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Nature of STEM Paper

A)

Teaching students to be scientifically literate challenges science teachers to employ a myriad of practices that include teaching students how to acquire and use scientific skills to explore natural phenomena and the methods for how to explain them. The Next Generation Science Standards (NGSS) distills the teaching and learning of the nature of science (NOS) into eight understandings or tenets that are woven into the practices and crosscutting concepts of grade-level curricula (Appendix H, NGSS Release).

In my teaching, I tend to address all the tenets of the NOS, with the exception of one: *Scientific Knowledge Assumes an Order and Consistency in Natural Systems.* In a recent unit on photosynthesis, I included activities that not only taught concepts, but also challenged the students to engage with the NOS. I began the lesson with an inquiry activity in which students observed three terrariums, made detailed observations, and then inferred explanations for what they observed based on their prior knowledge (*Scientific Investigations Use a Variety of Methods)*. Afterwards, students completed a virtual lab to investigate the effect light distance and intensity has on oxygen production in plants. They collected empirical data, compiled class data, identified patterns and relationships amongst the data, and used the data to support their explanation for their results (*Scientific Knowledge is Based on Empirical Evidence).*

Another tenet that I addressed in this unit is “Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena.” I wanted my students to engage with the understanding that chemistry is an integral part of biology and how laws of chemistry, such as the Law of Conservation of Matter or Mass, are applied to the production of glucose and oxygen during the process of photosynthesis. My students created models of the molecules that represent the inputs and outputs of photosynthesis using molecular model kits and then demonstrated how the building blocks (atoms) used to make the inputs can be rearranged by breaking the bonds between the atoms to form the outputs, thus conserving and transforming matter.

I have addressed the following tenets in my evolution unit: *Scientific Knowledge is Open to Revision in Light of New Evidence, Science is a Human Endeavor , and Science Addresses Questions About the Natural and Material World.* In this unit the students compare and contrast three different theories of evolution (Lamark, Darwin, and the Mutation Theory) to engage them in the discourse that “scientific knowledge…is subject to change based on new evidence and/or a reinterpretation of existing evidence.” During one lesson for this unit, my students compared experimental evidence and conclusions made by other scientists to investigate how

the environment plays a role in how organisms adapt and survive. Students then communicated and defended their scientific findings during a debate.

Teaching students about the theory of evolution helps them to also recognize that the nature of science is dynamic; theories can be revised and/or reevaluated based on empirical data and evidence(NOS Tenet: *Science is a Way of Knowing).*

B)

Our science department uses AERO standards based on the NGSS standards that incorporate some aspects of the performance expectations as outlined by the NGSS. However, before taking this course, my experience with NGSS had been at the surface level. While I have been incorporating some of the tenets of the NOS, I am excited to have a more straightforward framework for successfully building on these tenets in my lessons.

My goal for future unit plans is to utilize the NGSS website to enhance my lessons to include the three dimensions (practices, crosscutting concepts, and disciplinary core ideas) needed to engage my students in science education (NGSS Release, June 2013). For example, the *HS-LS3-3 Heredity: Inheritance and Variation of Traits* (NGSS, 2013) standard can be applied to my upcoming unit on heredity and used as a guide to help me integrate other STEM disciplines more specifically and transparently into my lessons. The standard specifically lists crosscutting concepts related to mathematics (i.e., Scale, Proportions, and Quantity) which students need to predict the probability of organisms inheriting specific traits. The standard also includes crosscutting concepts related to NOS (i.e., Science is a Human Endeavor), clearly establishing a relationship between advancements in technology and progress in scientific knowledge and the influence that science and engineering have on society and vice versa.

In addition to more effectively utilizing the NGSS in my planning, I also want to include more examples of phenomena into my lessons to engage students in inquiry practices (NOS Tenet: Science Addresses Questions About the Natural and Material World). The Wonder of Science website, created by Paul Andersen, is an excellent resource and time-saver for teachers using the NGSS to incorporate phenomena specific to the standard(s) they are applying to their unit of study. For example, there are several videos of phenomena for standard *HS-LS3-2 Inheritable Genetic Variation*; in particular, there is one about the Hemingway cats of Keywest that have six toes that invite students to question why and how this phenomena occurred. In addition to the video links, the website provides a wealth of clearly organized materials for teachers to use and modify for free.

My enthusiasm to engage in professional development and graduate courses that enhance my STEM and STEM integration knowledge constantly expands and challenges my understanding of the NOS. As an educator and lifelong learner, I have always desired to improve my education to become more effective in the classroom and facilitate a joy of learning.

C)

In addition to the NOS, I am also very interested in the "Nature of Mathematics" (NOM). The two disciplines are complementary, and many of the Common Core Standards for Mathematical Practice overlap with Chemistry and Life Science content that I teach. For example, in the Chemistry unit on Gas Laws, students utilize algebra and problem-solving strategies to solve word problems varying in length and difficulty. The standard *CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them* accesses a student's ability to "analyze givens, constraints, relationships, and goals" to solve a problem. My students are taught to solve gas law problems using this method.

Another example of overlap between the NOS and the NOM is the standard *CCSS.MATH.PRACTICE.MP4 Model with mathematics*. In the Life Science course I teach, students are required to use probability and a mathematical concept to solve problems involving the possibility of inheriting familiar human traits, like dimples or a widow's peak. Students proficient in math can recognize the mathematical implications of using a Punnett Square as a model for determining probable outcomes.

Furthermore, the standard *CCSS.MATH.PRACTICE.MP6 Attend to precision* assesses students' ability to communicate their work precisely. More specifically, this is shown by including correct units of measure, defining symbols, and expressing measurements to the proper degree of precision determined by the context of the problem (i.e., representing a numerical result to the hundredth place due to the accuracy of the scale used to find the mass of an object). As part of our introductory unit on the Nature of Science, we teach/review these same concepts, demonstrating the complementary nature of math and science.

References:

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.

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