



# Writing About Math

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Learning math through the lens of writing is natural for two reasons. First, as in any subject, writing about math forces students to articulate their thoughts on paper and encourages them to confront what they understand and what they don't. Writing can be a learning tool across the board, and it is no different in math.

Second, reading and writing about math is an effective way of keeping the "Math-English translator" sharp. Students often struggle with word problems because they require converting English into math, and vice versa. Although it is sometimes perceived as merely a torturous exercise, I see this translation as a useful skill because that is exactly how math is used in the world around us. When a math problem presents itself, whether to a supermarket customer calculating percentages or a scientist analyzing a climate model, it is rarely neatly packaged the way textbook problems are. Instead, it requires understanding a real-life situation well enough to be able to interpret it mathematically, doing some calculations, and interpreting the results in the context of the original situation. This is a skill best honed by writing thoughtfully about one particularly interesting math question rather than by doing dozens of practice problems focused on a single rote skill.

## **Writing in Math Class**

Writing about math is notoriously difficult but can enhance students' understanding in important ways. I believe that the difficulties arise due to the extra layer of translation that is required. Not only do many students lack (or think they lack) the intuitive ideas that may come naturally to them when writing about, say, their American Dream, but those who do have the ideas must first translate them from the original math. It's like asking a student to think in one language and write in another, a difficulty encountered every day by foreign language students and teachers.

Despite these difficulties, math can be the perfect subject about which to write. In fact, I find it difficult to write a non-technical piece because I am obsessed with precision. Do the words that I just put on the page accurately reflect my thoughts? Have I chosen the correct phrase to convey the exact nuance I'm looking for? More often than not, I feel that I haven't. When writing on a technical subject such as math or science, however, the precision comes for free. Not only is math a universal language, but there are conventions for what each symbol ("word") means. For example, in common parlance the word "equivalent" could take on a whole range of meanings, but in math the definition is unambiguous and determined wholly by which symbol ( $\sim$  or  $=$ ) is chosen.

As a mathematician, I came into teaching knowing that my students would write about math because that's what mathematicians do. When they solve an open-ended problem, they can't turn to the back of the book to "check" their answer. The only way to get feedback on a result and use it to generate new results is to communicate it to other mathematicians through lectures, published articles, or even casual email conversations. If this is how math is done by

actual practitioners, then it followed that this should be how math is done in my classroom.

## **Initial Attempts**

I integrated writing into my class through two projects first semester. One was a disease project in which students acted as epidemiologists and used a computerized model to simulate the spread of a fictitious disease. They explained their results and predictions in a scholarly article, using charts and graphs to support their arguments. The second project had students act as consultants for the City of Chula Vista; they chose an optimization problem to solve using linear programming techniques we had developed in class. For example, one problem asked students to decide on an optimal way to split the land around our school between buildings and green space, given several complicated limitations set by the school board and the town. They wrote up their results in the form of a land-use proposal to the city.

Finally, in preparation for their end-of-semester presentation (POL), my students wrote a one-page response to one of two essential questions, one about functions and one about linear programming. Both questions asked them to demonstrate a basic understanding of the concept and to analyze the use of that concept in solving real-world problems. Their responses were used as a starting point for their POL dialogue the following week.

## **What Went Well**

The linear programming project was the most successful of the three attempts. After reading their write-ups, I felt that many students understood the process of linear programming in several variables much more deeply than they would have had they not been asked to detail their solution in the form of a proposal. Linear programming can be complicated, especially for students with large gaps in their math backgrounds. Writing down all of their steps and knowing that they would eventually have to justify their process slowed down many students who would ordinarily rush through the problem, make several mistakes, and not actually understand what they were doing.

## **What Didn't Go So Well**

Both the project write-ups and the POL responses were content-based; that is, they required the students to respond to specific mathematical questions. Although some of these questions

were open-ended (such as “What are the limitations of using linear programming to solve real-world problems?”) they were technical enough that the students perceived them to have a correct answer. In fact, they were right. In all three instances I did have a clear idea in my head of the “perfect piece,” which means there was little room for creativity on the students’ part. We learned in my credentialing class that students often find writing difficult because they are worried about producing exactly what the teacher wants. In this case my students were correct to worry, and I regret this deeply.

This has caused me to re-think why it is I want my students to write in math class. The truth is that most of them are not going to become mathematicians or research scientists, and so insisting that they write papers about their mathematical results because “that’s what mathematicians do” is a much less compelling argument than it was before I started teaching. The writing assignments I gave them last semester reflected that prior motivation; now that I am re-thinking my purpose I must also re-think the writing assignments I am giving them.

### **Why Do I Want My Students To Write?**

Although I have figured out what won’t motivate my students to take pride in their mathematical writing, I have yet to figure out exactly what will. However, my own motivation for having them write is now clearer. I know that writing pushes students to articulate ideas that are already intuitive, thus providing a deeper understanding of the content. It also gives those less intuitive concepts the chance to be understood. One reason behind many students’ struggle with math is that they simply don’t give the material the time it requires. Writing, then, can be a mechanism for slowing down the thought process and tackling a difficult idea one step at a time. If students do not understand every aspect of a concept even after writing about it, they will at least know what they don’t understand. This will give them a starting point for asking questions, rather than simply floundering in the frustration of “not getting it.”

Finally, I truly believe that writing in math will help students’ writing across the curriculum. Writing about math first and foremost requires clear definitions and axioms. My students spent the first portion of their linear programming proposal defining the variables and constraints of the problem and deriving their method of solution from mathematical principles. This systematic approach to writing forces students to confront the fundamentals in a way that is useful even in science or humanities. For example, if a student is going to write a paper discussing the role of fate in *Romeo and Juliet*, the first thing that the student needs to establish is a clear definition of “fate.” True critical thinking happens when students tackle those fundamental questions; such questions are unavoidable in math and crucial across the board.

## Next Steps: Purpose and Audience

I have realized that whether I am designing a project or a shorter-term writing assignment, my main struggle is with audience: Who are my kids writing for? In both of the projects that I mentioned I tried to create an “authentic audience,” which of course made it completely inauthentic. I figured that in the real world epidemiologists publish articles in journals and consultants submit proposals to companies, so that’s what my students should do—even if the diseases and companies were fictitious. Of course, these were by no means “authentic audiences” because I was still the only person who read their projects. In fact, the students were so unexcited by the assignments that they didn’t even care to read each other’s work, thus depriving them of possibly the most authentic audience for a high school math project: each other.

Going forward, I aim to design projects and writing assignments that have an authentic audience and a definite purpose, even if the nature of the mathematics is such that the project itself is not quite “real-world.” I have learned that audience and purpose are intimately tied together in the minds of my students—if they don’t feel the presence of an authentic audience, they are unlikely to invest themselves in the writing and the refinement process that goes along with it. Instead, they will figure out what I want and execute it as quickly as possible, much as they would a set of repetitive, meaningless algebra problems. If a writing assignment is supposed to facilitate deeper learning, I must give them that audience. I do believe that the students can be each other’s “authentic audience” for a project or a technical piece of writing as long as the assignment allows them enough voice that they actually care to read each other’s work.

In addition, I believe there is a place for written conversations about math between the teacher and student in the form of a journal. Mett (1987) discusses journals in “Writing as a Learning Device in Calculus,” and I hope to use them with my students at least a couple of times each week. Some of the prompts will target a specific skill or concept from class. As Mett writes, asking students to write step-by-step explanations of their problem solving helps them become autonomous learners and focus in on what they don’t understand. Having spent much of the past semester hearing my students simply cry out, “I don’t get it,” I look forward to trying a technique that encourages them to articulate the gaps in their understanding.

Other journal prompts might be in the style of reading logs often used in Humanities classes. Rather than requiring the students to focus on a specific concept, I will ask them to respond to the following questions: What don’t you understand? What do you think you understand? What are you pretty sure you understand? This type of prompt would be appropriate before an end-of-unit test, as it would require students to recall the various concepts of the unit, how they fit together, and which parts are still fuzzy to them. It would also be useful to have students reflect on these questions at different stages of a project in order to monitor their growth and generate new questions. Finally, I hope to give students more opportunities to read about math, whether this is through simple example problems or something more complicated, like a newspaper article that ties together statistics and the healthcare debate. Just as my colleague, Peter Jana’s students used the three questions as a guide to decoding

Leviathan, my students can use them as a guide to decoding a difficult mathematical text.

## **Final Thoughts**

I have seen firsthand that nothing can be accomplished in the classroom without motivation. Students need a rationale for writing, and “because mathematicians do it” is a distant and unauthentic one. Indeed, valuable conversations with colleagues and mentors have clarified what should have been clear all along—I can have my students write as often as I want, but if I don’t consider the audience and the purpose for their writing, then nothing is going to feel authentic or result in the depth of learning that I crave for them. There should be a purpose behind every minute that students spend in our classrooms; when asking them to write about challenging math, that purpose is naturally achieved through communication to an audience that matters.

## **Reference**

Mett, C. (Oct. 1987).

*Writing as a learning device in calculus. Mathematics Teacher, 80, 534-37.*