Integrating Picture Story Books into the Algebra I and Geometry classrooms

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Integrating Picture Story Books into the Algebra I and Geometry Classroom

> The teachers today just go on repeating rigmarole fashion, annoy the students with constant questions and repeat the same things over and over again. They do not try to find out what the students' natural inclinations are, so that the students are forced to pretend to like their studies; nor do they try to bring out the best in their talents. As a result, the students hide their favorite readings and hate their teachers, are exasperated at the difficulty of their studies, and do not know what good it does them. Although they go through the regular course of instruction, they are quick to leave when they are through. This is the failure of education today.
>
> -Confucius (cited in Rubin, 1983, p. 16)

Introduction

There exist two classrooms as different as night and day; we'll call them classroom A and classroom B. In classroom A, the teacher enters the class and instructs her students to open their textbooks to page ___. "Today we will be learning about _____." We may fill in the blanks with any mathematical concept that appears in the curriculum for that year, covered on their particular pages in Houghton/ Mifflin. The teacher will then use examples to show the students how to do _____. There will, of course, be word problems relating _____ to the 'real world.' Then there may be class work and/or homework, along with a test on Friday.

Meanwhile, across town in classroom B, the teacher walks in, pulls out a fully illustrated book on relating mathematics to everyday life. She jokes with her students about the fact that she's about to teach them something from a children's book and begins to read.

She reads them a story called *If You Hopped Like a Frog*, by David Schwartz. In the book, Schwartz presents many situations which compare human actions to that of animals. The first of these is "if you hopped like a frog, you could jump from home plate to first base in one mighty leap" (Schwartz, 1999, p. 1). It sounds like a ridiculous statement when implying that a human could jump that far, so the teacher shows her students how this statement would be true were they able to jump like a frog. She does this by setting up a proportion:

$$\frac{\text{Length of human body}}{\text{Length of human leap}} = \frac{\text{Length of frog body}}{\text{Length of frog leap}}$$

As the lesson continues, students are required to set up their own proportions in order to justify other of Schwartz's assertions.

In this way, this picture story book is helping students learn about ratios and proportions. The book can act as either an introduction or as a supplement to the curriculum concerning ratios and proportions. Either way, when used properly, Schwartz's book can easily be used to demonstrate to students how ratios are formed, and how and why proportions are used. *If You Hopped Like a Frog* provides many different situations in order to practice setting up and solving proportions. The skills involved in the solution of these problems are on the secondary education level. Problems concerning ratios and proportions are found in algebra text books. Is using a

picture story book such as this, then, a viable way to complement the secondary mathematics curriculum? There are certainly those who assert very strongly that "using picture books written for younger children is an excellent way to explore topics in high school mathematics" (Spicer, 2003, p. 5).

Research Question

How can picture story books enhance a secondary mathematics curriculum?

Method

A brief history of secondary mathematics education was researched in order to display how the educational system has attempted to take the developmental and cognitive needs of students into account. Research concerning the integration of mathematics and literature was considered in order to determine whether the integration of reading and mathematics is seen as a viable option in the current mathematics curriculum. The potential drawbacks and benefits to such integration were discussed. In particular, the possibility of integrating children's picture story books into the secondary mathematics classroom was discussed. The research is followed by lesson plans that incorporate picture story books into the algebra I and geometry classrooms.

Review of Literature

A Brief History

The traditional and innovative classrooms described earlier can be found reenacted in countless classrooms across the United States. Classroom A seems to

develop, historically, from tradition and habit. Classrooms such as B developed when classrooms such as A were no longer producing the desired effects: students who had attained mathematical literacy.

Mathematical Literacy is:

- Connecting mathematics to the real world.
- Using mathematics appropriately in a variety of contexts.
- Communicating using the richness of the language of mathematics.
- Synthesizing, analyzing, and evaluating the mathematical thinking of others.
- Appreciating the utility and the elegance of mathematics.
- Understanding and being conscious of what has been learned mathematically.

(Mathematics Council of the Alberta Teacher's Association, 2002)

There is no arguing the fact that education has changed drastically over the past century in an attempt to achieve mathematical literacy. Educational practice and the theories behind it have had to develop to meet the need for an educated, literate America. "Our society's demands for math literacy are going up and up," says Walter Secada (cited in Lucas, n.d., paragraph 18). Secada visited the White House during the Clinton administration for the release of the twelfth-grade TIMSS (Trends in International Mathematics and Science Study) results. He is a UW-Madison professor of curriculum and instruction who is directing DiME (Diversity in Mathematics Education Center on Learning and Teaching). "It's not the case that schools aren't

improving," he says. "They are - but they are not improving fast enough to keep up with the increased demands for technical skill and mathematical knowledge" (cited in Lucas, n.d. paragraph 18).

There has also been a reoccurring and alarming realization that some of the population continues to remain immune to all of the changes that have taken place throughout the decades concerning mathematics education. This realization becomes even more evident in an area such as mathematics, where procedures are sequential and answers are more often than not considered strictly right or wrong. The 'drill and kill' method has come under harsh criticism in educational theory. This is due to the fact that this method of teaching only utilizes only the first levels of Bloom's taxonomy: knowledge, comprehension, and, sometimes, application (*Bloom's Taxonomy*, n.d) Consequently, it has failed to meet the needs of every type of learner on every level. It has, therefore, become necessary to meet the students where we have left them (Starr, 2002). Research on the issue has continued to imply that integrating mathematics with other subjects across the curriculum such as reading and technology will lead to a higher understanding of math as a whole. Efforts to reach the desired level of mathematical literacy have been numerous and diverse over the years.

With the plethora of changes that have occurred in the theory of mathematics education over the past century, it comes as no surprise that mathematics education as an area of study itself has also grown immensely over the past century. Secondary mathematics education was not even an area of study during the arithmetic era of the

early 20th century. This makes sense because the processes and answers for arithmetic problems could be seen as strictly right or wrong, not open to interpretation like the texts that were used in other subjects. Therefore, at this time, theory of teaching in mathematics was examined only at the elementary level. Research on secondary math education did not appear as a discipline itself until the late 1900s. In 1970, the first publication journal concerning secondary math education was released. It was the *Journal for Research in Mathematics,* by David C. Johnson, Thomas A. Romberg, and Joseph M. Scandura. After this first publication, from 1975 to 2000 the number of groups associated with doing research concerning mathematics education grew from a very small number to about 300 (Corno, 2001).

With the emergence of all of this research concerning mathematics education, educational practices have moved from the arithmetic of the one room school house to the variety of teaching styles the American school system employs today. In the beginning of the century, the general view of mathematics was, "nothing in mathematics should be taught unless its probable value could be shown" (Klein, 2003, p.4). The traditional high school mathematics curriculum was, therefore, only recommended to a select few. This recommendation appeared in the most influential document available for mathematics education at this time, *The Problem of Mathematics in the Secondary Education* by William Kilpatrick. The National Council of Teachers of Mathematics (NCTM) was created in 1920 so that any reforms to the curriculum would come from teachers of mathematics and not educational reformers. The NCTM also supported a publication in 1923 which

discussed the psychology of learning mathematics and supported the idea that mathematics could be studied and appreciated for its intrinsic value, as well as its application to the real world (Klein, 2003).

This suggestion from NCTM has grown from its appearance in a publication in 1923 into national standards required across the country. In 1989, the *NCTM Curriculum and Evaluation Standards for School Mathematics* were published. The NSF (National Science Foundation) launched the Statewide System Initiatives in 1991 in a successful attempt to encourage state education systems to align state standards with the NCTM Standards. The Standards have since been edited and republished in 2000; they are still very influential over the implementation of educational policies at the state level. Among the NCTM Standards are communication and connection. These imply that students become familiar not only with the mathematics that they are learning, but they be able to communicate mathematical ideas to their peers and to the world. Students are also supposed to learn how to connect mathematical ideas to contexts and situations that arise outside of the mathematics classroom (NCTM, 2000). This concentration on building communication and making connections has pushed the mathematics curriculum closer to the theory of integration.

Integration:

There is a great deal of evidence supporting integration, in general, across the curriculum. Elementary schools have been historically known for using this concept, and this is very easy to do at this level since the students visit the same teacher for all

subjects. It seems as though people are beginning to realize, however, that this sort of education should extend to secondary schooling, as well. “The characteristics of good content-area teachers do not vary substantially from those of elementary school teachers in a self-contained classroom except with regard to their orientation toward their subject matter” (Rubin, 1983, p. 17). It would then only makes sense to say that the level of learning would almost always be raised by integrating mathematics with language arts and science using creative problem-solving activities (Braddon, Hall, & Taylor, 1993). It is more common to hear of integrating science and mathematics, since areas of science such as physics and chemistry can be seen as applied math, but linking mathematics with language arts has been relatively rare in the secondary setting (Hurst, 1997). In classrooms such as classroom A, discussed previously, the extent of reading was done in the textbook with its word problems. More and more classrooms in high schools are shifting toward using reading and writing in every subject, even the quantitative field of mathematics (Hickman, 1997).

Why has this shift occurred? “Not very long ago it might have seemed odd to be talking about literature and science and math in the same breath” (Hickman, 1997, p. 2). With the emphasis of mathematics education shifting to communication and connections due to the NCTM standards, though, it comes as no surprise that they are now intermingled (Countryman, 1993). There were many reactions across the nation to the new emphasis given to the importance of not only learning mathematics, but being able to communicate mathematics. Tennessee, alarmed by its students’ declining reading literacy scores and encouraged by the NCTM standards, released a

mandate to ensure that all teachers would integrate reading into all content areas (Rubin, 1983). Students were reading far below their grade levels and consequently falling behind in all subjects due to the fact that textbooks are, of course, written on the grade level for which they are meant (Rubin, 1983).

It is worth mentioning that there was somewhat of a backlash by content area teachers to the idea of integrating reading into their content area classrooms (Rubin, 1983). They insisted that there was not enough time in their curriculum to teach reading; they were unfamiliar with methods of teaching or using reading in their content classrooms. The students were already supposed to be proficient readers by high school; and they were supposed to have been reading since the first grade, after all (Rubin, 1983). The response to this backlash, however, was that teachers were not being asked to teach reading, but rather that they use reading and study skill techniques to enhance the content area classroom (Rubin, 1983).

Reading integration in the mathematics classroom does not have to be seen as something that takes away from the time that is spent on content area learning; as students develop the necessary skills, reading becomes more of an integral part to learning mathematics, literature, social studies, and science (Braddon, Hall, & Taylor, 1993). "Literature in Mathematics class is not an oxymoron, but a viable and motivating activity to pursue with our students" (Pines, 2003, p. 3). Reading comprehension ceases to be just the end and instead is more of a means to an end, with the end being mathematical literacy, as described above. Instead of interpreting this push to integrate as all teachers having the added task of teaching students

reading and writing, it can instead be viewed as building reading and writing skills so that communication skills are improved, thereby, improving the learning experience (Sheppard, 1985). Reading comprehension and mathematical content then join in a symbiotic relationship, each building on each other and both enhancing the abilities of the learner. “It is possible that students who have a fear of working with numbers will have less anxiety if they can see the relationship between their language and mathematics” (Rubin, 1983, p. 206). Dennis Flannagan, the former editor of *Scientific American*, wrote for some time on the war that seemed to be happening between the cultures of science and literature. He quoted Vladimer Nabokov (from 1966) by pointing out that, “There is no science without fancy, and no art without facts” (cited in Hickman, 1997, p. 2). Take, for example, the list below detailing the functions of oral and written expression.

Functions of oral and written expression:

- Organize thoughts
- Discover meaning
- Inform, report, describe what one knows
- Plan (reports, how to solve problems)
- Analyze one’s thinking and the thinking of others
- Speculate, predict, reflect
- Invent a new perspective
- Verify information or ideas
- Interact (a vehicle for dialogue)

Ÿ Clarify, refine, and extend thought

(Sheppard, 1985, p. 3)

Now, one should add the words “about math,” “with math,” or “to math” to the end of each statement. This list begins to resemble the previous list concerning what mathematical literacy is. These are the means to the end goal that has been given as mathematical literacy.

Jack Price, the president of NCTM from 1992-1994, said, “If we think that mathematics is a language, how do we learn a language? We talk, we listen, we read, we write. We build the concepts underlying the ideas so we can communicate with meaning” (cited in Elliott & Lindquist, 1996, p. 5). It would then be acceptable to say that oral and written expression may lead to mathematical literacy. According to the 1996 NCTM yearbook, “to achieve true mathematical literacy, the old teaching of reading, writing, and arithmetic needs to move toward teaching reading and writing about mathematics” (Borasi, Fonzi, Sandridge, Siegel, & Smith, 1996, p. ix).

There are many who continue to argue that there is not enough time to carefully lay out all of these connections in a math class and still have the class cover all of the curriculum. Books and activities, however, are not meant to replace or encompass the entire mathematics curriculum. They are very helpful in procuring interest from students, showing applications for concepts, and showing that math is present in everyday life (Braddon et al., 1993). Furthermore, “Literature often reveals quantitative relationships that afford wonderful opportunities to communicate mathematical concepts” (Narode, 1996, p. 76). It certainly would be realistic to say

that if one were to attempt to present students with math, literature, and higher-order thinking skills all in isolation of each other, it would take much more time and energy than just presenting mathematical concepts. We know, though, that the mind is able to process many skills at once, and that a greater amount of meaning is attached when prompted to do so. Teaching all three at once allows them to build upon each other by using interconnections (Welchman-Tischler, 1992).

This has been done on the elementary level for years. This is evident in the number of books that contain counting or early mathematical concept for children. There are many books, such as *The wonderful world of mathematics: A critically annotated list of children's books in mathematics* (Matthias & Thiessen, 1992), that provide suggestions in order for the elementary teacher to become successful in integrating literature and mathematics. The abstract below provides insight as to what is contained in such annotated volumes.

> Abstract:
> This resource book contains a critically annotated list of children's books in mathematics for preschool through grade six. Each review includes the grade level along with descriptions of the book's content and accuracy, illustrations and their appropriateness, the author's writing style, and whether activities for the reader are included. A notation indicates whether the book develops a single concept or multiple concepts. Books are categorized according to content, and some books are cross referenced under more than one category. Vignettes give a flavor of how some of the books have been successfully used in classrooms. Each book is rated as highly recommended, recommended, acceptable, or not recommended in terms of its usefulness for teaching mathematical concepts. (Matthias &Thiessen, 1992, p. 1)

It then begs to be asked why there are no such resources available for the secondary mathematics teacher, at least to this degree. Research seems to indicate that,

> Elementary students who love good literature are often the same children who dislike completing worksheets filled with math problems and who struggle with those troublesome word problems… it became evident that integrating math and literature would be not only an exciting, but also a logical union. (Braddon et al., 1993, p. xiii)

This sentence could easily begin with "all students." Approaching mathematics through literature may be easier for the student who has had negative experiences in math (Braddon et al., 1993).

On Children's Books

"Mathematics should be a living, exciting activity for children" (Welchman-Tischler, 1992, p. 1). This is stated in the 1996 NCTM yearbook. Some of the goals in this yearbook deal with the fact that children's literature can be very powerful in gripping the imagination of students even when it has mathematical connotations (Welchman-Tischler, 1992). Mathematics through children's literature allows the children to be actively involved. Word problems come alive in familiar stories. They inspire students to explore and investigate concepts (Braddon et al., 1993). "The marriage of mathematics and literature fosters the realization that math is all around us" (Braddon et al., 1993, p. xiii). Welchman-Tischler (1992) implies that in order to achieve their full potential in mathematics, students must find their encounters with mathematics interesting. One suggestion, in order to do this, is to use literature as a springboard. Children's Literature also helps to, "breakdown the artificial dichotomy that sometimes exists between learning and mathematics and living mathematics"

(Whitin & Wilde, 1992, p. 4).

This list briefly details how children's literature can serve to enhance a mathematical curriculum. Children's literature:

- Ÿ provides a meaningful context for mathematics.
- Ÿ celebrates mathematics as a language
- Ÿ demonstrates that mathematics develops out of human experiences.
- Ÿ addresses humanistic, affective element of mathematics.
- Ÿ fosters the development of number sense.
- Ÿ integrates mathematics into other curriculum areas.
- Ÿ restores an aesthetic dimension to mathematical literature.
- Ÿ supports the art of problem posing.

(Whitin & Wilde, 1992, p. 4-16)

Picture Books in the Secondary Setting

The question then becomes whether or not using children's literature in grades 7-12 would be beneficial to the students. There has been much research over time and there are many resources available for elementary school teachers to do this type of integration, but it is very rare on the secondary level. "Teachers who are aware of the variety of children's books with mathematical themes have a tremendous range of resources available to them to help them accomplish these goals" (Whitin & Wilde, 1992, p. 17). This insightful quote came from the book, ***Read any Good Math Lately***, by Whitin and Wilde, however, this book is primarily geared to cater to teachers for grades kindergarten through 6. Whitin and Wide (1992) do mention that they have not

made grade level suggestions since it is too restrictive, and they want to encourage readers to use the books whenever and however they complement the lesson and goals. Yet, the book, which provides very useful tips on integrating children's literature into the mathematics classroom, was designed primarily to explore major topics in elementary school mathematics (Whitin & Wilde, 1992). An NCTM publication, *How to Use Children's Literature to Teach Mathematics*, also has a similar story. Grade levels are only suggested; the teachers' level of questioning determines the appropriateness of the material covered in the books (Welchman-Tischler, 1992). The suggestions that are provided, however, are also all in the kindergarten through sixth grade range.

"Thank goodness it's no longer a rarity to see picture books in upper elementary classrooms, but we still don't see many of them in the middle school" (Hurst, 1997, p. 50). Seen even less than that, though, is the use of picture books in the high school classroom. "Yet this very useful and often beautiful genre may be the very thing you're looking for to bring several disciplines and their teachers together" (Hurst, 1997, p. 50). The major suggestions that are found for successfully supplementing a secondary mathematics curriculum with picture books come mostly from recent publications such as ENC (Eisenhower National Clearinghouse) Focus and NCTM.

Jennifer Bay-Williams, a former mathematics education professor and high school math teacher, insists, in spite of the lack of resources on the secondary level, that "opening a Mathematics lesson with a children's book sparks enthusiasm…

Weeks after the activity, students will remember the story and its related investigation, and this will help them remember the mathematics" (cited in Spicer, 2003, p. 5). There has been some evidence to suggest that secondary teachers are beginning to use children's literature as a springboard to mathematics lessons. Around 1997, Laurie Pines, a high school teacher, became interested in integrating mathematics with literature. She now finds herself at the beginning of a successful mathematics literature program. She insists that "it is fun, relevant, and a great learning tool for my students" (Pines, 2003, p. 3). Children's picture books, although written and suited for younger kids on one level, can be geared towards older students and even adults in content and presentation (Spicer, 2003).

There is some evidence that for some learners, it is easier to recall facts that are presented in a narrative context. Negrete (2003) performed a study to see what the retention rate of information was for students who were taught a science using a narrative text. The conclusion was that the ability to recall information after reading a narrative text was just as good if not better than that of reading an informational text for the same facts. Other sources imply that narrative story telling is a natural way for students to learn. It allows students to make interpersonal connections to the world around them (Ellyat, 2002). In mathematics, this helps to meet the standard of connection. Narrative stories also help to reach certain intelligence types that may be immune to learning via textbook. Students who posess interpersonal or linguistic intelligence would benefit from such a teaching method (Hoerr, 2002).

Besides narrative story telling providing a strong basis for the use of picture

books in the secondary classroom, the pictures themselves provide a rationale. “It is amazing how artwork can make mathematics concepts real for students” (Spicer, 2003, p. 5). The artwork that brings the stories to life may help reinforce a mathematical concept into a student who relies on visual means to learn (Hoerr, 2002). There was also a similar comment on the web site for the National Council of Teachers of English. This was found in a discussion concerning literature in the mathematics classroom. The following response from Lin Williams, a high school teacher in Utah, posted is:

> I would suggest that the tenth grade math teacher use picture books rather than short stories. There are a plethora of picture books on math-related topics, and tenth graders would love them. What you do is just joke around about the fact that these are children’s books and then ham up the reading. Once you start reading the books, the tenth graders will love it. (cited in Spicer, 2003, p. 5)

In an edition of *ENC Focus Review*, Judy Spicer, in ENC‘s instructional resources department, continues the article with suggestions for using particular books in the high school math class. “We discovered that the books may be for children on one level, but on other levels they speak to older students and adults” (Spicer, 2003, p. 5). This is an important conclusion that has emerged with the appearance of various books that are suitable in content for the high school mathematics curriculum. ENC’s study provided specific suggestions for books that answer to the curriculum standards, goals, and expectations for high school

mathematics. Some of the books that they suggest and that are in the ENC collection are:

1. *The Librarian Who Measured the Earth* by Kathryn Lasky
2. *Sir Cumference and the Round Table* by Cindy Neuschwander
3. *Sir Cumference and the Dragon of Pi* by Cindy Neuschwander
4. *Math Curse* by Jon Scieszka
5. *How Much is a Million* by David M. Schwartz
6. *The Dot and the Line: A Romance in Lower Mathematics* by Norton Juster
7. *Is a Blue Whale the Biggest Thing There Is?* by Robert E. Wells
8. *The Token Gift* by Hugh William McKibbon
9. *If the World Were a Village* by David J. Smith
10. *G is for Googol: A Math Alphabet Book* by David M. Schwartz

Another ENC writer comments on the new emergence of mathematical literature. "There is considerable tension, I think, in regard to tying literature to math because the abstract facets of mathematics make it particularly difficult to write about in the terms of a children's book" (Hickman, 1997, p. 2). This tension seems to be easing as more books are appearing that successfully and colorfully address topics of mathematics. Hickman also notes the following:

> I have seen some encouraging changes in the relationship between children's literature and mathematics. Ten years ago, I could not find a professional book that presented a mathematical take on children's books, but now there are several major educational publishers who have been paying some attention to the topic. This is a sign of stretching, of beginning to see the connections. (Hickman, 1997, p. 2)

The mathematics educational community seems to be considering the integration of mathematics and literature as a viable option in the search for mathematical literacy.

There is also, obviously, an emerging group of educators who are considering picture books as a beneficial resource in the secondary mathematics classroom, due to their powerful narrative stories and striking illustrations. As more research is done connecting literature and mathematics, the possibility for successful integration of picture books into the secondary classroom will continue to increase. There will be more strategies and suggestions to help the secondary teacher effectively supplement the mathematics curriculum. Spicer suggests the following:

> As with any teaching technique, there is more than one way to present picture books in a high school math class. A teacher can choose one book to read aloud to a class to introduce or reinforce a mathematics topic, or even to encourage students to think differently about the topic. Or if a learning goal is mathematical communication, students can select a book from the list, report on the story (characters and setting), and explain the related mathematics. Another idea, depending on the book, might be to have students write sequels or prequels based on the mathematical story line. (Spicer, 2003, p. 5)

In *Read Any Good Math Lately*, Whitin and Wilde (1992) provide suggestions for integrating literature into a mathematics curriculum.

1. Enjoy the story. Don‘t destroy the magic of a story by interrupting it with mathematical questions as you read it aloud.
2. Read book aloud.
3. Use divergent questioning. Keep the experience open-ended to encourage

multiple interpretations.

4. Encourage students to respond to these stories through poetry, drama, art, written narrative, or oral discourse.
5. Integrate these books into current themes of study or relate them to impromptu questions raised in class.
6. Use your own students as a guide for deciding what to read, not a preordained grade-level index. Picture books are not only for the primary grades and parts of more difficult books can often be used with younger children.
7. Consider the age of your students and your intended use of a book to decide whether oral reading to a class or silent reading by individuals is more appropriate.

(Whitin & Wilde, 1992, p. 18)

While, again, these are suggestions from a book geared toward teachers for grades kindergarten through 6, Whitin and Wilde (1992) consider these to be suggestions for appreciating literature for people of all ages. When selecting literature to use in the mathematics classroom, these suggestions become even more important. As mentioned, books cannot be used as filler or fluff; they cannot be used to try to replace the curriculum. They should only be used to supplement the mathematical learning, to introduce, or to reinforce.

Purposes for reading in mathematics are given as the following:

Ÿ Making sense of mathematical concepts or procedures

- Seeing connections between mathematics and real life
- Developing broader views of mathematics
- Developing strategies for sharing information
- Valuing students' own ideas and those of others

(Borasi et al., 1996, p. 74)

Conclusion

When considering the ways in which picture books could supplement a mathematics curriculum, it becomes a possibility that should be considered. When it is looked into, it becomes obvious that there is some support for doing so, while there is some opposition for doing so. This is because there are many different types of learners in any particular classroom. While a narrative telling of information may reinforce a theory for one student, a factual text, practice problems, or an illustration may reinforce the same theory for a completely different child. This only serves to reinforce what has been learned since Howard Gardner's statement of multiple intelligences in 1983 (Hoerr, 2002). This is why every suggestion that is provided in my research has incorporated in it, multiple mathematical learning situations in addition to the reading of a picture book in the high school classroom.

Using picture books in the high school classroom could certainly broaden the range of intellectual learning styles that are addressed. The content would appeal to the predominately mathematical-logical intelligent students, the illustrations would appeal to visual-spacial learners, the narrative story form would appeal to the

interpersonal learners, and the shared readings would appeal to the linguistic learners (Hoerr, 2002). While using picture books in an algebra I and geometry class is certainly a viable option in supplementing the mathematics curriculum, it is not the only answer for attaining mathematical literacy for every student. It is simply a useful, creative way to reach the broad spectrum of learners that will be present in any classroom.

The lessons that follow use five picture books to supplement an algebra I or Geometry curriculum. The lessons try to take into account the multiple intelligences that will be present in the classroom. The lessons match the content of the books and the way in which the teacher presents the content and poses questions match Tennessee state standards for algebra and geometry in order to display that these choices could really benefit a student in these subjects (Tennessee Department of Education, 2003). The first lesson attempts to make various connections from mathematics to the students' lives using *The Math Curse* (Scieszka & Smith, 1995). The second lesson teaches students how to use ratios and proportions to compare one thing to another using *If You Hopped Like a Frog* (Schwartz, 1999). The third lesson shows students how ratios can be extended to geometric ideas, e.g., finding the circumference of a circle using *The Librarian who Measured the Earth* (Lasky, 1994). The fourth lesson demonstrates the ease of finding the circumference of a circle with a known value for pi. Students also learn how pi is derived through reading *Sir Cumference and the Dragon of Pi* (Neuschwander, 1999). The fifth lesson extends the idea of the circle by teaching students about different parts of circles

along with how they relate to one another using *The Missing Piece* (Silverstein, 1976).

More work that may provide positive data for the integration of mathematics and literature at the secondary level includes the following. A study to see whether or not picture story books could be used to supplement the curriculum in an advanced high school classroom, such as pre-calculus or trigonometry. A quantitative study could be performed to confirm or deny that there is a higher retention rate when using narrative texts verses informational texts when relaying mathematical information. A quantitative study on the correlation between mathematical literacy and reading literacy could be performed.

References

Bloom's taxonomy. (n.d.). Retrieved on November 4, 2004, from http://www.kent.k12.wa.us/KSD/MA/resources/blooms/blooms.html

Borasi, R., Fonzi, J., Sandridge, L., Siegel, M., & Smith, C. (1996). *Using reading to construct mathematical meaning. Communication in mathematics K-12 and beyond.* Reston, VA: NCTM.

Braddon, K. L., Hall, N. J., & Taylor, D. (1993). *Math through children's literature: Making the NCTM standards come alive.* Englewood, CO: Teacher Ideas Press.

Corno, L. (Ed.). (2001). *Education across a century: The centennial volume.* Chicago, IL: The National Society for the Study of Education.

Countryman, J. (1993, January). Writing to learn mathematics. *Teaching Pre-K-8.*

Elliott, P. C., & Lindquist, M. M. (1996). Communication- an imperative for change. *Communication in mathematics K-12 and beyond.* Reston, VA: NCTM.

Ellyat, W. (2002). Story telling and the power of narrative. *Paths of learning.* Retrieved December 9, 2004, from http://www.pathsoflearning.org/library/storytelling.cfm

Hickman, J. (1997). Children's literature across the curriculum. *ENC Focus 4*(5).

Hoerr, T. (2002). *Applying MI in schools. New horizons for learning.* Retrieved December 9, 2004, from http://www.newhorizons.org/strategies/mi/hoerr2.htm

Hurst, C. O. (1997, November/December). Picture books in the middle school. *Teaching Pre-K-8*.

Klein, D. (2003). *A brief history of American K-12 mathematics education in the 20th century.* Retrieved November 4, 2004, from http://www.csun.edu/~vcmth00m/AHistory.html

Lucas, J. (n.d.). *Making math add up.* Retrieved November 2, 2004, from University of Wisconsin, Madison Web site, http://www.uwalumni.com/onwisconsin/spring02/math.html

Mathematics Council of the Alberta Teachers' Association. (2002). *Mathematical literacy…an idea to talk about, 2.* Retrieved November 2, 2004, from

http://www.mathteachers.ab.ca/MCATA%20referent%20paper.pdf

Matthias, M., & Thiessen, D. (1992). *The wonderful world of mathematics: A critically annotated list of children's books in mathematics.* Reston, VA: NCTM.

Narode, R. (1996). Communicating mathematics through literature. *Communication in mathematics K-12 and beyond.* Reston, VA: NCTM.

Negrete, A. (2003). *Science via narratives.* Retrieved December 9, 2004, from http://www.saasta.ac.za/scicom/pcst7/negrete-yankelevich.pdf

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Retrieved December 7, 2004, from http://standards.nctm.org/document/chapter3/index.htm

Rubin, D. (1983). *Teaching reading and study skills in content areas.* New York, NY: CBS College Publishing.

Pines, L. (2003, October). Bringing literature into the high school math class. *ENC Focus Review.*

Seife, C. (2000). *Zero: the biography of a dangerous idea.* New York, NY: Penguin Putnam, Inc.

Sheppard, R. (1985). *Enhancing learning through oral and written expression.* Macon, GA: PenRow.

Spicer, J. (2003, October). Using picture books in high school math. *ENC Focus Review.*

Starr, L. (2002). *Math wars!* Education World. Retrieved December 7, 2004, from http://www.education-world.com/a_curr/curr071.shtml

Tennessee Department of Education. (2003). *Mathematics grades 9-12 philosophy. Mathematics curriculum standards.* Retrieved November 4, 2004, from http://www.state.tn.us/education/ci/cimathhighschool/cimath912intro.htm

Welchman-Tischler, R. (1992). *How to use children's literature to teach mathematics.* Reston, VA: NCTM.

Whitin, D. J., & Wilde S. (1992). *Read any good math lately? Children's books for mathematical learning, K-6.* Portsmouth, NH: Read Publishing, Inc.

Picture Story Book References

Lasky, K. (1994). *The librarian who measured the earth.* Hong Kong: South China Printing Co.

Neuschwander, C. (1999). *Sir Cumference and the dragon of pi.* Watertown, MA: Charlesbridge Publishing.

Schwartz, D. (1999). *If you hopped like a frog*. New York, NY: Scholastic Press.

Scieszka, J. & Smith, L. (1995). *Math curse*. Rutherford, NJ: Viking Press.

Silverstein, S. (1976). *The missing piece*. New York, NY: Evil Eye Music, Inc.

Lesson plans

Integrating Picture Story Books into the Algebra I and Geometry classrooms

By: Laura Poff

Instructor's Memo

The purpose of this mini-unit is not to replace the mathematics curriculum for these specific topics. It is, instead, supposed to supplement and enrich the mathematics curriculum. This unit should be used in conjunction with a regular curriculum in order to provide students with different perceptions and ways of using math in the world around them, as well as for the intrinsic value of mathematics itself. This unit should work together with the curriculum in order to strengthen student understanding of mathematics topics and the importance for literacy in a variety of areas.

All of the standards listed in the lesson plans are from http://www.state.tn.us/education/ci/cicurassessedstandards.htm. Whenever a standard was given on more than one level, I referenced it at the highest level.

For the sake of gender equity, I have alternated between genders when describing the teacher in each lesson.

Due to the nature of this unit, evaluation is largely informal. A rubric is provided for the final project, but it, along with the assignments in the lessons, can be graded as seen fit by the instructor in evaluation of student performance.

On Technology

In the early 1990s, the Tennessee State Board of Education became increasingly aware that "all students must have access to a rich curriculum emphasizing mathematical thinking and problem solving in order to ensure a mathematically literate work force and to promote equal opportunity for all citizens" (Tennessee Department of Education 2003, p. 1). They released recommendations based on where education was in Tennessee, and based on current research, where it needed to go. Two of the six suggestions listed imply that students should become fluent in technology.

> Students will:
>
> - use appropriate tools, such as measuring instruments, calculators, and computers, to solve problems;
> - understand the relationship between mathematics, the sciences, technology, and society.
>
> (Tennessee Department of Education, 2003, p. 1)

It seems very rational that these suggestions be made. Educational systems now have to accept that, "indeed technology is pervasive in government, industry, and business," (Tennessee Department of Education, 2003, p. 2). Students need to know how to use the technology that exists in the world around them.

Further than students needing to know how to use this technology, there is significant evidence that, like the integration of reading, learning technology can enhance mathematical learning, as well. "Technology is essential in teaching and

learning mathematics; it influences the mathematics that is taught and enhances students' learning" (NCTM, 2000). Technology acts much like has been previously discussed about literature. It cannot be used to replace the teacher or the mathematics curriculum, but it can allow students to, "work at higher levels of generalization or abstraction" (NCTM, 2000).

"In the mathematics classrooms envisioned in ***Principles and Standards,*** every student has access to technology to facilitate his or her mathematics learning" (NCTM, 2000). I have, therefore, provided the students with the opportunity to supplement many of the lessons in this unit with technology. This technology comes in the form of WebQuests, general internet searches, and enrichment with Java Applets. The WebQuests I have put together are geared only toward the students. The lesson plans can serve as guidance for the teachers. The WebQuests can be accessed at http://www.utc.edu/~laura-poff.

Lesson 1

Teacher: Laura Poff | Subject/Grade: Mathematics (7-12)
Time: 60 minutes | Date:

Lesson Title: *Math Curse*

Goal: The students will identify ways in which mathematics is used in the world around them and, in particular, in their everyday lives.

Specific Instructional Objective(s):

Students will:
1. Discuss ways in which math is used in *Math Curse*.
2. Understand the mathematics that is used in *Math Curse.*
3. Brainstorm other ways math is used in their everyday lives, especially math that is on a higher level than arithmetic.
4. Search the internet for ways that other people may use math in their lives (especially in jobs).
5. Produce a compilation of their brainstorms in order to present to the class for further discussion.

TN Standards	Benchmarks
MA 8.1.1	Understand numbers, ways of representing numbers, relationships among numbers, and number systems.
LA 1.01	Continue to develop oral language and listening skills
LA 1.05	Read to develop fluency, expression, accuracy, and confidence.
LA 1.08	Use active comprehension strategies to derive meaning while reading and to check for understanding after reading.
LA 1.09	Refine study skills and develop methods of research to enhance learning.
LA 1.10	Develop skills to facilitate reading in the content areas
LA 2.13	Locate and analyze information to prepare written words and presentations.

Materials:

1. *Math Curse* by Jon Scieszka and Lane Smith.
2. Overhead adaptations of *Math Curse* and/or copies to hand out.
3. Computers with internet access where the teacher's computer is projected onto a screen in the computer lab.
4. Chart paper and markers

Instructional Considerations:

This lesson's primary focus is to get students to realize the many ways that math is used in the world around them everyday. This lesson is student driven with much discussion and individual exploration. The teacher will serve to direct student discussion and moderate their progress throughout the lesson. The lesson will take place as a whole group and some small group discussion. The book will cater to the visual/auditory learners. The process of connecting math to the real world will appeal to global/analytic thinkers.

The teacher should be available at all times during the lesson to answer individual questions and to be sure the students remain on task.

The lesson is designed for 28 average students with a wide range of abilities and all learning styles.

Modifications can be made for learning disabilities and ADD such as providing copies of *Math Curse* and heterogeneous grouping.

Teaching/Learning Activities

1. **Introductory Activity/Initiating Procedures:** Invite students to join you in a part of the room where it is not necessary for them to sit in desks. Have a very informal discussion concerning math in everyday life. How have they seen it used or how could they anticipate using it later? Gauge prior knowledge as far as these connections go. Tell them that you are going to read them a book about someone who begins to notice all the ways in which math could be used in everyday life. Read aloud to the class the book, *Math Curse* by Jon Scieszka and Lane Smith. After the reading, ask students for some specific ways in which the little boy in the story found math throughout the day. Ask them if they see examples such as these around them. Continue whole group discussion, as needed.
2. **Connection To/Review of Previous Lesson Objectives:** This lesson will

connect to other lessons prior to this since it is calling for students to make connections between the mathematics they have learned to the world in which they live.

3. Procedures

A. **Information Giving:** Divide students heterogeneously, into groups of three or four. Challenge each group to come up with other ways in which they see math used around them in their lives. Inform students that this will be a list that continues to grow throughout the next couple of weeks. Let students brainstorm about their individual connections they have found between math and the real world for about 15 to 20 minutes. The students will also brainstorm mathematical ideas that after learning them, they have wondered when they would ever need to use it. Each student will have to have one topic in mathematics and they will go to the computer lab to perform searches on how that topic has been used or could be used in the real world. Each person in the brainstorming groups has to research a different idea. This should also last about 15-20 minutes.

B. **Modeling/Guided Practice:** First, start listing ways in which the instructor personally encounters math in his/her life. Tell students that the first part of their list as a group should only consist of ways in which they personally have encountered math, not ways in which it could be used. During the computer lab segment, the teacher will show the students how to access the WebQuests that have been created to go along with their research. The teacher will also show students how to perform a search using a search engine such as Google (http://www.google.com) upon the screen and type in words that would be relevant for a search (e.g. math, job, profession, etc.). Also demonstrate how to use the advanced search. The students will also be directed to the WebQuest concerning this topic. They will be directed to specific sites that outline the importance for mathematics in the real world, especially on the job. The teacher will be sure to walk around during this

time, especially to help students with their individual topics. Some may be harder to find information on than others or may require a little more interpretation. The teacher can lead the student to logical conclusions concerning their topic and the real world.

C. **Formative Assessment:** The teacher will walk around the room as the groups come up with their lists. She will answer questions and assure that each group is on task, monitoring their conversations in passing. The teacher will also ask each group randomly for what they think the best example of relating math to their lives has been, thus far. During the computer lab segment, the teacher will walk around the room and answer questions. She will ask students what they are finding, as far as integrating their topic of mathematics with the real world.

D. **Independent Practice:** Students will be asked to write a fictitious, short story one to two pages in length. They will come up with a situation in which they are required to use the mathematical idea that they did research on in order to 'save the day' or solve a problem.

Each student will also be asked to select one of the mathematical ideas that was used in *Math Curse*. They will have to justify the mathematics behind this idea, explaining each step with complete sentences, and providing an answer to the question the boy posed within the story.

Students will also be working cooperatively to complete a final project concerning the integration of mathematics into life. A major project description and rubric are included in Appendix A.

E. **Culminating Procedure:** Have the groups meet again after the internet searches and share with each other how they found their topic used in the real world. Have each group vote on the topic that they think is most helpful in the real world. For about the last 10 minutes of class, have each group present the ways in which they have used math in the real world, personally, and the most helpful topic on which they voted. Have each group hang a list on chart

paper of their initial brainstorms around the room as well as a list of their mathematical topics and how they are used in the real world.

F. **Enrichment/Extension:** Students should be encouraged to continue thinking about how mathematics is used in the real world. The teacher should also remind students to look for math in their lives during each day in order to keep adding to their lists.

4. **Evaluation:** The lists that each group posts will indicate that students were actively involved in the process. Successfully providing a way in which their topic of mathematics connects to the real world will show that the students were able to find information on the internet. The students will be evaluated on the completion of their story and using the mathematical concept within it. In addition, they will be evaluated on the final project, which will be a culmination of the tasks that students were to perform in this lesson and the ones to follow.
5. **Integration of Literacy Instruction:**

Text: *Math Curse* Jon Scieszka and Lane Smith.
Internet pages found by the students.

Strategy Focus of Lesson: Recognizing ways in which math is connected to the world around us.

The shared reading requires students to begin asking important questions. Through independent research, students find important details, ask meaningful questions, and prepare to use the information for later writing. Through independent writing, students integrate and gain ownership over their learning.

Lesson 2

Teacher: Laura Poff | Subject/Grade: Mathematics (7-12)
Time: 60 min. | Date:

Lesson Title: *If You Hopped Like a Frog*

Goal: Students will learn how ratios and proportions have been and still are used to understand the world around us.

Specific Instructional Objective(s):

Students will:
1. Examine the Pythagorean philosophy of 'all is number,' particularly in the way they dealt with ratios.
2. Deduce how ratios have been used to discover and/or create things in the world.
3. Compare characteristics of animals to themselves using ratios and proportions.
4. Produce new scenarios in which ratios and proportions are necessary to solve a question or problem.

TN Standards	Benchmarks
MA 8.11 (j)	Understand and use ratios and proportions to represent quantitative relationships.
MA 8.1.3 (d)	Judge the reasonableness of the results of rational number estimates and computations.
MA 8.1.3 (h)	Develop methods for solving problems involving proportions (e.g. scaling, finding equivalent ratios.)
MA 8.5.1	Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer questions.
Algebra I: 1.7	use real numbers to represent real-world applications (e.g., slope, rate of change, probability, and proportionality.)
LA 1.08	Use active comprehension strategies to derive meaning while reading and to check for understanding after reading.
LA 1.09	Refine study skills and develop methods of research to enhance learning.
LA 1.10	Develop skills to facilitate reading in the content areas.
LA 2.09	Write frequently across all content areas.
LA 2.11	Write in response to literature.
LA 2.13	Locate and analyze information to prepare written words and presentations.

Materials:

1. *Donald in Mathmagic Land* video
2. Computer lab with access to the internet
3. *If You Hopped Like a Frog* by David M. Schwartz
4. Copies of scenarios from *If You Hopped Like a Frog*
5. Poster board and markers

Instructional Considerations:

This lesson's primary focus is to demonstrate the ways in which ratios and proportions are used, when they can and should be used, and how to deal with them. This lesson is a combination of teacher- and student-driven, with much discussion and individual exploration. The teacher will serve to present the historical aspects of the Pythagoreans to the students and to direct students as they work individually and in groups. The lesson will take place as a whole group, with some small group exploration and discussion. The movie and book will cater to the visual/auditory learners. The process of connecting ratios and proportions to history and themselves will cater to the global/analytic thinkers. The teacher should be available, at all times during the lesson, to answer individual questions and to be sure the students remain on task.

The lesson is designed for 28 average students with a wide range of abilities and all learning styles.

ADD and other learning disabilities are accounted for by hard copies of scenarios for each heterogeneous group. Preferential seating would be good for the showing of the movie and in the computer lab.

Teaching/Learning Activities

1. **Introductory Activity/Initiating Procedures:**

   "In the beginning there was the ratio, and the ratio was with God, and the ratio was God" (John 1:1). This does not sound quite right when put like this does it?

The Greek word for ratio is *logos*. It is also the Greek word for *word* (Seife, 2000).

There are some schools of thought that believe that this translation makes much more sense. One of these schools would be that of the Pythagoreans. The teacher will tell students how they believed that 'all was number,' that is, positive integers. Any values that came up that were not positive integers, were considered a comparison, or a ratio between two positive integers. The teacher will then show students the part of *Donald Mathmagic Land* in which Donald Duck encounters the Pythagoreans and learns about ratio. The teacher then will provide more information on the Pythagoreans and ratios.

2. **Connection To/Review of Previous Lesson Objectives:** This lesson is a natural extension of the lesson on connecting math to the real world since it requires students to recognize ways in which ratios have been and are being used in the world.
3. **Procedures:**
   - **A. Information Giving:** The teacher will read aloud the book, *If You Hopped Like a Frog*, encouraging students to react to the proportions that are made in the book as it is read. The teacher will split the class into heterogeneous groups of three or four students. Each group will randomly be given one of the scenarios from *If You Hopped Like a Frog*. The students will then be required to back up the statements from the book with the mathematics behind it. Students will be encouraged to search the internet for information concerning the scenarios they were given. They will once again be directed to follow the WebQuest activity to guide them. The teacher will explain to students the importance of checking the reliability of web sources and of citing pages from which information was extrapolated. Students will use one side of the poster board to illustrate and explain the mathematics behind their scenario and to cite the sources from which the information was found. Students should also feel welcome to decorate their scenarios, as they see fit,

with pictures. Students will then be asked to think of other ways in which ratios could compare one thing to another that might be of particular interest to them on the other side of the poster board. Each team must come up with as many new proportions that they would like to know as there are members on their team.

B. Modeling/Guided Practice: The teacher will demonstrate how to back up a scenario with the proper mathematics. He will look on the internet for the required information concerning the first scenario, "If you hopped like a frog, you could jump from home plate to first base in one mighty leap!" The teacher will ask for guidance from the class as to what he needs to look up on the internet, and then how to set up the resulting proportions. He will then demonstrate how the statement in the book follows directly from the mathematics. The teacher will then read the opening of David Schwartz's book, addressed to the reader, in which he talks about where the idea for some of his proportions came from. The teacher will then present a new proportion to the class (e.g. "I have always wondered what it would be like to run like a cheetah; let's find out.")

C. Formative Assessment: The teacher will walk around the room while the students are working in their groups to be sure that they are finding the correct information and setting up their proportions correctly. He will listen to conversations in passing and gauge understanding by conversation levels and questions that are being asked.

D. Independent Practice: The students will take the idea that they came up with for their proportions and use them to create a situation similar to the ones Schwartz made. They will do all of the research regarding the mathematics to support their scenarios. They will write their situations out in any form that they find most pleasing (poetry, story, song); it does not have to be long. They will illustrate their scenarios. They will also complete and hand in the research and development that went behind supporting their

scenarios, being sure that credit was given to the sources that were used. This works well as an out of class assignment.

E. Culminating Procedure: The last 10 minutes of class should be reserved for each group to get up and 'teach' the rest of the class why their scenario in the David Schwartz book is supported by numbers. Have each group hang the poster of supporting evidence around the room.

F. Enrichment/Extension: Teams who finish early can be challenged to find out more about the golden ratio, where it appears in nature, and how it is used in the world. Why is it important? Why is it golden? What number is it? This would involve more searching on the internet.

4. Evaluation: The teams will be evaluated on defending their situation. This will demonstrate a true understanding of setting up proportions and solving them, not to mention why they are used. Each student will be graded upon their successful completion of creating a new scenario that uses ratios and proportions and then defending it.

5. Integration of Literacy Instruction:

Text: *If You Hopped Like a Frog* by David Schwartz.

Internet pages found by the students.

Strategy Focus of Lesson: Using proportions to compare one situation to another.

Through a shared reading, students begin to ask important questions. By searching on the internet, students find important details and ask questions. Independent research and writing strengthens understanding and builds upon prior knowledge.

Lesson 3

Teacher: Laura Poff Subject/Grade: Mathematics (7-12)

Time: 60 min. (requires field trip) Date:

Lesson Title: *The Librarian Who Measured the Earth*

Goal: Students will use ratios and proportions to find the circumference of the earth and understand how the ancient Greeks liked to think of algebraic problems such as these in their geometric forms.

Specific Instructional Objective(s):

Students will:

1. Extend the idea of ratios and proportions to the geometric realm.
2. Follow Eratosthenes' method for determining the circumference of the earth.
3. Convert the circumference of the earth from stades to miles.
4. Compare Eratosthenes' measurement to the modern estimation.
5. Determine the angle between two points on a circle.
6. Estimate the circumference of a large circle (without using pi and then using pi).
7. Determine whether or not using pi makes the process more efficient or not. Defend this choice.

TN Standards	**Benchmarks**
Geometry: 2.1	Use concepts of length, area, and volume to estimate and solve real-world problems.
Geometry: 2.2	Apply measurement concepts and relationships in algebraic and geometric problem-solving situations.
Geometry: 2.3	Choose appropriate techniques and tools to measure quantities in order to meet specifications for precision, accuracy, and tolerance.
Geometry: 3.1	Recognize, extend, and create geometric, spatial, and numerical patterns.
Geometry: 3.2	Analyze mathematical patterns related to algebra and geometry in real-world problem solving.
Geometry: 3.3	Solve problems in number theory, geometry, probability and statistics, and measurement and estimation using algebraic thinking and symbolism.
Geometry: 5.2	Apply geometric properties of solids, polygons, and circles to solve real-world problems.
Algebra I: 4.2	Analyze precision, accuracy, tolerance, and approximate error in measurement situations.
LA 1.08	Use active comprehension strategies to derive meaning while reading and to check for understanding after reading.
LA 1.09	Refine study skills and develop methods of research to

	enhance learning.
LA 1.10	Develop skills to facilitate reading in the content areas.
LA 2.09	Write frequently across all content areas.
LA 2.13	Locate and analyze information to prepare written words and presentations.

Materials:

1. *The Librarian Who Measured the Earth* by Kathryn Lasky
2. Copies of pp. 30-46 for each group
3. Yarn and tape measure
4. Protractors
5. Access to a (or several large) circle(s)
6. Worksheets to guide students in their quest for the circumference.

Instructional Considerations:

This lesson's primary focus is to relate the algebra to geometry and to the world. This lesson is a combination of teacher- and student-driven with much demonstration by the teacher for methods of discovery, and then student exploration. The teacher will serve to present the historical aspects of the problem of measuring the circumference of the earth and why this was an important accomplishment. The teacher will also provide strict guidance in the students' measurements to make sure they are following a process that leads to an answer to the problem. It is very easy to get sidetracked in a kinesthetic lesson such as this. The lesson will take place as a whole group, with some small group exploration and discussion. The book will cater to the visual/auditory learners. The process of connecting ratios and proportions to a specific geometrical idea will cater to the global/analytic thinkers. The process of physically measuring will appeal to the kinesthetic learners.

The lesson is designed for 28 average students with a wide range of abilities and all learning styles.

ADD and other learning disabilities are accounted for by assigning specific tasks for each student to accomplish and record during the measuring of the great circle. Heterogeneous grouping and close proximity of the teacher will guarantee

understanding and maximum on task time.

Teaching/ Learning Activities

1. **Introductory Activity/Initiating Procedures:** This lesson will culminate in a field trip to Coolidge Park in order to find the area of the big grassy circle in which everyone plays Frisbee and various sports. The teacher will begin by reading or having student volunteers read aloud the book, *The Librarian who Measured the Earth.* This will be an uninterrupted reading, even through the important mathematical concept. The teacher will ask questions about Eratosthenes' method for measuring the circumference of the earth. These questions should lead students to begin thinking about how he accomplished this huge task, such as:
   - How did Eratosthenes measure the earth?
   - What did he do first?
   - What was all of the information that he gathered?
   - How did he put all of the information together?

   Students will be split into groups to fully analyze Eratosthenes' method and to discover the mathematics that went into his calculation. They will be given the copies of the pages that contain pertinent information for their search. They will figure out the ratio that led to Eratosthenes' estimate and the other math that leads to how amazingly accurate Eratosthenes was.
2. **Connection To/Review of Previous Lesson Objectives:** This lesson utilizes ratios and proportions in order to figure out a problem that plagued a mathematician centuries ago, also connecting the lesson to the real world.
3. **Procedures:**
   A. **Information Giving:** The teacher will split the students into teams, as described in the Procedures of Measuring Circumference found after this lesson plan. Each student will be given these procedures so that they know their teams' goal(s) and how the goal fits into the big picture. Students will be going to Coolidge Park in Chattanooga, TN (any place will do that has a big circle within it). Students will understand Eratosthenes' method for

measuring the circumference of the earth. Each team will have a particular talk to do in order to use this method to measure the giant circular field in the middle of Coolidge Park. When the students return to school, all of the information will be compiled in order to figure out the circumference of the desired circle. Students will do this first using Eratosthenes' method, and then using our modern method with the value for pi. This would probably work best in the small groups that were assigned in order to create Eratosthenes' proportion at the beginning of class.

B. Modeling/Guided Practice: The students, in their small groups, will attempt to interpret the mathematics in *The Librarian Who Measured the Earth* using their prior knowledge of ratios and proportions. The teacher has already shown how to set these up. The teacher will give students a procedural outline for their trip to the park in order to ensure that all students know how they are taking an active part in the learning process. When they return, they will already know Eratosthenes' method from the beginning of the lesson and will extend that to finding the circumference of the circle. They will need to take averages of the angle measures and the distance between the two points on the circumference. Averages can be quickly reviewed, and any outliers that may have occurred in the measurements, discussed.

C. Formative Assessment: During the introductory activity, the teacher will walk around the room to monitor group discussion leading to the proportion. She will be available to answer questions, and will ask procedural questions in order to gauge individual student understanding in each group. During the trip to the park, the teacher will monitor each step performed by each team to be sure that they understand how their task is to be performed and will ask them questions about how their specific tasks will further the quest for the circumference as their tasks are being performed.

D. Independent Practice: The students will determine whether or not it is

more efficient using the known value for pi to find the circumference of the circle. They will also determine the method that they think is more accurate. They will write a statement defending their decisions, and venture to provide reasons for why Eratosthenes was not able to use our modern method of finding the circumference of the earth (i.e., he could not measure the diameter of the earth).

E. Culminating Procedure: Each team will post their determined values for the circumference of the circle using both methods along with the proportion and any work that they used along the way to get to the answer. Students can illustrate diagrams or get as creative as they like in defending their mathematics.

F. Enrichment/Extension: Students can sign onto the internet and perform searches to attempt and find out when and why pi became a value helpful for determining various aspects of circles. What else did mathematicians of the past do in order to get around not having a value for pi.

4. Evaluation: Students will be graded according to their participation during the trip to Coolidge Park. Students will also be graded on their individual statements defending Eratosthenes' method or pi. This will give the teacher insight as to if students are really making a distinction between the two, and further, if the students understand that pi was not always a value for use in geometrical problems involving circles.

5. Integration of Literacy Instruction:

Text: *The Librarian who Measured the Earth* by Kathryn Lasky

Strategy Focus of Lesson: Connecting algebra to geometry throughout history, using proportions instead of pi for solving circle problems.

Through a shared reading, students begin to ask important questions and build upon prior knowledge. Independent writing strengthens understanding and

gives students ownership over the learning process.

Procedures for Measuring Circumference

Team 1: (4 students)

Materials: One ball of yarn.
Goal: Find the line that represents the diameter of the circle.

1. All four people start at one point on the outer rim of the circle.
2. Two will stay that one place holding the end of the yarn.
3. The other two will begin walking around the circumference of the circle. They will let the yarn out as they walk, being sure that it is kept taught.
4. When they take a couple of steps and notice that the yarn is not needing to be let out and beginning to become untaught, they will have found the longest distance around the circle between them and their partners. This is the diameter.

Team 2: (4 students)

Materials: One ball of yarn.
Goal: Find another line that represents the diameter of the circle so that the intersection of the two lines is the center of the circle.

Starting from a different point on the circle from Team 1's start or finish, Team 2 will follow all of the directions for Team 1.

Team 3: (2 students)

Materials: A marker, a weight (rocks, paper weights, anything semi-heavy), and yardstick
Goal: To mark and keep the center of the circle.

1. After Team 1 and Team 2 are in place, the yarn will be lowered to the ground.
2. The intersection of the two pieces of yarn will be tied together and a weight will be added in order to keep the yarn from blowing away.
3. A marker will also be placed on the ground to represent the center of the circle in case the yarn is moved.
4. After the rest of the measurements have been made, they will determine the length of the diameter of the circle. They will measure both lengths of yarn and report their findings to Team 4.

Teams 4: (2 students)

Materials: Paper and pencil.
Goal: To record every measurement that is made and from what team.

1. They will record the information as accurately as it is given to them.
2. When we return to school, they will transfer all of the information to chart paper in order to be used by the class for finding the circumference.
3. They will be the ones who watch for, and try to account for, outliers or possible mistakes in any of the measurements as they are taken.
4. They may ask a team to retake a measurement if they do not think it is reasonable.

Teams 5,6,7,8: (2 students each)

Materials: Protractor.
Goal: To measure the acute angle of intersection between the two pieces of yarn, hence measuring the angle between two of the teams that are on the circumference of the circle.

1. Taking turns, each team will carefully use the compass to measure the acute angle of intersection, independently of the other teams.
2. Report measurement to Team 4, out of hearing range of the other teams. (This is important in order to get the most precise reading we can.)

Teams 9,10,11,12: (2 students each)

Materials: Yarn and yard stick or cloth measuring tape and scissors.
Goal: To determine the distance between the two teams that are on the circumference of the circle between whom the acute angle of intersection was found.

1. The teams will take turns determining this distance independently of the other teams. (Again, this is very important for precise calculations.)
2. Both students in each team will begin at one of the teams on the circumference.
3. One student will hold the yarn (or measuring tape) to the ground.
4. The other student will carefully lay the yarn along the circumference of the circle as she/he makes his/her way toward the other team along the circumference.
5. The students will cut off the yarn and measure it against a yard stick. (Or take the distance of the measuring tape.)
6. They will report this distance to Team 4, out of hearing range of the other teams.

Lesson 4

Teacher: Laura Poff | Subject/Grade: Mathematics (7-12)
Time: 60 min. | Date:

Lesson Title: *Sir Cumference and the Dragon of Pi*

Goal: The students will derive pi using the circumference and the radius of circles. They will understand how the derivation of pi helped the mathematical world.

Specific Instructional Objective(s):

Students will:

1. Measure the circumference and radius of various circles.
2. Derive pi using their measurements.
3. Use all of the measurements in the class in order to come up with a class average for the value of pi.
4. Speculate as to why pi was an important development in mathematics.

TN Standards	Benchmarks
MA 8.4.1 (b)	Understand relationships among units and convert from one unit to another within the same system.
Geometry: 2.1	Use concepts of length, area, and volume to estimate and solve real-world problems.
Geometry: 2.2	Apply measurement concepts and relationships in algebraic and geometric problem-solving situations.
Geometry: 2.3	Choose appropriate techniques and tools to measure quantities in order to meet specifications for precision, accuracy, and tolerance.
Geometry: 3.1	Recognize, extend, and create geometric, spatial, and numerical patterns.
Geometry: 3.2	Analyze mathematical patterns related to algebra and geometry in real-world problem solving.
Geometry: 5.2	Apply geometric properties of solids, polygons, and circles to solve real-world problems.
Algebra I: 4.2	Analyze precision, accuracy, tolerance, and approximate error in measurement situations.
LA 1.08	Use active comprehension strategies to derive meaning while reading and to check for understanding after reading.
LA 1.09	Refine study skills and develop methods of research to enhance learning.
LA 1.10	Develop skills to facilitate reading in the content areas.

LA 2.09	Write frequently across all content areas.
LA 2.13	Locate and analyze information to prepare written words and presentations.

Materials:

1. *Sir Cumference and the Dragon of Pi: A Math Adventure* by Cindy Neuschwander
2. Different circular objects
3. Measuring tape
4. Computer lab with access to the internet

Instructional Considerations:

This lesson's primary focus is to derive pi and to understand why this was an important value to find. This lesson is a combination of teacher- and student-driven with much discussion and individual exploration. The teacher will serve to direct student discussion. The lesson will take place as a whole group with some small group exploration and discussion. The book will cater to the visual/auditory learners. The process of measuring the circles and relating circumference to radius will appeal to kinesthetic learners. Learning how pi has helped the entirety of mathematical learning will appeal to global/analytic thinkers. The teacher should be available at all times during the lesson to answer individual questions and to be sure the students remain on task.

The lesson is designed for 28 average students with a wide range of abilities and all learning styles.

ADD and other learning disabilities are accounted for by heterogeneous grouping and many different activities to cater to different types of learners. Preferential seating would be good for the computer lab.

Teaching/ Learning Activities

1. **Introductory Activity/Initiating Procedures:** The teacher will have students begin the class by discussing what they decided as to the efficiency of using pi to get the area of a circle instead of using Eratosthenes' method.

The teacher will read or let student volunteers read the book, *Sir Cumference and the Dragon of Pi.* The teacher will use the book as a springboard to begin discussing pi.

- How accurately does the book depict how pi was derived? What do they think is wrong with the book's portrayal?
- Where does pi come from?
- Why do you think this was an important discovery?
- When was pi assigned a numerical value?

2. **Connection To/Review of Previous Lesson Objectives:** This lesson connects to the previous lessons in that it examines another aspect of measuring circles. It allows students to compare and contrast the two methods. It uses the ratio of circumference to diameter.
3. **Procedures:**
   - **A. Information Giving:** The teacher will split students into groups of three or four. Each group will be given measuring tape. The teams will work cooperatively to walk around the room and/or hallway and find circular objects to measure. They will have a minimum of five objects to measure. Ideally, each student should have a chance to measure at least one object. They will measure the circumference and diameter of each object of their choosing. They will record their findings. The teacher will then prompt students, urging them to recall how Radius found pi using his measurements for circumference and diameter. He will also ask them to recall the equation for the circumference of a circle.

     C = 2(p**)r**

     Students will be reminded that the diameter is twice the radius, so the equation then becomes

     C = p **(d).**

     Solving this equation for p yields

     p **= C/d.**

The students will then use this equation, that coincides with Radius' method in the book, in order to find the value of pi for each of their five items. Each team will take turns recording their values on chart paper. They will then come up with a class average for the value of pi.

B. Modeling/Guided Practice: The teacher will select a circular item randomly from the room. She will take the tape measure and measure the circumference to the nearest tenth of a centimeter. Find the length of the diameter, as well. The teacher, after deriving the equation with the help of her students, will write pi as the ratio of the circumference to the diameter. When the students are finding the averages between all of the values of pi, the teacher will remind students how to find an average and why taking an average will give the students a more accurate representation of pi.

C. Formative Assessment: The teacher will gauge student understanding during the discussion that will take place. The teacher will walk around during the measuring of the objects to be sure students are on task, are working together, are taking the right measurements, etc. When students return and begin recording their values for pi, the teacher will know whether they have understood the derivation and put it into practice.

D. Independent Practice: The students will then be prompted to go to the computer lab to find out more about pi. They will use the WebQuest provided for pi in order to discover certain aspects of this number that were not covered during class. There will be an emphasis given to how pi was progressive as far as relating math to the real world is concerned. A sheet to guide their exploration will be helpful in keeping students from becoming overwhelmed by information and more likely to be distracted. Students will also be prompted to write down any other questions they have about pi that were not answered on the WebQuest; a minimum of one question will be required of every student. They will be allowed to perform their own internet searches for the answers to these questions. If they find the answers, they will

also write down the Web address that provided the answer to their question.

E. Culminating Procedure: The teacher will present the class average for the value of pi. Any outliers will be accounted for. The teacher will also present the actual value for pi. How close was the class average? The teacher will show students how to find the accuracy of their estimation for pi:

$$\frac{\text{(actual value - estimated value)}}{\text{actual value}} \times 100\% = \text{percent error.}$$

Each team will then find their own personal team average for the value of pi. They will use this average and the given equation to determine the level of accuracy of their estimation for pi. The team with the closest approximation will be rewarded with something of the teacher's choice (points on a test, stickers, etc.) This contest can be announced before the assignment begins or come as a surprise at the end.

F. Enrichment/Extension: The students will be using this information along with the information from the other lessons in this mini-unit in order to create a product that demonstrates how math is connected to the real world: past, present, and future. These products will be a compilation of what has been done in class concerning the past, what students have searched on the internet concerning the present, and then speculation on what may be to come. This particular lesson will allow students to connect pi to the real world. The WebQuest will provide them with ways in which it was done in the past; possible questions they might pose could have to do with present or future uses of pi.

4. Evaluation: Each team will be evaluated on the completeness of measuring five items and determining pi for each, as well as finding the accuracy of their estimations. Each student will be responsible for finding the important information in the WebQuest to use in their final projects. Students will be evaluated on the completion of their worksheet showing that they have found

information on the internet about pi. Each student will also be required to turn in a question that was unanswered about pi during the class and WebQuest, as well as some attempt at finding the answer via an internet search such as Google (http://www.google.com).

5. **Integration of Literacy Instruction:**

Text: *Sir Cumference and the Dragon of Pi: A Math Adventure* by Cindy Neuschwander.

Internet pages through a Web Quest and as found by students

Strategy Focus of Lesson: The derivation of a numerical value for what is known as pi, as well as why and how it is used in the world around us.

Through a shared reading, students access prior knowledge and ask important questions. Through independent research on the internet, students ask important questions and search for main ideas and important details.

Relationships: Sir Cumference and his son

Directions: Fill out this chart as you measure. Be sure to include units.

Circles Measurement Data

# #	Diameter	Circumferenc e	p
1			
2			
3			
4			
5			
6			
7			
8			
9			

It's all about Pi

1. How many digits of pi have been found?

2. When is national pi day? Why?

3. Where did the name for this number come from?

4. What is the rational number that is often used for pi?

5. Find a quote about this number/symbol.

6. What is the first recorded estimation for pi? By whom?

7. When was the notation of pi introduced? By whom?

8. What is a formula for finding pi, besides $C = p\ (d)$?

9. How did Archimedes estimate pi? What was his estimation?

10. What is pi?

Lesson 5

Teacher: Laura Poff | Subject/Grade: Mathematics (7-12)
Time: 60 min. | Date:

Lesson Title: *The Missing Piece*

Goal: Students will understand angle measures in degrees and radians and how angles are related to one another.

Specific Instructional Objective(s):

Students will:

1. Convert angle measures between degrees and radians.
2. Understand what supplementary and complementary angles are.
3. Create a physical representation of an angle measure.
4. Produce circles (360°) by adding angle measures together.
5. Write a creative piece using the acquired vocabulary.

TN Standards	**Benchmarks**
MA 8.3.1 (b)	understand relationships among the angles (e.g., complementary, supplementary…)
Geometry: 2.2	Apply measurement concepts and relationships in algebraic and geometric problem-solving situations.
Geometry: 2.3	Choose appropriate techniques and tools to measure quantities in order to meet specifications for precision, accuracy, and tolerance.
Geometry: 5.2	Apply geometric properties of solids, polygons, and circles to solve real-world problems.
Trigonometry: 1.1	Use degrees and radians interchangeably to represent angle measure in problems and explain the advantages/ disadvantages of a particular choice.
LA 1.01	Continue to develop oral language and listening skills.
LA 1.05	Read to develop fluency, expression, accuracy, and confidence.
LA 1.08	Use active comprehension strategies to derive meaning while reading and to check for understanding after reading.
LA 1.10	Develop skills to facilitate reading in the content areas.
LA 2.09	Write frequently across all content areas.
LA 2.11	Write in response to literature.
LA 2.13	Locate and analyze information to prepare written words and presentations.

Materials:

1. *The Missing Piece* by Shel Silverstein
2. Index cards with different angle measures written on them, in degrees and radians, where angles match up to 360° in sets of 2 or 3
3. Paper plates
4. Compasses
5. Scissors

Instructional Considerations:

This lesson's primary focus is to understand angle measurements, how they relate to one another, and what they are used for. This lesson is a combination of teacher- and student-driven, with discussion and exploration. The teacher will serve to explain angle measures and demonstrate conversions. The lesson will take place as a whole group and then small group exploration and discussion. The book and the teacher's instruction will cater to the visual/auditory learners. The process of creating physical representations of angle measures will appeal to kinesthetic learners. Finding how angles are used in the world around them will cater to the global/analytic learners. The teacher should be available at all times during the lesson to answer individual questions and to be sure the students remain on task.

The lesson is designed for 28 average students with a wide range of abilities and all learning styles.

ADD and other learning disabilities are accounted for by many different activities to cater to different types of learners. Preferential seating is good for the whole class portion of the lesson.

Teaching/ Learning Activities

1. **Introductory Activity/Initiating Procedures:** The teacher will read or have student volunteers read aloud the book, *The Missing Piece* by Shel Silverstein. The teacher will ask the students what mathematical properties they can see in

this book. Hopefully, this discussion will lead to a conversation about circles. The students will talk about how many degrees are in a circle. They will talk about other important degree measures, specifically 90° and 180°. The teacher will describe complementary and supplementary angles and ask the students for pairs of examples for both types of angles, as well as angles that add up to a full circle. The teacher will keep a running list of each pair that is listed.

2. **Connection To/Review of Previous Lesson Objectives:** This lesson connects to the previous lessons in that it provides more information on the properties of circles. It uses ratios to convert to and from radians and degrees.
3. **Procedures:**
   A. **Information Giving:** The teacher will randomly let each student select an index card with an angle measure on it. She will tell the students that some of them have angles that are in radians and the others have angles that are in degrees. They will have to know their angles in both radians and degrees, so they will have to convert the given angles either way using the correct ratio. The students will then have to use a paper plate and a compass to create a physical representation of whatever angle they have and write their measurements on the representation. The students will then have to find other students in the class that are their complementary or supplementary angles. The students will record the name and angle measure (in degrees and radians) of their complementary and/or supplementary angles. If they have no complements or supplements, they will have to be able to explain why (e.g., they are greater than or equal to 90° and/or greater than or equal to 180°, respectively). The students will then find the angles that make them a full circle; these may be either with two or three students. They will tape their parts together to make a full circle and put it on the wall.
   B. **Modeling/Guided Practice:** The teacher will, with suggestions from the students, derive the conversion factors for changing between degrees and radians:

$1 = \frac{\pi \text{ radians}}{180^\circ}$ and $1 = \frac{180^\circ}{\pi \text{ radians}}$

The teacher will also demonstrate how to measure angles with a compass and explain how to know if the angle looks to be about right (comparing obtuse and acute angles, as well as ones that are greater than a straight line). The teacher will convert some angles from degrees to radians and vice versa as examples for the students to follow. The teacher will walk around and make sure that students are measuring correctly in the making of their plates and direct that construction on an individual basis.

C. **Formative Assessment:** The teacher will gauge student responses when they are suggesting pairs of complementary and supplementary angles to know where students stand on these two topics. The teacher will understand whether the students are understanding the assignment by understanding how to convert the angle measures. This will be apparent as the plates are being made and labeled. The teacher will gauge student progress and questions as they are trying to accomplish the goal to see if more explanation or intervention is needed.

D. **Independent Practice:** Students work independently to convert their angles into the different modes of measurement. They also work independently to compare their measurements to other students' measurements to find their supplements/complements/circle completers. Students can be given more angle measures in degrees and radians and instructed to convert them to their counterparts, as well as list any complementary and/or supplementary angles for home work. Students will also be asked to write a one- to two-page story/poem/vignette, fiction or nonfiction/etc., using the following words, independently on their own time:

complementary or supplementary,

obtuse,

acute,

angle, and
circle.

E. Culminating Procedure: The students will put their plates together and post them around the room. The students each individually share what their angle measurement was in degrees and radians. They will say whether they are acute or obtuse. They will give any complementary and/or supplementary angles that they have. They will also list any other properties of their angles that are important, or the teacher will take this opportunity to report any more important properties of angles. These will be recorded and posted in the room, as well.

F. Enrichment/Extension: Students can use extra time and this lesson to further their major projects. They can discover why radians are used in most measurements and calculations. They can discover more of the important geometric results that come from using complementary and supplementary angles, or just angle measures, in general. They can use past results, how they are used now, or how they could be used in the future, in their final compilation.

4. Evaluation: Each student will be evaluated on correctly converting between radians and degrees and finding their complements/supplements or correctly identifying why they don't have any. They will also be evaluated on the completion of their team's circle. Each student will also be evaluated on the completion and accuracy of their extra problems for practice and on the completion of a creative writing using the given vocabulary. A rubric is available for their final projects tying this unit together, as well.

5. **Integration of Literacy Instruction:**

Text: *The Missing Piece* by Shel Silverstein.

Strategy Focus of Lesson: Converting angle measures between degrees and radians as well as relating certain angle measures to each other.

Through a shared reading, students access prior knowledge and ask important questions. Through an independent writing students reinforce the skills and gain ownership over their learning, as well as make connections between mathematical language and the world around them.

ACute Worksheet

Directions: Convert each degree angle to radians or degrees. Provide the complementary and supplementary angles when able to do so. Explain why there is no complement or supplement, if applicable. Provide exact answers when possible. Round to nearest thousandth if the answer is not exact.

1. 30°

2. $\frac{3\pi}{2}$ radians

3. 135°

4. .514 radians

5. 305°

6. $\frac{3}{5}$ radians

7. 12°

8. 5π

Bonus: What is one reason why this worksheet could be considered misnamed?

Major Project Description

Students will be split into heterogeneous groups of four. Each group will consider all of the ways in which we, as a class, have discussed mathematics being integrated into the real world, past, present, and future. The students are to take the stories they have written and research they have done in order to make a group picture book of short stories and other creative ramblings on how mathematics relates to the real world. These ramblings are to be fully illustrated and must demonstrate the specific mathematical concepts that are contained within the writing.

Students have made significant progress on these compilations because the lessons have research time built in to them. Students will still have to do much individual research and come up with more stories/poems/vignettes using any mathematical properties that have been studied during the course of the unit. Exceptions can be made if there is particular interest in another subject that has been covered in the course of the year.

Each student is to contribute five of these creative ramblings in order to compile a picture story book that is no less than 20 pages long. Students can use the ones that they have already created as independent practice in some of the lessons, if they want to, but they do not have to do so. Each picture book is to be turned in with an informational pamphlet also compiled by the students. The pamphlet should contain information regarding each mathematical concept that is covered in the picture book and be organized in the same order. The name of the story being discussed should be at the top of the page. The mathematical concept contained

within should be outlined and discussed. How this mathematical concept connects to the world should also be discussed. Students should attempt to provide connections between each mathematical concept in the past, present, and future. The pamphlet also needs to contain a bibliography for all of the information contained within.

Major Project Rubric

Picture Book:

Writing 1	20 points	_____
Writing 2	20 points	_____
Writing 3	20 points	_____
Writing 4	20 points	_____
Writing 5	20 points	_____

Informational Pamphlet on and supporting:

Writing 1	20 points	_____
Writing 2	20 points	_____
Writing 3	20 points	_____
Writing 4	20 points	_____
Writing 5	20 points	_____
Final Grade	**200 points**	_____

Writings from the Picture Book will be graded as follows:

0 No participation.
5 Work is unsatisfactory, story is incoherent and/or does not use mathematical topic, no analytic thinking.
10 Work is adequate, but the mathematical concept is not clearly tied into the writing.
15 Work is good, contains mathematical concept and connection, but lacks structure, uses incorrect grammar, is not illustrated, etc.
20 Work is coherent, connection between math and writing is clear, writing is structured, very few grammatical errors.

Informational Pamphlet of supporting evidence will be graded as follows:

0 No participation.
5 Work is unsatisfactory, lack of evidence supporting connection, no analytic thought.
10 Work is adequate, but relationship between math and the real world is still unclear.
15 Work is good, but lacks structure and organization or proper references to support the evidence.
20 Work is coherent, effective relationship is established, argued effectively, is well structured, and properly cited.