Brittany Tompkins

Methods of STEM Education

June 19, 2022

Nature of STEM Assignment

a. *Critical reflection*

When reflecting on my curriculum and pedagogy, I see some key ways that I address the tenets of the Nature of Science. In general, my Physics courses tend to explore the tenets more closely related to the process and practices of science. For example, I address how “Scientific investigations use a variety of methods” and how “Scientific knowledge is based on empirical evidence” (NGSS, 2013, p. 5). Many of my lab activities in my Physics classes are inquiry-based, and require students to develop their own lab procedures before collecting, analyzing, and reporting their data. We talk about experimental design and how to construct scientific arguments that are supported by evidence, and often each lab group has a slightly different approach to the assignment. In Physics, we also cover the tenet that states that “Science models, laws, mechanisms, and theories explain natural phenomena” (NGSS, 2013, p. 5). I usually discuss how laws differ from theories, and we do a lot of work around modeling throughout the year. The last unit in Regents Physics, modern physics, provides many jumping off points for discussing scientific theories and how they are developed and refined. After learning about Newtonian mechanics which all seems so neat and tidy, students are typically

shocked to learn that physics is still an ongoing, changing field with lots of questions still remaining.

I find my Astronomy class to be a conducive environment for incorporating more of the NoS tenets that relate to the NGSS crosscutting concepts, such as “Scientific knowledge is open to revision in light of new evidence” and “Science addresses questions about the natural and material world” (NGSS, 2013, p. 6). In Astronomy, we often discuss how scientific beliefs and ideas have changed over time – for example, from the geocentric to heliocentric model of the solar system. We also discuss new technologies that are being developed for space travel, exploration, or observation, including new telescopes or probes. This is a great way to link technology to science and emphasize how the two are interconnected. Astronomy also gives me the opportunity to bring up one of the understandings that falls under the “Science addresses questions about the natural and material world” tenet, which is that “Not all questions can be answered by science” (NGSS, 2013, p. 6). I think this is one of my favorite things to talk about in the field of Astronomy, because there are so many philosophical, existential, and even ethical questions that are brought up by the subject. Many students are surprised at how many unanswered questions there are in the field of astronomy, and how much we have yet to learn about our universe and our role in it. They love to ponder questions about space colonization, life in the universe, and how the universe itself originated.

I also find it easier in Astronomy to address how science is culturally and societally embedded, and is not at all removed from ethics. I recently tried out a new debate activity about the issue of asteroid mining in my Astronomy class. Students explored the topic through videos, articles, and a compilation of quotes from many different stakeholders. In groups,

students discussed the environmental, ethical, and economic implications of asteroid mining, and students were able to argue whether they felt that asteroid mining was a worthwhile endeavor. Students learned how the materials found in asteroids are extremely valuable, yet could flood our economy's markets for platinum and other precious metals. They learned about the special mining technologies that asteroid mining would require, but also how the space debris released could cause pollution and damage to spacecraft. They also pondered whether humans have an absolute right to all of the resources in the Solar System, or if some of it should be left as wilderness – or as resources for future generations. This activity was applicable to many of the points made in the High School understandings for "Science addresses questions about the natural and material world" (NGSS, 2013, p. 6). These understandings include: "Science and technology may raise ethical issues for which science itself does not provide answers and solutions," as well as "Science knowledge indicates what *can* happen in natural systems, not what *should* happen. The latter involves ethics, values, and human decisions about the use of knowledge" (NGSS, 2013, p. 6).

b. *Enhancing my teaching of the tenets*

Peters-Burton (2014, p. 100) states that a commonality between the Natures of Science, Technology, Engineering, and Mathematics is that all these disciplines "depend on iterative cycles of inquiry that lead to the development of valid and productive ideas." This is one thing that I would love to expand upon in my own classroom. When reflecting on my own practice, I know that incorporating engineering into my lessons is one of my weak spots. While some of my classes have time constraints because of mandated Regents exams, I'd still like to include

more lessons or lab activities that allow students to partake in authentic iterative cycles. These cycles could focus on inquiry, engineering, or problem-solving, depending on the content. These activities could help students see that science is not an exact sequence of prescribed steps, but is more cyclical in nature. I think this is also a great way to help students develop growth mindsets and learn that 'failure' is an essential part of learning, progress, and science itself.

I think I'd also like to better address many of the tenets by emphasizing that STEM is, by nature, complex and sometimes messy. Especially in STEM courses, students tend to want a "correct" answer to everything. Many students want the content to be black and white, with no uncertainty. However, the natural world is not so black and white, and partaking in STEM means sorting through some of that chaos. I could try to incorporate more real-world data into my classes and have students explore what might cause noise or error in the data. I might also include more constraints in engineering design activities, where students might have to consider the cost of materials or energy in their design. I think we are doing our students a disservice by teaching them that science is a perfect, complete subject, when in reality it is still ongoing, messy, and always changing. I really resonated with this statement from Peters-Burton, and feel that it underscores the need to teach STEM in more of a real-world context:

> *"Perhaps the reason STEM subjects hold together so well is that together they have the capacity to describe complexity and interactions – that everything humans can discover about the world around them helps to better refine ideas and tools to shape the world – and the more accurately we can anticipate benefits, costs, and risks to shaping the world, the more harmoniously we can live in the natural world" (2014, p. 100).*

c. *Overlap between NoS and NoT*

I see a lot of overlap between the Nature of Science and the Nature of Technology, specifically how human creativity and imagination contribute to both. In the tenet of the Nature of Science that states that "Science is a human endeavor," science is described as a product of human imagination and creativity, and a field which has been shaped by people from multiple backgrounds and cultures (NGSS, 2013, p. 6) The tenets of the Nature of Technology include that "the development of technology is a human activity and is the result of individual or collective needs and the ability to be creative," and "technology is closely linked to creativity, which has resulted in innovation" (ITEA, 2007, p. 27-28). Both the tenets Nature of Technology and the Nature of Science describe how each field is inextricably linked to humans and society. According to the ITEA's tenets of the Nature of Technology (2007, p. 26), "creative thinking and economic and cultural influences shape technological development." The NGSS's Nature of Science echoes that connection, stating that "science and engineering are influenced by society and society is influenced by science and engineering" (NGSS, 2013, p. 6).

I also think that science and technology are two very interdependent fields, and that each progresses only as the other progresses. This is outlined in one of the High School level understandings of the NGSS tenet of "Science is a human endeavor," which states that "technological advances have influenced the progress of science and science has influenced advances in technology" (NGSS, 2013, p. 6). By learning more about the natural world – through science and math, we are better able to develop technologies and solutions to problems through engineering. By developing better technologies through engineering, we are able to

continue learning more about the natural world. This is even more reason to teach STEM in an integrated manner, rather than treating Science and Technology as two completely separate subjects.

References

ITEA. (2007). Standards for technological literacy: Content for the study of technology. Retrieved from https://www.iteea.org/File.aspx?id=67767&v=b26b7852

NGSS. (2013, April). Appendix H - Understanding the scientific enterprise: The Nature of Science in the Next Generation Science Standards. Retrieved from https://www.nextgenscience.org/sites/default/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf

Peters-Burton, E. E. (2014). Is There a "Nature of STEM"? *School Science & Mathematics*, *114*(3), 99–101. Retrieved from https://doi-org.ezproxy.montclair.edu/10.1111/ssm.12063