of the summer. He is still sponsoring Joey Pow and his company is still growing. While his parents head out on a five-day search for a lake cottage to buy, many events begin to unfold while he is left at home with his grandmother. Arnold suggests to him to hire a manager, a lawyer, and many more important executive people for the company. He also ends up employing his two friends that have returned home. In the end, he makes the decisions with his parents support to back out of the company; however, Arnold and all the other employees keep his name in the company and he continues to make money from it. Also, to avoid hefty taxes on all of his money, he becomes the owner of a lake house and a lake. He has gone from nothing to way more than he could imagine.

Classroom Notes and Uses: This text explores many more avenues in economics and creating a business with less mathematics references and calculations than Lawn Boy. Similar to a use of Lawn Boy, a portion of this text could be read aloud and then the mathematical calculations and references can be dissected and explored to see practical applications of mathematical concepts being learned.

Title: Math Curse
Author: Jon Scieszka + Lane Smith
Grade Level: K-4
Description: This story begins with a girl in math class where her teacher, Mrs. Fibonacci, tells her “You know, you can think of almost everything as a math problem.” Throughout the entire next day, everything becomes a math problem for her. When she wakes up, she wonders if she will have enough time to get ready before the bus picks her up. She finds another problem in her closet when she counts her shirts and realizes how many she has to choose from and what would happen if she got rid of one. When she is eating breakfast many more math problems come to mind. She believes her teacher put a math curse on her. At the bus stop she is counting more and more things. In every class she finds another math problem, including in P.E. where she learns about pro baseball players and their statistics and salaries. She learns there are many ways to count in math class that day. When she is eating dinner at home that night, math is still haunting her.
Finally, while sleeping that night, she dreams that her room is filled with math problems, but she only has one piece of chalk. She thinks to break the piece in half. "One half plus one half equals one whole." She is then able to get out of the room through the hole in the wall and is free from the math curse.

Classroom Notes and Uses: While this book's reading level may be for those in elementary school, the concepts can be used throughout middle school and possibly even further. The humor in the books makes it a book that will work for almost any age. There are illustrations of counting numbers, base numbers, and the Fibonacci series. There is a problem that involves critical thinking skills about how many Washingtons are in Lincolns and visa-versa with Washingtons being quarters and one-dollar bills and Lincolns being pennies and five-dollar bills. This book can be used to liven up a class period or to simply show the many "math problems" in everyday life, which makes it all the more important for students to learn math and understand it.
programming, there are many great examples of how to write computer programs to find certain types of numbers.

**Title:** Minnie’s Diner: A Multiplying Menu  
**Author:** Dayle Ann Dodds  
**Grade Level:** K-2

**Description:** Papa McFay reminded those working on the farm that there would be no eating until the work was finished for the day. However, with a delicious diner, Minnie’s Diner, down the road the smell made one of the boys “itching” for some food. Will, the youngest, was the first to go to the diner and he ordered the special, which included 1 soup, 1 salad, 1 sandwich, some fries, and 1 of Minnie’s special hot cherry pies. As the smell continued to waft through the farm, Bill, who was twice as big as Will, headed to the diner and ordered twice as much as his brother. As the day continued, more and more of the workers on the farm traveled to Minnie’s Diner, each ordering twice as much as the first. Eventually, Papa McFay noticed that nothing was done on the farm and headed to the diner to order everyone back to work. However, when he got to the diner and smelled the hot cherry pies, he ordered twice as much as the last worker had ordered.

**Classroom Notes and Uses:** This book shows multiplication in action. So many middle school students struggle with their multiplication tables and this book can be used to reinforce the importance of students knowing their multiplication tables. The application and use of multiplication provides vivid examples of multiplication, which show what is happening when multiplying.

**Title:** One Hundred Hungry Ants  
**Author:** Elinor J. Pinczes  
**Grade Level:** K-2

**Description:** A whole anthill of one hundred hungry ants is headed to a picnic for some food after the wind fanned the yummy smell by their anthill. As the ants are traveling to the picnic spot, they march in rows. At first it was one long line of 100 ants with the littlest ant in the back. The littlest ant in the back repeatedly speaks up about making more rows in order to make it to the picnic site faster. However, after eventually breaking up into 10 rows of 10, they arrive at the picnic site too late to get any “yummies.”

**Classroom Notes and Uses:** While this is a book at a significantly lower reading level than any students I intend to teach, this book can still be brought into a sixth grade class, a pre-algebra class, or even an algebra class. This book provides good story problems involving skills of multiplication and division. This book can be used as a good refresher of multiplication and division concepts at the beginning of the school year after summer break. The teacher could read it aloud and leave out some of the numbers, requiring the students to think on their feet and come up with the missing numbers. Also, this book provides a visual of multiplication and division for students struggling with multiplication and division.
| Title: *Sir Circumference and the First Round Table: A Math Adventure*  
| Author: Cindy Neuschwander  
| Grade Level: 3-6  
| Description: This story begins with a problem that King Arthur comes across when his knights get together. The table that they have to sit at is too long and people have to shout to be heard by everyone. Sir Cumference and Lady Di of Ameter are then challenged to create a better table for all of King Arthur’s knights to gather around when they meet. Lady Di first suggests cutting the table in half and then placing the two halves side-by-side. The carpenter, Geo of Metry, is then put to work to help them build the new table. However, when this square table was finished and the knights gathered around it, those sitting in the corners would whisper in conversation ignoring the person who was speaking to the group. This square was not going to work. Lady Di went back to work to create another table. She explored cutting the table diagonally to make a parallelogram, making the table a triangle, making the table an octagon, and even making the table an egg shape. Yet, each time the product was finished and the knights gathered around it a new problem arose. Finally, Lady Di, Sir Cumference, and their son Radius came up with the idea of a circle table after seeing a tree that had fallen over in the forest. The circle table is a success and the knights celebrate and thank Sir Cumference, Lady Di, and Radius for their hard work. Since Lady Di is equal to the distance across the table, it becomes the diameter, and Radius is half the distance across the table, thus that becomes the radius. Lastly, Sir Cumference came up with the idea to leave the bark on the outside edge, so the outside edge of the table became known as the circumference.  
| Classroom Notes and Uses: This book can easily be used to introduce a lesson on circles and the parts of a circle, including circumference, diameter, and radius. The problem solving and application of circumference, diameter, and radius provide practical applications. Also, there are several additional books about Sir Circumference that explore various other components of geometry through problem solving including pi, angle measures, perimeter, and vertices. |

| Title: *Spaghetti and Meatballs for All! A Mathematical Story*  
| Author: Marilyn Burns  
| Grade Level: 3-8  
| Description: The story begins when Mr. and Mrs. Comfort decide that it is time for a family reunion. After calling the 30 people on their guest list, they had 32 people, including themselves, attending the party. They decide to make spaghetti and meatballs with salad and garlic bread. To have enough room for everyone to sit and eat they must rent tables and chairs. With 8 tables and 32 chairs, Mrs. Comfort figures out the perfect arrangement so that everyone will fit. However, as the guests begin to arrive, they begin to rearrange the tables and chairs so that certain people can sit together instead of just four people to a table. As more and more people arrive, the tables and chairs are continually rearranged to accommodate everyone. When the last few people arrive, the tables and chairs end up in the same arrangement that they started in, the one way that 32 people would be able to have a place to sit and eat.  
| Classroom Notes and Uses: This book explores area and perimeter, but in a different way than generally talked about in school. As far as perimeter is concerned, each person needs 1 unit length of space to sit and each table has 4-unit lengths. As the tables are |
Title: *The Great Number Rumble: A Story of Math in Surprising Places*

Author: Cora Lee and Gillian O'Reilly

Grade Level: 4-6

Description: Can you imagine a school curriculum without mathematics? This is exactly what is about to happen when Jeremy's and Sam's school district decides to eliminate it. While this does make most of the students and teachers happy, Sam, a math whiz, is far from it. At lunch the next day at school, Sam challenges the Director of Education in hope to persuade him to reinstate mathematics in the school curriculum. During his challenge with the Director of Education, Sam explains, and in some instances demonstrates, the importance and significance of mathematics in daily life. Mathematics is everywhere. Sam explores mathematics in art, nature, biking, music, and much more. Sam also discusses various types and patterns of numbers. In the end, Sam is able to convince the Director of Education to reverse his decision.

Classroom Notes and Uses: This book can be used in a middle school mathematics classroom to explain various types of numbers, the importance of math in everyday activities, how mathematics is used, and the study of some mathematicians. The book is interspersed with short mathematical applications related to what is being talked about in the story, images of some of the explanations of mathematics, and one-page biographies of mathematicians.

Title: *The Number Devil: A Mathematical Adventure*

Author: Hans Magnus Enzensberger

Grade Level: 4-8

Description: Robert, a sixth grade student, dislikes mathematics because of his dislike for his mathematics teacher. But when Robert is visited by the number devil in his dreams he begins to like mathematics. The number devil begins visiting Robert in his sleep over a period of twelve nights. Throughout the nights, the number devil takes Robert to various locations where he teaches Robert about different, but related, areas of mathematics. They talk about all the numbers and how one is the one and only number you need. They discuss Roman numerals and zero, prima donnas, the garden variety, taking the rutabaga, unreasonable numbers, triangular numbers, Bonacci numbers, and many more, along with the relationship between these and the origin of many of them.

Classroom Notes and Uses: This book can be used to provide an explanation of several mathematical concepts that can then be discussed, explained, and expanded upon to help the students gain a solid understanding of how or what it is and how it is practical outside of the classroom. For example, the number devil explains to Robert the concept of fractions. After reading the chapter about fractions, the teacher can then talk about fractions as the number devil does and then introduce more applications with fractions and even adding, subtracting, multiplying, and dividing fractions. This similar approach can be taken with many of the other concepts that the number devil explores.
Title: *What's Your Angle, Pythagoras? A Math Adventure*

Author: Julie Ellis

Grade Level: 3-6

Description: This book is about a little boy named Pythagoras who is interested in building. He goes on a trip with his father one day to Alexandria, Egypt where he meets a great builder who briefly explains how he builds his buildings so straight. Through the use of rope, this builder Nef is able to build straight buildings. Pythagoras goes on to explore the rope and right triangles. While using some tiles and working around the right triangle, Pythagoras discovers the Pythagorean theorem. He then goes on to show his dad how far it is to Crete, so that he can get there faster and not get lost, and he fixes a ladder to the perfect height for his friends to finish the roof of a building they are finishing.

Classroom Notes and Uses: This book provides a vivid explanation of the Pythagorean theorem and can be used in any lesson on teaching and explaining the Pythagorean theorem. While exploring right angles, Pythagoras comes up with a theorem by placing different colored tiles around a right triangle. This alone provides a great visual as to why the Pythagorean theorem works and is arranged the way it is arranged. This book provides practical applications of the Pythagorean theorem that can help to show students the importance of understanding the theorem.