Nature of STEM Assignment

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a) Engage in a critical reflection of how you address the tenets currently in your teaching. You may talk about one specific lesson that you use to address the tenet.

I teach at a Catholic school in NJ as a gifted and talented program coordinator (3rd through 8th grades). This was my first-year teaching; it was a trial-and-error period to build up my own curriculum.

I am very unfamiliar with NGSS and CCSM, because my school follows the standards set by the Archdiocese of Newark's curriculum maps. I don't teach specific subjects like math or science, because my course is designed to be an enrichment program. I am working to build up a curriculum that is not only STEM-focused but has connections to various relevant disciplines such as history, science, art, and political science.

Although I was not aware of the tenets of the *Nature of Science* in NGSS while teaching this year, I now realize that some of my activities and lessons are aligned with those tenets. Among them, one lesson that students and I enjoyed the most was analyzing a historical example of the scientific method*: Galileo's hypothesis on gravity*. This lesson addressed the following tenets of the Nature of Science:

1. Science Knowledge is Tentative and Open to Revision in Light of New Evidence: In this lesson, students first reviewed the brief history of Galileo's hypothesis challenging existing beliefs (e.g., Aristotelian view on gravity) based on his observation and experiments, including his famous *Leaning Tower of Pisa experiment* (I pointed out though that historical records suggest that the actual experiment may not have taken place). Then, I showed the video clips of Apollo 15 conducting the famous "Feather and Hammer" experiment in 1971 to test Galileo's hypothesis @NASASolarSystem (https://www.youtube.com/watch?v=oYEgdZ3iEKA). In addition, I showed the BBC experiment where Brian Cox visits NASA's Space Power Facility in Ohio and did an experiment of dropping a bowling ball and a feather in a vacuum condition (https://www.youtube.com/watch?v=E43-CfukEgs). Through this lesson, students understood that science knowledge is open to revision based on new evidence.

2. Scientific Knowledge is based on Empirical Evidence: In this lesson, students clearly acknowledged that science is rooted in empirical evidence obtained through scientific observation and experiments.

3. Science is a Human Endeavor, involving creativity, imagination, and the benefits of teamwork: Through this lesson, students understood the overall concept of the scientific method. They learned that science requires *curiosity* to question and *creativity* to formulate hypotheses and design experiments through Galileo's endeavor (his creativity led him to question existing beliefs and proposed his bold hypothesis). They also learned how the Apollo 15 crew conducted the experiment through creative & problem-solving thinking on the Moon and shared its discovery with the scientific community and the public.

I am especially happy to find out that my lesson for the students was aligned with important tenets of the Nature of Science. Through this specific lesson, I was able to address how scientific knowledge is constructed and the importance of the role of empirical evidence, creativity, collaboration, and communication in scientific endeavors.

b) Consider how you might enhance your teaching to address tenets outlined in Appendix H. You may review and cite resources from the course as well as others.

As a first-year teacher, I tried to incorporate my professional experience in political science, policy formulation, and scientific research skills into the curriculum. However, I realized that I need more pedagogical structure and resources to build up my own curriculum. Also, I want to enhance my curriculum by incorporating STEM education methods. That's the main reason why I am taking this *STEM Teaching Certificate* program as my professional development opportunity. I am already learning a lot from this *Method of STEM Education* course through readings and exploring various resources on the course website (@wiki).

Based on the lessons and resources I learned so far, I am considering the following strategies and resources to enhance my teaching, especially to address tenets of the Nature of Science:

1. Encourage students' engagement and creative thinking: *By centering on phenomena in science education, the focus of learning shifts from **learning about** a topic to **figuring out why or how** something happens*. This sentence resonates with me most after reading the article "*Using Phenomena in NGSS-Designed Lessons and Units*". I acknowledged the importance of phenomena-based learning in science education based on my experience and lessons from this course. Discussing phenomena will encourage students' engagement and improve their problem-solving skills, critical thinking, and creativity. I will make the most out of all the sources posted on the Wiki page on the course's website. Among others, I find this website https://www.ngssphenomena.com/ very useful because it also encourages sharing and communicating phenomena among the community members.

2. Utilize more historical case studies: I will explore more historical case studies as my previous lesson on Galileo's hypothesis and Apollo 15 experiment captivated students and made them understand the ***tentative and evolving*** nature of scientific knowledge. From this perspective, I used *Build It Yourself Series* books (*e.g. Great Ancient China Projects and Amazing Leonardo da Vinci Inventions*) to teach 3rd and 4th graders this year.

The students and parents gave me excellent feedback on this lesson. I will explore more books and resources for different grade levels. I also found this website from the course resources https://www.nsta.org/, which also provides very interesting various historical case studies.

3. Introduce NASA-STEM connections by using NASA databases, experiments, and NASA STEM websites: One of the great benefits of this course is the connection with NASA resources and education. I am very excited to introduce this NASA-STEM connection and relevant lessons to my class. Using a *variety of inquiry methods in scientific investigations* is one of the tenets of the Nature of Science. Many useful NASA websites showcase how scientists use all different approaches to gather evidence and test hypothesis. Websites like SpaceMath@NASA and https://www.nasa.gov/stem-ed-resources/nasa-stem-stars-mechanical-engineer.html could be very useful in this regard.

4. Investigate and incorporate various methods, such as 5E learning model and 3D learning framework of NGSS in the classroom: As this course progresses, I would like to develop deeper knowledge and pedagogical methods on 5E learning model and 3D learning framework of NGSS through assignments, readings, and discussions.

I am already learning a lot through this *Method of STEM Education* course, which helps me to reflect on what I have taught throughout the year. I believe this course will guide me on how to incorporate various effective STEM methods into my lessons and enhance my future curriculum.

c) Identify three ways in which Nature of Science overlaps with the Nature of Math.

To answer this question, I chose to read a document related to the Nature of Math. While the Nature of Science and Math each has its own unique nature, there are several ways where they overlap. Here are three examples I identify as overlaps:

1. Problem-Solving through Critical Thinking: Both the nature of science and the nature of math require problem-solving skills through critical thinking and logical reasoning. Both scientists and mathematicians use critical thinking to understand problems and look for solutions through logical reasoning. Scientists use critical thinking to observe, collect evidence, test hypothesis, and analyze data & evidence to come up with solutions to problems. In math, critical thinking helps mathematicians identify givens, constraints, relationships, and structures within the problems. Logical reasoning assists them to develop problem-solving strategies based on established mathematical principles, theorems, and definitions.

2. Data Analysis and Mathematical Modeling: Modeling is a key method to learning and practicing both science and mathematics because it involves building, testing, and applying conceptual representations of phenomena (Eric Weber, 2014, *Principles for Quantitative Reasoning and Modeling*). Scientific investigations are conducted to collect empirical evidence through data analysis, among other methods, and mathematical

models are developed to understand and predict phenomena. In math, mathematical modeling is a powerful tool to explore mathematical ideas, formulas, and equations to investigate mathematical relationships.

3. Communication and Presentation through Logical Arguments: Both scientists and mathematicians construct logical arguments to justify their steps, validify their solutions, communicate them to others, and respond to the arguments of others. Effective communication and presentation of findings within the science and math communities play a crucial role in advancing knowledge in these disciplines.