

Cindy Phillips, Week 4 Assignment “The Nature of...”

PhillipsTheNatureofMathematics

- A. *After reading Peters-Burton (2014), think about the various fields that comprise STEM and the “nature of” each: NOS, NOT, NOE, and NOM. Directions for Secondary Teachers: From the perspective of the subject area(s) that you teach, think about how the “nature of” your area speaks to others. Engage in a critical reflection of how you address the tenet(s) currently in your teaching. Describe how you currently address the tenets. You may talk about one specific lesson or activity that you use to address the tenet. If you do not address any of them, talk about the way that your curriculum treats the nature of mathematics. (about 1 page)*

Standards of Mathematical Practices:

- 1. Make sense of problems and persevere in solving them.**
- 2. Reason abstractly and quantitatively.**
- 3. Construct viable arguments and critique the reasoning of others.**
- 4. Model with mathematics.**
- 5. Use appropriate tools strategically.**
- 6. Attend to precision.**
- 7. Look for and make use of structure.**
- 8. Look for and express regularity in repeated reasoning.**

The above practices reflect a few different tenets of what it means to be a mathematician.

Mathematicians are problem solvers, and we equip ourselves with a bag of tricks to do so: technology, logic, theory, algorithm, and rigorous algebraic, geometric, trigonometric, calculus-based methods of solving equations that model real-life phenomena.

Mathematics is the workhorse of the STEM disciplines. Give a mathematician a real-life phenomenon with an inherent problem to solve, and we will find a solution for you. Or multiple solutions. Or tell you that the solution does not exist. Or tell you to what degree of certainty that problem is solvable or unsolvable.

The beauty of mathematics lies in its ability to be useful tools for other STEM disciplines. But mathematics is also beautiful in and of itself, even if it seemingly applies to nothing. I call this math for math’s sake.

Mathematicians like actuaries, statisticians, futures and derivative traders, economists, specialize in applications, and theorists generally care just about finding patterns and solving problems just because they can. Of if they can’t, and sometimes spend their whole lives trying.

This is something math teachers often don’t say out loud to our students. Most of us became math teachers because the notion that “there is always a right answer” was comforting to us at some point. Students often say the same.

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Mathematical discomfort usually is greatest for students who can't find that solution. Or for those students who can, but find it to be too much work.

Of course, the real nature of mathematics is that often equations and data do not play nice, and solving real-world problems requires technology or complicated techniques. For example, if we are trying to teach modeling of exponential decay, we usually have to work with “nice” numbers at the beginning so our growing mathematicians can see the simple multiplicative relationship between one data point to another. In mathematics, and in life, most problems are very hard to solve efficiently with simple algorithms and simple answers.

And most of us, myself included, stay in that comfort zone of problems that work out nicely. Math teachers know the truth, but don't tend to address it, as teaching math and doing math is hard enough even when the problems work out nicely.

The AP Calculus curriculum has addressed this problem by creating two different sections of the exam: one with “nice” problems that do not require a calculator and one where a calculator is required as the integrals and equations don't have “nice” problems. Both sections require the ability to read, interpret, and reason. Ultimately, the entire calculus curriculum can be seen as a nod to the history and techniques developed in Calculus since its “discovery,” which I love. Calculus is the course where all of the mathematics ever learned comes together. But even this calculus course, as rigorous as it is, as expertly crafted as the College Board exam is, only touches upon the uses of calculus, its history, and its connection to other areas of STEM.

One of the courses I usually teach besides calculus is Algebra 2. The newest incarnation of the regents in Algebra 2 incorporates more real-life applications than ever before, mostly during the exponential and logarithmic functions unit and the trigonometric graphs unit. There are applications to finance, Newton's law of cooling, half-lives, and modeling periodic functions with trig curves.

However, we find ourselves in a pickle, especially post-pandemic. The Algebra 2 curriculum is packed solid with disjoint topics. Most of us find we are consistently revisiting Algebra 1 topics that were never developed appropriately or skipped entirely, which takes a lot of time. Math, to a greater extent than most other curricula, is cumulative and it is practically impossible to thrive in Algebra 2 if you don't have a firm grasp of Algebra 1.

Because of these challenges, I find that I have less and less time to delve into rich and important applications of the math I am teaching. For example, I like to spend an entire period talking about why people put their money in banks, the terminology involved in investing, and different types of investment instruments. I like to talk about why people, especially people from other cultures, or people who survived the depression, do not trust banks. When talking about logarithms, I like to talk about the linearized scale that comes from the scoville units derived from how much capsaicin is in a hot pepper. These are great examples of ways we can integrate math and science in a way that is significant and culturally relevant to kids. Unfortunately, we are just given an equation to give and how to use it whether we are solving for

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time or future value. We barely scratch the surface on something that will actually impact every student in the room.

Most of the applications that are so exciting to us as math teachers, we don't get to teach because we feel our hands are tied, hurtling towards a finish line someone else has set for us.

B) Consider how you might enhance your teaching to address the tenet(s) outlined in Appendix H. You may review and cite resources from the course as well as others (please cite them). Discuss specifically how your thinking/understanding of the “nature of” is dynamic. (about 1 page)

From Appendix H of NGSS: “science is both a set of practices and the historical accumulation of knowledge. An essential part of science education is learning science and engineering practices and developing knowledge of the concepts that are foundational to science disciplines. Further, students should develop an understanding of the enterprise of science as a whole—the wondering, investigating, questioning, data collecting and analyzing.”

When I first started teaching, I was at an alternative school which adopted a curriculum called “Interactive Mathematics.” It was NSF funded, problem-based, and at its essence was using a rich problem that required a solution. Every lesson in each unit forced on some aspect of solving the problem.

Every lesson, every day, the students were required to make conjectures, try something, see if that provided an adequate solution. If it didn't, more inquiry was necessary. The kids were required to think critically, work with others, and take risks. This was neither easy for the kids nor the teachers who were more like “math coaches” than teachers.

I left that school in 2000, and the two schools I have worked in since, up until this year, have put a lot of emphasis on the state exam, and quickly I had to learn how to teach more traditionally. And sadly, that meant giving up a lot of what I did.

If I was the only one doing this, I was in it alone. It was frowned upon.

But that was a different school than I'm in now, and now that we are moving away from the regents as a summative assessment (at least for everything past Algebra 1) I will have more of an opportunity to revisit the manner of teaching I started with all those years ago.

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Hopefully we will be allowed to eliminate some vestiges of topics no longer useful or only lightly touched upon to make space for more inquiry-focused and STEM integrated lessons. I am taking a year sabbatical to research and write lesson plans that do this, and because of this course I will have a better idea of how to do so that integrates the NOS, NOE, NOT, into the lessons that already will address the NOM.

My plan is to start with the science, start with the machine, start with the history, the art, and the technology, and connect things together using mathematics.

For example, one of the places I most recently found inspiration was from a museum in Warsaw that had all of these machines throughout modern history. Printing presses, calculators and computers, the enigma machine, you name it.

There’s so much rich conversation that can happen by taking a machine, thinking about why the machine needed to be invented, how the machine changed over time as technology improved. So much learning connected the history of the machine with what was going on in the world at that time. And all of this integrates not only math, science, engineering, and technology, but connects those things to history and culture, not just of what is happening in America but historically what has happened in the world.

Like written in Appendix H of NGSS: **“science is both a set of practices and the historical accumulation of knowledge”** I do usually touch upon the fact that a lot of the math we teach is historically significant. Why do we still rationalize denominators (sometimes)? Why is PEMDAS a thing? Why is a Taylor series so exciting? But I don’t currently emphasize that we as mathematicians also **“understand the enterprise of science as a whole—the wondering, investigating, questioning, data collecting and analyzing.”**

Just a few weeks of looking at what NASA has to offer STEM education has helped me connect some previously unconnected dots into how I can further push my ideas into other realms, and I’m super excited by this.

Math teachers always fall back on the idea that “math is always math” and that math in and of itself doesn’t change too much. But math education has to change, and I can’t wait to start to change how I teach, to go back to my roots, and hopefully impact others to do the same. It’s hard to step outside of the box you’ve become comfortable in. But with support, it becomes easier.

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C. Read an additional document from the list above that addresses the “nature of” a different discipline. Identify 3 ways in which your content area overlaps with the second area that you selected.

From the Nature of Engineering,

https://www.nsf.gov/attachments/117803/public/1b--Eng_in_K-12_Ed.pdf

The design process, the engineering approach to identifying and solving problems, is (1) highly iterative; (2) open to the idea that a problem may have many possible solutions; (3) a meaningful context for learning scientific, mathematical, and technological concepts; and (4) a stimulus to systems thinking, modeling, and analysis. In all of these ways, engineering design is a potentially useful pedagogical strategy.

Although this is from the “Nature of Engineering,” it is also how we should approach mathematics. When I am given a problem to solve, I always try for an algebraic solution first. If that doesn’t work, I move to something else. In this manner, I am aware that a problem might have multiple solutions or multiple approaches to a singular solution.

Problem solving in math is not only an iterative process (try, revisit, repeat) but the process of iteration is an important concept we teach during a unit on sequences and series.

Math gives the logical ability to approach the analysis required in the other disciplines.