For the purpose of this assignment, I will be speaking to the Nature of Science, as I am a middle school physical science teacher. There are eight tenets of the nature of science. Four of them address understandings that are associated with practice and the other four address understandings associated with crosscutting concepts. The practice tenets state:

- Scientific Investigations Use a Variety of Methods
- Scientific Knowledge is Based on Empirical Evidence
- Scientific Knowledge is Open to Revision in Light of New Evidence
- Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

The crosscutting tenets state:

- Science is a Way of Knowing
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science is a Human Endeavor
- Science Addresses Questions About the Natural and Material World

In my classroom students often have the opportunity to use a variety of tools to make measurements and observations when we are completing our laboratory investigations, though as I am learning, our laboratory investigations function more like a cookbook with a set of ingredients and instructions. I'm thinking particularly of a lab we do in class regarding physical

and chemical properties and changes where students are presented with 13 different sets of materials and they have instructions to do something. (Measure 5g of sugar into the beaker and stir it in to 100 mL of water. Now repeat this process with 5g baking soda and 100 mL of vinegar. Explain which is the physical change and which is the chemical change. What evidence supports your claim?) My favorite part of that is when they get to the chicken livers and hydrogen peroxide. But I digress.

I see this investigation also addressing the second tenant that scientific knowledge is based on empirical evidence since the students have to use their observations to support the claim they make about physical and chemical changes. Students do struggle to grasp the idea that when sugar is dissolved into water, it remains sugar molecules in smaller particles, mixed in with water molecules and is a change that can be reversed by evaporating the water. Grasping that the baking soda and vinegar is a chemical change is a little more available to them because they easily see that a gas forms as the mixture fizzes and since it’s an endothermic reaction the temperature drops.

We do a lot of talking in my class about scientific findings being open to revision in light of new findings and any time new information happens in scientific world, I make time to share and discuss it with the students. We’ve discussed the new elements recently added to the periodic table as well as the most recent planet being theorized to exist on the edge of our solar system. And of course, there is the back and forth with poor Pluto. These are the current ways I am addressing practice tenets in my classroom.

As for the crosscutting tenets, this also occurs in the content lessons I teach where we discuss the back ground information of scientific work and

discoveries that led us to the information we know that makes up physical science. Additionally, in all years prior to this one (because of Covid-19 cutting us short) I take students on a tour offered by the engineers at Roper Corporation so they can see first-hand all the science, technology, and engineering that goes into building the ovens that we have in our very homes. They even get to visit the test kitchen where two home economists perform scientifically precise baking projects to discover any flaws with the ovens. (This is the students' favorite part because it always ends in them getting to eat cookies.)

Now, as addressed in the NGSS Appendix H, I find myself considering how do I put all the elements of practice and crosscutting concepts together to help my students better understand the nature of science. This ties into the question: how can I enhance my teaching to address the tenets of the nature of science. I am coming to understand that this would be achieved through a design process that begins with anchoring phenomena related to the content standard, that will make students curious so they understand the why behind the what of what they're learning in my class. As the topic progresses, students will also encounter other types of phenomenon as well. Paul Andersen suggests shifting exploration to the beginning in his YouTube video Scientific Phenomenon and Sense Making. (Andersen 2019) He suggests that this process of inquiry is the way that students go through the process of making sense and then after ample investigation time the teacher helps students pull together all of the knowledge toward the end of the

exploration. Andersen defines good phenomena as sparking curiosity and wonder as they address your standards.

A further way that I can use good anchoring phenomena to enhance my teaching is to be sure that it builds on my students' everyday experiences. Using the phenomenon of beach erosion is going to be meaningless to my students who have never experienced the ocean. In order to really hook my students into the concepts of my standards with phenomena I need to understand what experiences are relevant to them or be able to bring the experience to them in other ways, for instance, with videos. This will help to meet the goal of building knowledge in science, which is to develop general ideas based on evidence, that can explain and predict phenomena. (NGSS 2016)

These concepts I am learning through the reading and viewing material this class are doing for me exactly what I talk to my students about on a regular basis: shifting my understanding as I gain new information. I am learning that the nature of science is to get students engaged in the material in authentic ways based on empirical evidence, with an understanding of the human aspect that goes along with doing science. The phenomena don't have to be drastic, fun, flashy events, but they do have to get students connected to what they are expected to learn. Just as science itself is open to change, so is my thinking about the nature of science and how to get my students to an understanding of that nature.

I read all the “nature of” documents and find a lot of overlap to the nature of science in all of them, but for comparison, I chose to look at the nature of engineering. The first area of overlap I identified is the idea that a problem may have many possible solutions, just like in science, with the human component, varying conclusions can be drawn from the same set of evidence by people with differing biases and backgrounds. Methods of scientific inquiry themselves can support engineering design. That interconnectedness indicates another area of overlap. And finally, there are several overlapping habits of the mind in engineering. There has to be a sense of curiosity, wonder, optimism, communication, attention to ethical consideration in order to do science well and to do engineering well. As I work to integrate the distinct components of STEM in my classroom from a three dimensional approach, I will be using these considerations to improve the quality of what my students experience throughout the year.

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