

Nature of STEM

Exploring the Relationship between Nature of Science and the Nature of Technology

Humans are born curious. As children we are full of wonder and seek to connect with and understand the world around us. As we grow, we name this undertaking to explain the natural world science. Appendix H of the Next Generation Science Standards (NGSS) emphasizes the need for students to “develop an understanding of the enterprise of science as a whole—the wondering, investigating, questioning, data collecting and analyzing.” The NGSS identifies eight fundamental understandings of the Nature of Science (NOS) laid out in the NGSS NOS Matrix as follows:

- Scientific Investigations Use a Variety of Methods
- Scientific Knowledge is Based on Empirical Evidence
- Scientific Knowledge is Open to Revision in Light of New Evidence
- Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
- Science is a Way of Knowing
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science is a Human Endeavor
- Science Addresses Questions About the Natural and Material World

As students become increasingly familiar with these understandings, they build upon their awareness of science practices and crosscutting concepts within the context of the Nature of Science.

In my classroom, I feel I am a novice just beginning to undertake addressing these tenants in my teaching. To support the idea that science addresses questions about the natural and material world I have opened lessons by introducing a phenomenon. This leads to a guiding question that is then addressed by the lesson. For example, a short slow motion video of a person using his voice to shatter a wine glass or a clip demonstrating acoustic levitation to suspend droplets of fluid at wave nodes might launch a lesson about sound waves. Throughout this

process, I try to encourage students to ask questions based on their observations and exploring how they might investigate or what data would be helpful to them.

This questioning process then leads to developing investigations. I try to guide the class through designing an investigation by helping students to identify what data or evidence they seek to collect and what method would best support their goal. Over the course of the class, students utilize different methods and tools for investigation. For example students might compare a series of satellite images of a coastline to study erosion, use digital thermometers to measure temperature change in a chemical reaction, or Newton-meters, meter sticks and stopwatches to explore force and motion. Not only are the tools different from investigation to investigation but the methods and they type of data collected are also varied.

Stressing the importance of accurate data collection is one way in which I address how scientific knowledge is based on empirical evidence. Once students have gathered their qualitative or qualitative data, I guide the class through constructing claim-evidence-reasoning statements. Students argue how the data did or did not support their claim amidst conversations of sample size, consistent results, repeatability, sufficient number of trials, and other factors that might have influenced the results of the investigation.

Finally, current events provide wonderful opportunities for “teachable moments.” For example, NASA’s recent Cassini spacecraft revealed startling discoveries including the existence of spectacular jets of liquid water erupting from the poles of Enceladus and the California Academy of Sciences announced the discovery of 71 new plant and animal species in 2019. These provide fantastic, intriguing, contemporary examples of how the body of scientific knowledge continues to change in light of new evidence.

While I have begun to incorporate some of the tenants of the Nature of Science in my teaching, I still have much to learn to in this field. As my understanding of the NOS grows and I continue to cultivate my own science practices, I will be able to serve as a better model for my class. In particular, I aspire to curate more meaningful and relevant learning experiences that connect to my students’ lives, highlight and capitalize on existing “funds of knowledge,” especially for non-dominant student groups, and to consistently and explicitly articulate parallels between classroom activities and NOS.

Heretofore, I have attempted to backwards-plan topics of study based on grade level curriculum, but would like to develop more complex ways to anchor units of investigation in phenomena relevant to students' lived experiences. The readings from Week 5 including the NGSS text *Using Phenomena in NGSS-Designed Lessons and Units* and Paul Anderson of Bozeman Science's video *Scientific Phenomenon and Sensemaking* clearly explain the dynamic shift in learning created by beginning with phenomenon to investigate. Starting with a quality phenomenon not only piques student curiosity and increases engagement, but it provides a purpose for the learning. As students wrestle with trying to explain the phenomena, the need for vocabulary to communicate ideas precisely, investigations to gather data, and argumentation to clarify understanding emerges. Particularly in light of course readings such as Larkin (2001) *Before Today I was Afraid of Trees* and Ladson-Billings (2003) *I used to Love Science—and then I went to School*, I see now that not only should this phenomena engage students in the science learning, it should also be culturally relevant.

NGSS Appendix D “All Standards, All Students” emphasizes the need to create “equitable learning opportunities for non-dominant student groups” by “capitalize[ing] on funds of knowledge.” It explains, “Science learning builds on tasks and activities that occur in the social contexts of day-to-day living.” In this regard, students “bring to the science classroom funds of knowledge from their homes and communities that can serve as resources for academic learning if teachers understand and find ways to activate this prior knowledge.” I need to cultivate a better understanding of my students' lives in order to more effectively help them recognize and identify the scientific value of everyday practices such as making observations and recognizing patterns across systems. Doing so will help me to engage students that may otherwise be marginalized, avoid some unintended barriers to including students in science, and help to empower my students by valuing their funds of knowledge and identifying them as part of the larger science community.

Explicitly drawing parallels between classroom activities and science community are important for students to understand the Nature of Science. The University of California, Berkeley's *Understanding Science* website identifies some common misconceptions about NOS. One misconception it identifies is that students will learn the nature and process of science

simply by engaging in inquiry-based learning. The website states, “Students do not automatically make connections between their science activities and what scientists actually do.... Teachers must explicitly draw students' attention to aspects of nature and process of science that their activities demonstrate, making these clear, cognitive objectives for the lesson and assessing these outcomes along with basic science content” For example, while I try to emphasize to students that science knowledge is open to revision in light of new evidence, I would like to make this a more personally reflective activity for students. Particularly at the conclusion of an investigation or unit of study, it would be beneficial to have students reflect on how their own thinking has changed in light of the observations they made, the data they collected, and the learning process they engaged in. Similarly, I will seek to articulate and reinforce these parallels in investigation processes, data collection and analysis, and argumentation. In this way, I hope to draw parallels between student classroom experiences to the larger human endeavor of science.

Technology becomes a valuable tool to support and enhance science learning in the classroom. In the article, *Is There A Nature of STEM?* Burton beautifully describes the balanced relationship between NOS and NOT. She writes, “NOE and NOT tend to be about shaping the world, and NOS and NOM tend to be about discovering secrets of an already established natural world. These differences in focus can be considered harmonious, two sides of the same coin.” The International Technology Education Association (ITEA) Standard for Technological Literacy strikes a similar tone stating that, “Science seeks to understand a universe that already exists, while technology is creating a universe that has existed only in the minds of inventors.” NOS and NOT are deeply intertwined, overlapping in numerous ways including the relationship between systems to develop core competencies, tools and systems of data and measurement, and the need for relevant content to support meaningful learning.

ITEA identifies three standards students should understand about the nature of technology to become technologically literate as follows:

- 1) Students will develop an understanding of the characteristics and scope of technology
- 2) Students will develop an understanding of the core concepts of technology

3) Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

These three standards function to collectively create proficiency in utilizing technology, an understanding of core concepts, and a study of continuity and relationships across systems in technology. This echoes the three dimensional learning of science practices, disciplinary core ideas, and cross-cutting concepts. In both science and technologies there are components of both “knowing” and “doing” that are complimentary to each other. Furthermore, understanding how different technologies work together, just as fields of science are interrelated, reveals patterns across systems similar to the cross-cutting concepts of science.

More concretely, technology provides science with functional tools for investigation. From slow-motion video, stopwatches, thermometers, accelerometers, photo-gates, and countless other examples, technology provides tools that support scientific investigation in a variety of methods. Furthermore, there is a common numerical language of measurement shared by the science that seeks to understand phenomena and the technologies that help us to record, analyze, and measure its components. In seconds, centimeters, amps, degrees, and Newtons, we collect data using technology to be interpreted by science. The data collected provides evidence in support of a hypothesis. Technology also provides students with access to the existing body of scientific knowledge. In this way technology provides a doorway to ways of knowing and traces a historical path of how that knowledge has changed in light of new evidence.

Finally, as with science, it is critical to create relevance as a foundation for why technological competencies are important. ITEA Standards for Technological Literacy explains, “Learning becomes more meaningful when students can connect knowledge gained in the classroom to their everyday experiences.” This is consistent with our readings from NGSS, Ladson-Billings, Larkin, STEM Teaching Tool Briefs, and countless others. As ITEA describes, technology is “how humans modify the world around them to meet their needs and wants or to solve practical problems.” Technology, therefore, is a valuable tool to further our understanding of nature and to address real and complex problems that matter to my students such as tracking

and reducing local plastic pollution, climate change, community food deserts, or protecting urban wildlife.

Burton stated, “content knowledge is not enough to develop a literate citizenry.” Science and technology work in harmonious concert to help us explore and investigate the world. NOT is the study of humans influencing the world, and [NOM] is about humans understanding the mechanisms in nature” (Burton). Crafting rich, relevant, and complex learning experiences using science and technology will support students today in developing skills, practices, and knowledge to address the multi-faceted challenges of tomorrow.

Resources

Anderson, Paul. *Scientific Phenomenon and Sensemaking*. Bozeman Science.

<https://www.youtube.com/watch?v=3ps3Js-psgo>

California Academy of Sciences. “Academy Scientists describe 71 species in 2019.”

<https://www.calacademy.org/press/releases/academy-scientists-describe-71-species-in-2019>
(February 15, 2020).

ITEA Standards for Technological Literacy

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

Ladson-Billings, G. (2007). I used to love science and then I went to school: The challenge of school science in urban schools. *Teaching science to every child: Using culture as a starting point*, xiii-xix.

Larkin, D. B. (2011). Before today I was afraid of trees: Rethinking nature deficit disorder in diverse classrooms. *Rethinking Schools*, 26(1).

NGSS Appendix D – All Standards, All Students

NGSS Appendix H - Nature of Science in the NGSS

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

University of California, Berkeley. *Understanding Science: How Science Really Works*

<https://undsci.berkeley.edu/teaching/misconceptions2.php> (February 15, 2020).

Acoustic Levitation Videos:

Harvard Natural Sciences Lecture Demonstrations. <https://youtu.be/XpNbyfxxkWE>

Physics Girl’s DIY acoustic levitator. <https://youtu.be/ABjRnSYw-4k>

Smarter Every Day Acoustic Levitation in Ultra Slow Motion (134).

<https://www.youtube.com/watch?v=0K8zs-KSitc>