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Week 4: 6/1/20-6/7/20
Methods of STEM Education

Nature of STEM assignment

a) 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 science. (about 1 page)

As a physical and life sciences teacher (I hold both Earth Science and Biology teaching certifications), I will focus my exploration on the Nature of Science (NOS). To me, the NOS hinges on using our interactions with, and observations of, the world around us in order to better understand the natural world. I have always been drawn to the scientific disciplines in part due to the guiding principle that if you collect enough data and make enough observations, you can develop an scientific explanation for most observable phenomena.

The tenets of the NOS that I believe that I currently address in my teaching are: *1) Scientific Investigations Use a Variety of Methods*; *2) Scientific Knowledge is Based on Empirical Evidence*; *3) Scientific Knowledge is Open to Revision in Light of New Evidence*; and *4) Science is a Human Endeavor*. I currently teach Earth Science to 9th- and 10th-grade students and have worked to emphasize the use of narratives, case studies, and phenomena as the lenses through which I structure each unit of learning. For example, my second unit of instruction focuses on plate tectonics, convection currents, and related earth surface features and processes. I structure the unit around the story (phenomenon) of the Nevada de Ruíz volcanic eruption of 1985 in Colombia using first person accounts of the harrowing events and footage from the disaster. Through this phenomenon, we explore the tectonic processes that led to the disaster as well as the various methods that the Colombian government has since implemented to collect real-time data from the volcano in order to warn the surrounding communities of future eruptions. The process of scientists using improved technology in order to collect information and advance their knowledge and expertise is an example of NOS tenet *1) Scientific Investigations Use a Variety of Methods*. The real-time seismic and volcanic gas data that we examine is an example of NOS tenet *2) Scientific Knowledge is Based on Empirical Evidence*.

Within the same unit we explore plate tectonics and how over time, through different scientific investigations and the accumulation of scientific evidence, the theory of continental drift evolved from being widely ridiculed to being the scientifically accepted explanation for the movement of Earth's plates. Through telling the story of Alfred Wegener, a meteorologist who developed the theory of continental drift based on observations of varied evidence, I illustrate the NOS tenets of *1) Scientific Investigations Use a Variety of Methods*; *2) Scientific Knowledge is Based on Empirical Evidence*; *3) Scientific Knowledge is Open to Revision in Light of New Evidence*; *4) Science is a Human Endeavor*. Wegener faced derision throughout his lifetime from the geological community who believed his claims were preposterous because they couldn't comprehend a mechanism that would explain how the tectonic plates moved. I like to use this story to show students how the body of scientific knowledge that we take for granted as 'fact' today is a result of observations and data (empirical evidence) gained through a variety of scientific investigations. Perhaps most importantly, this story show that over time, with the accumulation of more and more evidence, our knowledge has evolved and ideas that were once ridiculed by most scientists as absurd (tenet 4), have become the accepted scientific explanation (tenet 3).

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)

The tenets of the Nature of Science that I want to incorporate more into my teaching are: *1) Science Addresses Questions About the Natural and Material World*; *2) Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena*; and *3) Science is a Way of Knowing*.

For tenet *1) Science Addresses Questions About the Natural and Material World*, I think that I often over emphacize in my teaching the power of science in terms of collecting information to make informed decisions. While this is important, I think it is equally important that students understand the limits of science and which questions science can answer and which questions it can't answer. Further, just because we can use science to 'answer' a question about the natural world, it doesn't mean that we are going to like the answer or that others will value, agree with, or implement the answer. Other societal concerns or personal values can be just as important when addressing a question even when all of the evidence is present.

In reference to *2) Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena,* one of the most confusing areas of scientific language for students are the terms models, laws, mechanisms, and theories. Students often have the misconception that a model either has to be a detailed 3D representation of a system or a complicated mathematical formula. Students are often incredulous when told that a drawing that they themselves create to represent a natural system is considered a model. Similarly, the colloquial use of the word *theory* creates misconceptions for students regarding the meaning of the word *theory* in science. I often forget that I should explicitly teach the terms *law* and *theory* in the context of the nature of science so that students understand the extensive bodies of knowledge/evidence that exist with both of these terms. This would address the common misconception that a scientific theory is a scientist's best guess.

One of my primary motivations for becoming a science teacher was to give students the tools they need to make informed decisions about any aspect in their lives. This has proved to be one of the most challenging goals. I try to instill in my students that *3) Science is a Way of Knowing* that is accessible to everyone, not just scientists, by modeling how to think through a problem using a scientific framework: identifying a question, forming a hypothesis, collecting evidence through an investigations, and then analyzing the evidence to yield a conclusion. In practice though, this has proved to be very challenging and many of my students just don't see themselves as 'scientists.' This is an area of my practice that I continue to analyze and ponder.

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.

Reviewing the Nature of Math (NOM) tenets as explained in the Common Core Mathematics Practices, there is significant overlap with the Nature of Science tenets. Three specific examples of the overlap between the NOM and NOS tenets are:

1) ***NOM:*** CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others and ***NOS:*** Scientific Knowledge is Open to Revision in Light of New Evidence.

2) ***NOM:*** CCSS.MATH.PRACTICE.MP4 Model with mathematics and ***NOS:*** Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena.

3) ***NOM:*** CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically and ***NOS:*** Scientific Investigations Use a Variety of Methods

The first example shows how both the NOM and NOS place value on the use of evidence (arguments) to support a claim or statement. Additionally, both disciplines expect and rely on peer review of the claims or statements made by other professionals in the discipline in order to vet the arguments put forth. Based on peer review of the evidence and reasoning presented, the body of knowledge of both disciplines is either confirmed or revised.

An obvious overlap between the NOS and NOM is highlighted in the second example above, the use of models. Mathematical models are use to analyze and solve diverse problems related to everyday life as well as theoretical problems. Science relies on the use of mathematical models to explain may different natural phenomena. Often, scientists will propose a hypothesis that explains how a natural system functions and then work to create a mathematical model to support their hypothesis. For problems that are especially complicated, or impossible to actually simulate in a lab setting, mathematical models provide an additional way of creating the conditions on paper for a given problem to determine if a particular explanation may be valid.

Finally, both the NOS and NOM emphacize the use of appropriate tools to conduct investigations and solve problems. 'Tools' in this instance is a very expansive term meant to encompass anything and everything from rulers, calculators, and compasses to computers, models, and other digital technology. In both disciplines, a variety of tools are available for use to solve problems and one component of 'knowing' in both disciplines is determining the most appropriate tool for the task.