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The Nature of Science

The topic in which I felt most comfortable exploring was the nature of science. This is directly related to my context as I teach three sections of fifth grade science using the Next Generation Science Standards. As I was reading through the tenets of science, I found that I am addressing five of them throughout my school year. I also was able to reflect on my teaching practices and found that I can enhance my teaching of three tenets of science. Additionally, I directly connected the nature of science to the nature of engineering as there are many practices found in both.

The first tenet I am addressing in my science teaching is that: “Scientific investigations use a variety of methods.” The perfect example of this in my teaching is during our unit on the structure and properties of matter. In this unit, we discuss how to make observations and measurements in order to identify materials based on their properties. For part of this time, I have students practice various measuring methods, such as, measuring volume, height, mass, and knowing the difference between all of them. They move on to a three-day investigation in which they are tasked with identifying matter as being: reflective, electrically and thermally conductive, soluble, and magnetic. They distinguish this by measuring the materials in a variety of ways. For this investigation it is important that they understand that observations can use a variety of measurements and methods to arrive at a conclusion.

The next three tenets that I utilize in my classroom are: “Scientific Knowledge is Based on Empirical Evidence”, “Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena”, and “Scientific Knowledge Assumes an Order and Consistency in Natural Systems.” There is one investigation I do during our space systems unit which hits each of these three tenets. For this investigation, students are asked: How does the position of the Sun affect the length and direction of shadows? They then are given a protractor, paper with compass rose on it, ruler, flashlight, and small toy. Their directions are to measure the length of the shadow when they shine the flashlight on the toy from a certain degree on the protractor. They then need to graph their results on a bar graph and analyze their data in order to arrive at a conclusion. This connects to the tenet that science knowledge is based on empirical evidence because their findings are based on recognizing patters in their data. This investigation also connects to explaining natural phenomena and the order of natural systems because we connect this lab to shadows, we then track of ourselves outside and further connect it to the rotation and revolution of the earth on its’ axis and around the sun.

The final tenet I feel is met in my classroom is that “science is a human endeavor.” There are five units to our science curriculum and throughout each of the five units there are three to four partner or group investigation or projects that the students are engaging in. We discuss a lot at the beginning of the year that no great feat of science was accomplished alone. My students understand collaboration to be a vital part of the scientific process and have often known that despite it not always being their favorite type of activity, it comes with the territory. Within this tenet I noticed the Appendix H specifically mention that, “creativity and imagination are

important to science." This is something that has driven my science teaching since the adoption of the Next Generation Science Standards. I think it is incredibly important to give my students choice in how they learn certain standards and allow their personal creativity and imagination to shine in whatever they have chosen to embark on. By reading *APPENDIX H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards* I feel I have a greater understanding of how to utilize the tenets of science throughout the variety of standards and topics I teach.

While reading *APPENDIX H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards* I was able to reflect on my lesson planning and teaching of science in order to see three areas in which I can improve. A statement that stood out to me from this article was, "Students need to understand what is meant, for example, by an observation, a hypothesis, an inference, a model, a theory, or a claim and be able to distinguish among them" I agree with this statement as so much of the Next Generation Science Standards use this vocabulary in an effort to expose students to the vast opportunities scientific exploration has to offer. However, when reflecting on my own teaching, I feel I do not establish enough of a clear definition for each of these concepts. My students are tasked with making a model, defending a claim, etc., but do they know what that means in the grand scheme of the nature of science? No. I can see in the future altering my beginning of the year lesson plans in order to establish a clearer division between all of these very important concepts they will be exploring throughout the year.

A tenet of the nature of science in which I could also improve is that, "Scientific Knowledge is Open to Revision in Light of New Evidence." Often times when I have students conduct an investigation I do so with a correct answer in mind. I don't allow for opportunities for students to return to conclusions days later to revise them or find new evidence to improve upon their theories and ideas. This is something I want to incorporate more often as it is so often true in the world of science that theories are consistently being tested, debunked, or added to. On a related note, the tenet that "Science is a Way of Knowing" is a new concept for me. When I looked at what my fifth graders need to understand from that topic the article stated, "Science is both a body of knowledge and processes that add new knowledge." As stated previously, I do not feel that I mention the adding of knowledge into my lesson planning often enough. A goal that I have to enhance this is that I can be look at the fourth grade NGSS standards to see where the students will be adding to their previous knowledge. By doing this, I can connect the idea that science is a way of adding new knowledge to past knowledge.

"Science Addresses Questions About the Natural and Material World" is a tenet of science that I would also like to improve upon in my teaching. Although, I do only teach to the standards and so much of the standards is addressing the phenomena that happen in the natural and material world, I don't mention the limitations of science. A way in which I can enhance this in my teaching is to utilize current scientific events around the world and what scientists are doing to help. By using the videos on the website: pulitzercenter.org and mentioning what is being done vs. what would be done in an ideal world will make this concept more real for my students. After viewing some of these videos I could see my students wanting to solve the

problems of climate change and plastic pollution. This could start a debate about what can be feasibly done using science vs. what we can do in our imaginations.

The additional discipline that connects to the nature of science is the nature of engineering. As stated in *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*, "Engineering "habits of mind"1 align with what many believe are essential skills for citizens in the 21st century.2 These include (1) systems thinking, (2) creativity, (3) optimism, (4) collaboration, (5) communication, and (6) attention to ethical considerations." This directly connects to the tenet of the nature of science which states, "science is a human endeavor." Both disciplines thrive on communication, collaboration, and creativity to drive the momentum of knowledge forward. Whether students are conducting a scientific investigation or attempting to create using the engineering design process, they need to communicate with their peers to help them solve problems and come to conclusions. The second connection between science and engineering is that, "Certain science concepts as well as the use of scientific inquiry methods can support engineering design activities." (Kathi, Pearson, Feder) This is evident in the Next Generation Science Standards when students are tasked with creating a model to help illustrate and explain natural phenomena and scientific systems. Students follow the engineering design process as they are also attempting to explain scientific concepts. This cross-cutting concept helps to deepen their experience with the engineering design process as well as give them a more meaningful understanding of the scientific topic.

The additional connection between science and engineering is that the end result can have many possible solutions. *Engineering in K-12 Education: Understanding the Status and Improving the Prospects* states, "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." The idea that engineering can result in many possible solutions connects to the tenet of science with states, "Scientific Knowledge is Open to Revision in Light of New Evidence." These two ideas are related because science is an ever changing field where new discoveries and theories are being made or tested every day and engineering is a practice in which being different and thinking outside of the box is encouraged. In order to succeed in both science and engineering a spirit of innovation and imagination are necessary to arrive at any conclusion.

By reading both *APPENDIX H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards* and *Engineering in K-12 Education: Understanding the Status and Improving the Prospects* I see that my philosophy for teaching science and engineering is both encouraged and differs from the nature of these disciplines. Through the analysis of these texts and my own teaching I am able to see the areas in which I can improve my teaching of science and where there is more room of integration of other disciplines, such as engineering. My understanding of the nature of the STEM disciplines has come alive through this research and will continue to reinvigorate my teaching.