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How Come? What If? So What?

Reading in the Mathematics Classroom

WHEN YOU THINK ABOUT STUDENTS reading in the mathematics classroom, what immediately comes to mind? What text sources do students generally read in a mathematics classroom? Are you picturing students reading a textbook or a workbook? Do you see students reading problems and checking their answers? In many classrooms across the United States, this textbook work is exactly what reading in the mathematics classroom entails (Alvermann and Moore 1991; Bean 2000; Hiebert et al. 2003), particularly since the textbook has a profound influence on both what is taught and what is learned (Koehler and Grouws 1992). Is this an accurate portrayal of

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reading mathematics outside the walls of school? When was the last time, as an adult, that you pulled out an algebra textbook for a daily dose of mathematics problem solving?

In all likelihood, your current mathematics problem solving occurs as you read articles in *Consumer Reports* or *Discover* magazine. This type of reading often answers our How come? or Why? questions as we learn about behind-the-scenes mathematics in our daily lives. Take, for instance, the article *Winning the War on Spam* (Johnson 2004), which presents the underlying mathematical principles of spam and possibilities for eliminating it. A mathematics formula was derived to send unwanted e-mails to large numbers of users. Therefore, eliminating spam can also be based on mathematics. A filter that appears to show promise is based on the work of Bayes, an obscure mathematician from the eighteenth century; the filter uses a theorem for making predictions based on two or more independent events.

Maybe you prefer to explore the possibilities of mathematics, or the What if? questions, as you read bestsellers like *The Da Vinci Code* (Brown 2003). The mathematical anomaly embedded within this mystery is called the golden mean, which is found throughout nature. The golden mean is a relationship among three different dimensions that form a proportion. The ratio itself is actually a unique number called phi. This type of reading for pleasure merges our understanding of mathematics concepts with fictional adventures and forces us to re-examine taken-for-granted rules. It often provides a context for discussions to occur about mathematical ideas. For example, not only have readers across America been interested in the mathematics properties based on *The Da Vinci Code*, but mathematicians have been analyzing and refuting the accuracy and precision that Brown used within this work of fiction.

On the other hand, perhaps you ponder percents and probability as you read your weekend newspaper's advertisements and sports predictions. Statistical reasoning is one of the most practical and relevant of all quantitative skills. There is a critical need to be able to interpret, conduct, and assess statistical studies and understand bias, sampling, and notions of discrete probability. This type of mathematical reading focuses on the So what? questions. In other words, why are these mathematics concepts integral to our everyday lives? What do numbers have to do with sociopolitical issues? Answering these questions can help us become more discerning consumers.

These examples showcase the integral, yet commonplace, nature of reading mathematics (e.g., in magazines, newspapers, fiction) in our daily adult lives. Since our students are on their way to becoming productive adult members of society, it makes sense that we infuse these naturally existing text sources into mathematics instruction, thus facilitating student engagement with mathematics on new levels. Primarily, we want students to be able to ask and answer How come? What if? and So what? questions by exploring (1) informational trade books, (2) literature, and (3) environmental print. The following sections outline related texts and illustrate examples and resources for middle-grades teachers.

How Come? Informational Trade Books

MOST OF THE READING WE DO AS STUDENTS, teachers, and adults is nonfiction, or informational, rather than fiction or stories (Harvey 1998). In fact, adolescent boys tend to favor nonfiction over fiction. This interest only increases as they become adults (Sullivan 2003). Nonfiction texts come in all shapes and sizes, cover myriad topics, and differ in many ways from a traditional textbook. Textbooks often contain numerous concepts that are unfamiliar to students, uncommon and shifting text structures, and few connections to students' prior knowledge or everyday life (Harvey 1998). In contrast, informational trade books that are available at local bookstores or through online book warehouses present accurate knowledge about a given topic, provide compelling details, illustrate concepts with attractive designs, offer fascinating comparisons, link content to students' lives and experiences, and engage students in learning about a particular topic (Tunnell and Jacobs 2000). In addition, these informational trade books come in a variety of formats and can include activities, interviews, pictures, or reference information (Harvey 1998; Harvey and Goudvis 2000; Tunnell and Jacobs 2000). The use of informational trade books in mathematics classrooms provides a much-needed addition to academic textbooks. Students can ask and explore How come? or Why? questions such as these: How come dome structures can stand without support columns? How do you actually calculate a batting average? How come the florets in the head of the sunflower are organized into two intersecting families of spirals?

There are numerous informational trade books for middle-grades teachers to choose from. For example, *Fantastic Feats and Failures* (Wyatt 2004) is an engaging book of modern engineering that highlights incredible feats (e.g., the Georgia Dome, Eiffel Tower, Brooklyn Bridge) and failures (e.g., the Leaning Tower of Pisa, Tacoma Narrows Bridge, South Fork Dam). The descriptions are loaded with facts, figures, and geometry that entertain, dazzle, and startle readers. A mathematical knowledge of measurement is critical for understanding each feat and

failure. The reader learns, for example, that the CNN tower measures 553.33 meters, the Georgia Dome uses 35,000 m^2 of fabric, and the metal girders of the Eiffel Tower are 260 feet tall. The descriptions also provide details about costs; sometimes American dollars are discussed, and sometimes foreign currency is involved. Activities are posed throughout the text to give readers a chance to explore the engineering concepts of geometry and measurement. For example, after the Georgia Dome is discussed, readers learn how to construct a gumdrop dome using triangular shapes. After reading about the Brooklyn Bridge, readers are challenged to create a beam, arch, truss, cantilever, or suspension bridge. Each section is relatively short but loaded with engaging text; it can be used to transition from a class period or a group activity or it can simply be added to a class library. Augusta Livingston, a sixth-grade mathematics teacher, keeps *Fantastic Feats* in her classroom library. She uses the book to talk with students about the importance of mathematics in their everyday lives (e.g., engineering) and notes that many of the boys in her classroom check out the book for independent reading. She says, "I think the boys like reading nonfiction, and that book has pictures in it that pique their interest and get them to read it."

Math Stuff by Theoni Pappas (2002) is an informational trade book devoted to the wonder and power of mathematics in our daily lives. In this book, Pappas answers questions dealing with mathematics in our world. She tackles topics such as the millennium clock, fractals, the fourth dimension, and nanotechnology. For instance, Pappas explains chaos theory and how mathematicians are looking for patterns within the chaos to help them make predictions. Their work has identified possibilities for determining "at what point order can revert to chaos" (p. 14). Detailing this concept, Pappas walks readers through iterative equations and a constant ratio. Some of the more light-hearted sections amuse and delight. In one example, Pappas writes, "Who would have thought that the weather's temperature and a cricket's chirps are related? Just consider either of the equations: $t = (c/4) + 40$ or turned around $c = 4t - 160$" (p. 26). Apparently, during cold weather (40°F or below), you cannot hear the cricket's chirp. In contrast, when the temperature rises, the chirps of the crickets become louder and faster. In another section of the book, Pappas discusses mathematics and architecture, which provides a great link between *Math Stuff* and *Fantastic Feats and Failures.* Each section, while engaging, is relatively short. Thus, this text is a flexible resource that can be used in a classroom with relevant topics, providing an interesting source that can be read aloud or added to a library. The section on crickets is only one page. When read aloud, students can actually think through the given equation.

Informational trade books provide a much-needed addition to academic textbooks

Math Stuff is not the only informational trade book that explores the natural link between mathematics and the everyday world. *Why Do Buses Come in Threes?* (Eastaway and Wyndham 1998) explores the mathematics in our everyday lives, such as survey reliability, coincidences, sports rankings, bad luck, and more. One interesting chapter, "Why Do Clever People Get Things Wrong?" discusses the fact that percent and speed should not be added and averaged when calculating data. One example illustrates what happened when two researchers with successful results from testing a particular medication combined those results: "Even though Problezene [the name of the medicine] was more successful than placebo in both of the tests, when the tests are combined, the placebo patients turn out to be more successful than the Problezene" (p. 33). This example is further illustrated with a chart showing data from each researcher and their combined results. With these visual additions, the reader can easily see and understand the data being discussed. Each chapter in this book contains a variety of examples and explanations of the general topic, which gives educators the freedom to pick and choose examples that they feel best meet their needs for a particular topic of study. Discussion in the mathematics classroom should include an examination of the sample sizes, data collected, and analysis methods.

Another informational trade book that explains the natural link between nature and mathematics is *Nature's Numbers* (Stewart 1995). Stewart has artfully created an accurate and informative portrayal of mathematics without using equations. The mathematics concepts that underlie our world are explored from the history of numbers to explanations of chaos theory and complexity theory. For example, Stewart discusses flower petals that follow the sequence 3, 5, 8, 13, and 21, which is the Fibonacci number sequence. The text shows examples of the preponderance of Fibonacci numbers in nature and illustrates how mathematical mechanisms must be present in genetic instructions within the dynamics of plant growth, an interesting and peculiar phenomena. Such a trade book could only enhance the study of corresponding mathematics concepts. One middle-grades student responded that he had never heard of the Fibonacci sequence, but after reading one section of this book about plant life, he wanted to know more about the mathematics. "I want to know other things in nature that follow this pattern. After looking at this book, there seem to be many examples and the mathematics seems hard!"

Learning about numbers, facts, and figures and the way in which mathematics plays an integral part in our world is only part of the importance of informational trade books. Our students need to be empowered to think critically about the use of numbers in society, to think deeply about the reasonableness of statistics, and to question misleading information. In *Numbers* (Boyle and Roddick 2004), the authors have gathered some of the strangest numbers they could find and grouped the information into large sections, each section introducing the numbers by giving a short description of the data to follow. The section on health statistics contains information about the "number of antibiotic prescriptions prescribed for viruses written by U.S. doctors every year: four million" (p. 23), although the authors point out that antibiotics have no effect on viruses. This and many other numbers in the book are provided in the hope that readers will pay attention to the reasonableness of numbers in everyday life. This book can elicit rich discussion throughout the year. The highlighted number sections are short and can be used as a warm-up exercise or to close a regular classroom period. When talking about ratio and proportion, for example, the authors discuss the Barbie doll: "If Barbie were human, she'd be 7 feet tall, with a neck twice as long as normal and the measurements 39–23–33" (p. 53). Statistics such as the "speed at which a sneeze travels out of a nose: about 100 mph" (p. 33) are intriguing and entertaining, but this book should not be placed in the class library since some topics are inappropriate when discussed without adult guidance.

Informational trade books that deal with topics related to mathematics are not difficult to find. Such texts are readily available at local bookstores and online book warehouses. Authors write informational trade books for general public use, not for a school curriculum, so they provide a particular perspective and message for a wide range of readers. Therefore, they help bridge thinking about mathematics content in the classroom with the everyday world of mathematics understanding. These texts help students to think about and answer a variety of How come? questions ranging from measurement and geometry to the latest and greatest technological advances to the reasonableness of reported statistics.

What If? Literature with Mathematical Themes

LITERATURE WITH MATHEMATICAL THEMES CAN provide a familiar context and can link naturally to everyday experiences, spark excitement, provide a context for learning, introduce vocabulary and other abstract concepts, and show how mathematics can cross curricula (Miller 1998; Murphy 1999; Whitin, Mills, and O'Keefe 1990; Whitin and Wilde 1992). Literature is not designed to be a textbook or to be read to learn information. Reading authentic literature necessitates students being able to visualize scenes and characters, make connections to their own life and the lives of others, put themselves in the character's shoes, pass judgment, and hypothesize (Cox and Many 1992). In other words, these works cause them to read aesthetically (Rosenblatt 1978) and explore mathematical possibility or the What if? questions. When students read aesthetically in a variety of content areas, they "acquire not so much additional *information* as additional *experience*. New understanding is conveyed to [us] dynamically and personally. Literature provides a *living through*, not simply *knowledge about*" (Rosenblatt 1978, p. 38).

Since mathematics is a natural part of life, there *is* literature that contains natural links to mathematics concepts. Many well-known titles serve as engaging mathematics books. That is, the characters in the story must solve problems that are openly presented to them throughout the text, such as found in *Jayden's Rescue* (Tumanov 2002), *A Gebra Named Al* (Isdell 1993), and *The Number Devil: A Mathematical Adventure* (Enzensberger 1997). In *Jayden's Rescue*, the main characters must save a princess being held captive in a labyrinth. At each doorway in the labyrinth, the characters are given a riddle that contains a mathematics problem usually covering topics such as whole numbers and measurement. As the characters work through the problems, the reader learns about their problem-solving process as well as the correct answer. Middle-grades mathematics teacher candidate, David Heiser, says *Jayden's Rescue* will be in his classroom library: "*Jayden's Rescue* by author Vladimir Tumanov is a wonderful classroom resource for those special students who love the fantasy genre and would benefit from being validated by using their thinking skills to save the good Queen from the evil King Sorcerer. The reader is challenged in fantasy jargon to solve a string of urgent mathematical obstacles that only they have the key for. What a gift to the reader—validation and enhanced problem-solving skills."

Other stories explain mathematics concepts as they are relevant to the story line rather than just presenting a problem. In this way, the mathematics concept is integral to the story development. Such is the case in *The Toothpaste Millionaire* (Merrill 1972), *The Math Wiz* (Duffey 1990), and *A Grain of Rice* (Pittman 1986). For example, the main characters in *The Toothpaste Millionaire* decide to attempt to create their own toothpaste for a fraction of the price of the national brands. Once they figure out that it is possible, they wonder how much money they could

make if their profit from the sale of the toothpaste was only one cent. Their business venture becomes increasingly complex as the characters begin advertising and the size of their operation increases. Mary Cherry created a class project that mirrors the product creation and distribution in *The Toothpaste Millionaire*. Students are required to address the concerns and issues that the main characters face in the book, such as choosing an item to make and sell and calculating the cost of materials, packaging, and labor (their time), then use these factors to create wholesale and retail prices. A worksheet for this project is included at the end of this article.

Mathematics can also be important in science fiction. In "The Cold Equations" (Godwin 1970), a young woman is a stowaway on a spaceship. The pilot thinks she is too heavy for the spaceship to make it to its destination in space to provide ill men with a serum that will save their lives. The plot uses laws from mathematics and physics to determine whether or not she will be able to live. This story can supplement a discussion on number sentences and the construction of formulas within different contexts. The formula, albeit simplistic, helps the reader understand that the pilot must either let the stowaway die or allow the troop of men to die who are desperate for the serum.

The most sophisticated stories imply mathematics content that is critical to the appreciation of the story; sometimes it is not obvious or detailed. That is, the stories do not always openly discuss the mathematics or use mathematics terms, but the reader must have an understanding of these concepts to fully appreciate the story. For example, "Different Kinds of Darkness" (Langford 2003) is a science fiction story where mathematics is being used as a weapon in a new form of terrorism. Through the action and description, the reader will only understand that the weapon is a complex fractal if the reader knows and understands the concept of the fractal. The term *fractal* is never used or defined within the story. A group of students find this visual weapon and try to withstand its effects. When a group of teacher candidates read "Different Kinds of Darkness," they were compelled to learn more about fractals.

"The Mirror" (Bradbury 1997) tells the tale of twins living in perfect symmetry and harmony. They did not live like two people but as a mirror image of the other until the mirror broke. This is a nice example of reading aesthetically in mathematics, with the underlying mathematics ideas of patterns and symmetry woven within the text. One fifth grader started to wonder about the concept of refraction when discussing this story: "Is it when the one sister decided to look different than the other sister? But at the end, did they look alike again? Why did she say, 'I'm Julia; who are you?' Did her sister look so different that she did not recognize her?" As he talked about the story, a deeper meaning of both the story and concepts were gleaned.

These stories require students to read aesthetically and think through the possibilities of mathematics, or the What if? questions where the mathematics is subsumed in the understanding of the story. The world of young adult literature continues to use mathematics as a way of telling a compelling story. In *Lunch Money* (Clements 2005), two students compete to make money creating business ventures at their schools, similar to *The Toothpaste Millionaire*. In *Midnighters: The Secret Hour* (Westerfeld 2004), multiples of thirteen are key to protecting a group of teenagers from an ancient evil. New titles in the series can be found by reading book reviews in young adult literature journals and Web sites, such as *The ALAN Review* (www.alan-ya.org/), *SIGNAL Journal* (www.kennesaw.edu/english/education/signal/Home.htm), and *Teen Reads* (www.teenreads.com/).

So What? Environmental Print

ENVIRONMENTAL PRINT (HARRIS AND HODGES 1995) is a catchphrase referring to real-time text that occurs naturally in our environment, such as advertisements, containers, and junk mail. Such print is in great supply and rich with mathematics content. Environmental print links mathematics instruction with everyday life (Wallace, Cherry, and Clark 2005; Wallace and Clark, in press) and often includes sociopolitical issues as a way to empower students within our consumer society (Steen 1997, 2001; Stoessiger 2002). Use of this information helps students answer the So what? questions regarding their mathematics learning. Students see that mathematics is an integral part of the decision-making process in our consumer society. Environmental print also offers the opportunity to examine competing authorities; bring in unique mathematics ideas and experiences; and support the notion of mathematics discourse, argumentation, debate, and socially constructed ideas with deep mathematics insight.

One example that provides relevance to the decision making of middle school students is the CD and Video/DVD club solicitation that offers 10 CDs or DVDs for one dollar. These offers must be compared and contrasted, analyzing the acceptance of the free item, shipping and handling that may not be explicitly discussed, and the quantity of items that has to be purchased within a particular time frame. In examining this printed offer, students can use measures of central tendency or ratios to examine the details of cost per item; consider when they would break even for the different clubs; and use algebra to construct tables, create graphs, and determine the equations of lines as a way to justify their solutions for the best

CD club. Whatever problems the students are ultimately asked to solve, students engage in critical numeracy to examine their own decision-making process within a consumer society. One fifth-grade teacher, Cece Nelson, shared her thoughts on using environmental print in the classroom:

> These open-ended problem-solving problems that use newspapers and advertisements challenge my fifth-grade students. They are engaged and enjoy class when I add supplements to the curriculum. My students enjoyed analyzing different CD advertisements the best, and there was much debate about the "best" program because it really wasn't cut and dry, rather it was based on personal preferences.

Weekly department store sale flyers in most newspapers are a great source of real-life numbers to be used as the context for problem solving. Sale coupons advertise an additional 20 percent off the original price. Percent problems abound. If an item of clothing is advertised for an additional 20 percent off the already 10 percent discounted price, does that mean that the piece of clothing is 30 percent off? Conceptions and misconceptions of percent problems can be examined. In addition, fine print is also the key to department store advertisements. What brands or departments are excluded from the promotion? What is the return policy? These types of advertisements are rich in supplementary text for classrooms that require students to carefully analyze text sources, then apply mathematics principles to the problem-solving situations.

The sports section is also prime material for problem solving. Team statistics can be analyzed, and articles can also provide additional insight into other teams. For example, if Shaquille O'Neal was injured on the basketball court, and the Miami Heat lost all its games after that point, this information would provide data that make sense of the Heat's statistics. Another example might be to explore the use of steroids in sports. It might be interesting to analyze how athletes performed when they said they were on steroids versus when they were not. Students could mathematically justify their ideas and use qualitative data to support their position. To implement this type of supplemental problem in your classroom, newspapers would need to be organized based on themes. Keeping newspapers over time would provide a deeper context for study, additional data for analysis, and additional relevant qualitative details regarding the theme not often explored in classroom data-analysis problems.

Reading the fine print on a lottery ticket should not be overrated. Middle school students can be overheard fantasizing about winning the lottery, sometimes overlooking the mathematical complexity of actually purchasing the winning ticket and collecting large sums of money. What are the odds that a lottery player will actually win? If you do find yourself with a winning ticket, what restrictions are placed on collecting the prize money, even when the sum is as small as $599? You can make sure your students are educated about the lottery before they make plans to survive on their winnings instead of hard work. One fifth-grade student thought that just buying more tickets would ensure a win. When he realized that he had spent more than he won on five lottery tickets in the class experiment, he was shocked. He was also surprised to learn that you did not necessarily win the big jackpot. A winning ticket could be just one or two dollars. The fine print was enlightening.

Literature with math themes can link naturally to everyday experiences

Whatever elements of environmental print are explored in the mathematics classroom, students are becoming more knowledgeable about their role as citizens in this consumer society. Students have the chance to see the So what? questions with regard to learning mathematics. Environmental print is also easy to find—just look in your mailbox today and pick out all the junk mail. Spam, when carefully previewed, often includes the same types of information.

Conclusions

USING THESE MULTIPLE TYPES OF TEXT IN MATHematics classes provides students with real-life contexts in which to explore, discuss, and debate mathematics in ways that encourage numeracy. To this end, mathematics can be seen as a relevant subject that impacts students' lives with issues that they truly care about. Informational trade books, literature, and environmental print provide an abundance of different types of text to connect to mathematics and students' lives. When students become curious and ask How come? or Why? they find out how mathematics can answer many questions they have about their world. When an engaging text triggers students' interest to wonder and ask What if? students are deepening their understanding of mathematics to make sense of the possible. When a newspaper or magazine article focused on local, state, or national political issues that may impact students' lives becomes the context for mathematics problem solving, students find the answer to the So what? question. Using multiple types of text to engage students in mathematics is one way to empower them to become more discerning citizens and advance through higher mathematics with confidence as they build a conceptual understanding of numbers. ☞

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Toothpaste Millionaire Project

Name _____

Objective: To make and sell a product for a profit—does not have to be completely original, but you are not trying to figure out how much it costs to make a pair of Abercrombie jeans or T-shirt.

Tasks

1. Create a scale drawing of the product.

2. Determine the cost of the product.
   a. The wholesale price: calculate the cost of materials, your time (labor), and the packaging, then calculate 200 percent of that amount, which will be the selling price. Stores, in turn, will sell it to a consumer for the retail price.
   b. Retail: wholesale price + 30 percent.

3. Optional: Make an actual object, and bring it to share with the class.
   a. Create an advertisement and explain where it would be shown, such as magazines, flyers around the school, neighborhood, and so on.

Checklist

1. Product being made: _____

2. Needed materials: _____
_____

3. Production time (how long does it take to make the item?): _____
Labor costs (how much is my time worth?): _____

4. How will I package the item? _____

5. What will it cost to package the item? _____

6. What is the wholesale price of the item? _____

7. What is the retail price of the item? _____

8. Scale drawing attached; scale: _____

Optional components

1. Advertisement included _____

2. Location of advertisement _____

3. Approximate cost of advertising _____

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