Journal of Urban Mathematics Education
December 2015, Vol. 8, No. 2, pp. 44–52

PUBLIC STORIES OF MATHEMATICS EDUCATORS

Practices and Benefits of Reading in the Mathematics Curriculum

Matthew G. Caputo
Thurgood Marshall High School

> I think that the article shows that some people think that math can be changed by laws, when it actually cannot.
>
> – Ninth-grade Algebra I student, Reading Assignment 1

> The differing opinions of mathematics and mathematics education tell me that the world isn't perfect. Everybody has their own opinions, and that can or cannot be changed.
>
> – Ninth-grade Algebra I student, Reading Assignment 1

While these quotes may lack complexity, they are actual written responses by ninth-grade Algebra I students in reaction to a reading assignment based on the article "Alabama's Slice of Pi," written by Mark Boslough (2015). As part of the reading assignment, the students were asked to summarize and critique the fictitious article in their own words. While the ideas represented in these quotes are somewhat contradictory, they illustrate how these students read and analyzed the story with respect to current trends in mathematics and mathematics education.

In the past several years, especially with the adoption of the Common Core State Standards, emphasis has been placed on connectivity among different academic subjects as well as between those subjects and the world. Simultaneously, there has been an increasing trend toward examination questions that are wordier and require more thinking and unpacking of the concept (McTighe & Wiggins, 2014). The purpose of this public story is to elaborate on some classroom techniques that might assist students in becoming comfortable and more successful with interpreting and answering text-based mathematics questions.

This past school year was the first year that I had taught ninth-grade Algebra I in the past several years. Also, it was the first year since reading and writing across the curriculum has received increased national attention (Sultan & Artzt, 2010). Early in the year, I noticed that several students, from all ranges of abilities, were struggling with word problems. While all students were having difficulty with understanding and unpacking word problems, it was especially evident among the students classified as English Language Learners (ELL), roughly 5% of my class

MATTHEW G. CAPUTO is a teacher in the Department of Mathematics at Thurgood Marshall High School in the Fort Bend Independent School District, 1220 Buffalo Run, Missouri City, TX 77489; email: matthew.caputo@fortbendisd.com. His research interests include classroom technology, reading and writing in the mathematics curriculum, and use of projects as a learning tool.

enrollment. Obviously, this struggle was not something I considered to be news, but I took the opportunity to employ some new techniques in the classroom.

Current research shows that reading and writing in the content areas leads to a higher level of understanding in the content, more use of content-based vocabulary, and greater ease in unpacking the content from questions that involve lengthy reading passages (Tompkins, 2013). In addition, reading and writing in mathematics has often coincided with increased problem-solving skills, creativity in solutions, and in-depth explanations of concepts (Sobecki & Mercer, 2014).

Early in the semester, I noticed a number of students in my Algebra I class struggling with an examination question involving the classification of numbers that was presented in such a way that many were confused. The question read:

> A set of numbers is said to be closed under a certain operation if, when you perform the operation on any two numbers in the set, the result is also a number in the set. Is the set of irrational numbers closed under addition? Explain.

The four choices gave "yes" and "no" answers followed by explanations to support the claim. The correct answer: "No, the set of irrational numbers is not closed under addition. For example, the sum of $(\sqrt{5})$ and $(-\sqrt{5})$ is not an irrational number" (Burger et al., 2007, Chapter 1 Examination Question 16).

The concept of closure was new for many of my Algebra I students, and that is why it was difficult for them to understand, especially when they were first introduced to it during a test. While the concept of classifying numbers was one that many of the students understood thoroughly, they had difficulty extracting the necessary information from the question. Seeing a term to which they had not been previously introduced confused some; others were simply intimidated by the length and wordiness of the question.

When I originally taught number classification, I compared the idea to classifying living things according to their taxonomy. I felt this method was particularly relevant given that many of the students were also taking Biology. After introducing the topic, I asked the usual barrage of questions, such as:

- List all categories the number -5 would fit into.
- List all the categories that ½ would fit into.
- If a number was classified as rational, must it also be an integer?
- If a number was classified as an integer, must it also be rational?
- Is it possible that an integer is rational?

Considering that I felt my students understood the nomenclature of numbers well, and considering that the question on closure was the only one that stood out as in-

correct by a significant amount, I decided to review it with the entire class in the following session.

We analyzed the question together carefully, and I showed them an example using integers with addition, and then integers with division to show them the idea of a set with closure and then one without closure. Next, we looked at the choices, one by one, and most of the students identified the correct choice.

Afterward, I spoke with one of my students who did not answer the question correctly. This question was, in fact, the only one on the test that he answered incorrectly. I asked him to explain why he thought he made the mistake when, obviously, he understood the concept being tested. His explanation was simple and predictable, "All the reading made the question confusing." Further discussion with several students revealed that they were not comfortable with reading for content. Many of them felt intimidated by questions that were given in paragraphs containing words they had not seen before. Almost all the ELL students tried to guess at these questions.

I remembered my own experiences in education when textbooks transitioned from nothing more than bound sets of examples to be completed for homework to actual paragraphs and chapters that needed to be read, understood, and then applied. As with most students making such a transition, I floundered when that happened, and I was watching my own students do the same. It has been shown that a growing number of students are discouraged by the increased rigor they experience when transitioning from elementary school to secondary school. This increase in rigor can lead to a change in student attitudes toward the subject and, more generally, their academic future, which results in lower grades, higher drop-out rates, and decreased interest (Brunner, 2013). I did not feel that the "sink or swim" approach that I experienced would be successful with all of my students, so I decided to try a different method. As I do often in the classroom, I tried to make it something a little more fun and a lot more unexpected.

I assigned the students a passage to read and respond to (see Figure 1); it was a fictional article titled "Alabama's Slice of Pi" (Boslough, 2015). The passage was written in the style of an actual journal article. It described how, for religious reasons, the legislature of Alabama voted to redefine pi from an irrational number with an approximate value of 3.14 to the exact value of 3, referencing a passage from the Old Testament. I advised my students that it was a fictitious article and asked them to read the explanation as part of their assignment. In response, the students gave varied summaries and reactions to the article. Many of the students did not find the article funny or entertaining, and several thought the references to religion in an article about mathematics were not appropriate. However, regardless of whether they understood the author's statement or received the message that was covertly delivered, they all read the article and gave some sort of analysis.

Please read the "article" entitled "Alabama's Slice of Pi," written by Mark Boslough and found at the website http://www.snopes.com/religion/pi.asp.

In addition to reading the article, also read the *Origins* and *Sightings* section located beneath it.

While this "article" is a work of fiction that was originally published as an April's Fool's Day joke, what does this tell you about some of the differing opinions of mathematics and mathematics education today? Also, consider the following: Based on the geometric definition of Pi given in the second paragraph, what is wrong with the biblical definition given in the fourth paragraph?

In a three well-constructed paragraphs, give a brief summary of the article making reference to the *Origins* and *Sightings* section. (Keep in mind that this article is fictitious!) Also, within these paragraphs, answer the two questions posed in the above paragraph. In your conclusion paragraph, give an opinion of this article (did you enjoy it or find it humorous? Regardless of your answer, say what you enjoyed or did not enjoy.)

This essay should be typed, in 12 point found, double-spaced, and be no more than 1 page.

You will be graded in the following categories:

Accuracy of your summary

Explanation of the "Origins and Sightings." (This can be within the summary itself. It does not need to be a separate paragraph).

Explanation of how this related to differing opinions of math or math education.

Explanation of the how the biblical definition of Pi given differs from the geometric definition.

Your opinion (and support of your opinion).

Figure 1. Instructions for Reading Assignment 1.

I did not make an effort to align the reading assignment with the content we covered at the time because the purpose of this assignment aimed at providing the students with an opportunity to practice their skills at extracting subject-related content from a work of writing. The reading assignment was meant to be concurrent to the curriculum as a means to exercise their skills at unpacking a wordy question. When selecting the writing, my objective was to find a genre the students would enjoy and a content level that was not beyond their ability to interpret. I felt that "Alabama's Slice of Pi" satisfied the indicated criteria.

I eagerly waited until their next chapter examination. When those results came in, I was pleasantly surprised. The number of students receiving grades above 80% increased from 15% to 25% of the class population. On average, the ELL students showed a 5% improvement over their previous test scores. What was even more impressive was that in performing the item analysis of these results, I noticed no particular question stood out as missed by a majority of students. In reviewing

their work and speaking to them individually, I understood a great many of the mistakes to be simple errors rather than conceptual misunderstandings.

As with the previous examination, there were several wordy and lengthy questions. In the administration of this test, however, the students appeared more comfortable with reading the question and interpreting what was actually being asked. It would appear that the students were beginning to understand how to unpack a word problem to see the concept that was actually at the heart of the question.

Despite these improvements, a number of students mentioned to me that they did not like the story or the assignment. They felt that the author's attempts at humor were unsuccessful, and that the story was not applicable to their lives or interests. When the assignment asked them to describe how the supposed legislation to truncate the value of pi to an integer value related to the fields of mathematics or mathematics education, it appeared that the students lacked enough background information to make such an assessment and, from their point of view, it became an exercise in tedium. From day one, I tried to create an atmosphere where the students felt comfortable discussing these issues with me, so these reactions were not unexpected. I felt that this time was crucial in their work with literacy in mathematics, and I did not want to discourage any of the students by forcing them to read an article that they did not enjoy. I found myself with the profound task of trying to find another reading assignment for the next marking period that both would be interesting to the students and would address the appropriate mathematical content.

Based on what I observed about student interests during the following weeks, I selected an old newspaper article as their next assignment (see Figure 2). "Mars Probe Lost due to Simple Math Error," written for the *Los Angeles Times* by Robert Lee Hotz (1999), was a nonfiction newspaper article about how a mistake in converting standard units to metric units caused NASA to lose millions of dollars in a space probe explosion, thankfully with no loss of life. In addition to the benefit of working within students' reading abilities, I decided this reading assignment would further reinforce the need for accuracy in calculations, something that the students had insisted was not that important in previous conversations. Additionally, this topic was more interesting for the students, especially given that part of the assignment was to describe a similar experience they had in their lives. Again, the number of students that obtained a grade above 80% on the next chapter examination increased to 40% of the class.

The actual written responses improved with every attempt as well. While grading, the summaries of the articles became of decreasing interest and the student analyses became much more amusing. When asked to describe their own experiences with calculation errors, students provided some interesting stories about purchasing shoes in foreign countries, talking to relatives overseas about their height

and weight, and problems concerning culinary mishaps as a result of not monitoring time or temperature closely. Aside from my students having further honed their reading skills in mathematics, they learned more about how the accuracy of their calculations could make a difference in real-life situations.

The following article, "Mars Probe Lost Due to Simple Math Error," by Robert Lee Hotz is an actual article from the *Los Angeles Times* in October 1999. Please read and summarize the article.

Your response should be a three-paragraph response, approximately 1 page in length (double-spaced, 12 pt font). While summarizing the article, be certain to answer the following questions:

1. What was the error that caused the Mars Probe to be lost?

2. How could this have been resolved?

3. Considering the conversion 1 pound of force = 4.45 Newtons of force, perform the following conversion: A space vessel exerting 15,000 pounds of force would exert how much force in Newtons?

4. Have you encountered similar issues in your life (think of communicating with relatives in different time-zones, or discussing height or weight as possibilities)?

As before, this writing assignment will be graded on a scale of 0-4 in the following categories:

A. Accuracy of Summary (includes Question 1)

B. Possible resolution for this problem (Question 2)

C. Example of Conversion (Question 3)

D. How this relates to your life (Question 4)

E. Structure and completeness of assignment.

Figure 2. Instructions for Reading Assignment 2.

Bringing this personal aspect into the assignment allowed the students the opportunity to share cultural experiences in ways that previously had not been available. Many students who struggled in class and felt disconnected from the main cultural dynamic of the school began to feel that they could speak openly about their family's heritage even if it was only limited to mistakes they made cooking empanadas or trying to account for time zone changes when calling relatives in Turkey.

In addition, the students enjoyed this article more than the previous one. They felt it was far more applicable to their lives, and they enjoyed sharing their embarrassing stories about how they struggled in converting units or miscalculated measurements at some point in their lives. Seeing that everyone—including NASA engineers—can make mistakes made these teenagers feel less self-conscious about the mistakes they would make.

I decided to up the ante, so to speak, a little bit more in the following marking period with Reading Assignment 3 (see Figure 3). They had to read "The Secret Number" by Igor Teper (2000), a fictitious story that involved a mathematician who discovered another integer, called Bleem, between 3 and 4, resulting in his being ostracized by the mathematics community and eventually committed to an asylum. After many failed attempts to prove the existence of this integer to his therapist, the main character escapes toward the end of the story. I decided to make the assignment a little more interesting than the previous two. Along with asking the students to describe a mathematics problem or assignment they struggled with and how they resolved it, I also asked them to research a persecuted mathematician or scientist from history and to describe why that person was shunned for her or his beliefs.

Read the following short story, entitled "The Secret Number" written by Igor Teper. Obviously, this story is a work of fiction, but relates certain themes that have been present throughout the history of mathematics.

Summarize the story, including both main characters' points of view about the existence of the secret integer. Try to reference this in a historical context based [for example, how were people treated when explaining that the world was round when many considered it flat and how has that changed?]

As discussed in class, several mathematicians and scientists in history have had to deal with persecution, ridicule, or even execution as result of developing theories that were not held by most people. Pick one of these people from history and briefly describe the theory and what penalties resulted from this. [We have mentioned several during class, but if you are stuck do an internet search on "Famous persecuted scientists" or "famous persecuted mathematicians."]

Do you think that there are mathematics ideas or formulae that have yet to be discovered? If so, do you think these would be accepted easily or would someone presenting these ideas experience a situation similar to what occurs in the story? Explain why you have this opinion.

Finally, we have all (myself included) felt stressed over a problem or assignment that seemed too difficult to manage. Briefly describe a situation like that this that you experienced. Reference the last scene of the story and the condition of Ercheim's room. While I am assuming none of us were writing equations in grape juice on the walls all night, what sort of strange things have you done when trying to solve that problem?

This paper should be 4 paragraphs (the summary, your research, your opinion, and the relevance to your life). Each of these will be graded out of 5 points [Not Completed (0) – Excellent (5)], and the entire assignment will count as a quiz grade.

Figure 3. Instructions for Reading Assignment 3.

Considering that the students had grown accustomed to this sort of assignment by this point, the results were nothing short of stellar. I was impressed by the

research component of this assignment as well as the personal anecdote and the description of the story plot. Descriptions of Galileo and Archimedes were accompanying my students' stories of their own experiences struggling to explain a problem. The students enjoyed both the story and the opportunity to share how frustrating a difficult task could be. Again, giving the students the chance to describe the story in terms of their own lives gave the assignment a more personal feel that they appeared to enjoy. While the research component frustrated some of the students, they enjoyed learning more about people from the history of mathematics and the sciences that they had heard about in their classes. They found it remarkable that even brilliant people were not always praised for their insights.

Still, their examination grades continued to increase. In the last mock State of Texas Assessments of Academic Readiness (STAAR) examination that was given to my Algebra I students, the passing rate increased from 96% to 98% and the number of commended students (those earning scores over 80%) increased from 30% to 40%.

In May of that year, the students took the STAAR. We reviewed earnestly, as did everyone else, and I spent weeks pacing my classroom like an expectant father waiting for the results. Finally, in the last week of the school year, we received our results. An impressive 99% of my Algebra I students passed the assessment and 40% of the students received commendations for their scores of 80% or above. Needless to say, there was a communal sigh of relief in my classroom when those results were posted.

The issue of students being unable to unpack the mathematics from a lengthy word problem concerned me in the beginning of the school year. Creating assignments in which the students read, analyzed, and wrote about published works in mathematics provided them with practice of this skill. With high-stakes examinations moving toward an increased amount of reading and interpretation, I felt it was important to expose my students to reading and writing in the discipline early in the school year. Giving them these opportunities to practice extracting the mathematical content from a work of writing helped them to interpret the paragraph-sized questions they encountered on the Algebra I state assessment. While this was not the only factor their success can be attributed to, I feel this approach is worth further scrutiny and replication.

References

Boslough, M. (2015). *Alabama's slice of pi*. Retrieved from http://www.snopes.com/religion/pi.asp

Brunner, J. (2013). *Academic rigor: The core of the Core*. Retrieved from http://www.nassp.org/tabid/3788/default.aspx?topic=Academic_Rigor_The_Core_of_the_Core

Burger, E., Chard, D., Hall, E., Kennedy, P., Leinwand, S., Renfro, F., Seymore, D., & Waits, B. (2007). *Algebra I*. Orlando, FL: Holt, Rinehart and Winston.

Hotz, R. L. (1999, October 1). Mars probe lost due to simple math error. *Los Angeles Times.* Retrieved from http://articles.latimes.com/1999/oct/01/news/mn-17288

McTighe, J., & Wiggins, G. (2014). *From Common Core standards to curriculum: Five big ideas*. Retrieved from http://www.hopefoundation.org/from-common-core-standards-to-curriculum-five-big-ideas/

Sobecki, D., & Mercer, B. (2014). *Pathways to math literacy*. New York, NY: McGraw Hill.

Sultan, A., & Artzt, A. (2010). *The mathematics that every secondary school math teacher needs to know*. London, United Kingdom: Routledge.

Teper, I. (2000). *The secret number*. Retrieved from http://www.strangehorizons.com/2000/20001120/secret_number.shtml

Tompkins, G. (2013). *Literacy for the 21st century: A balanced approach* (6th ed.). New York, NY: Pearson.