The Nature of STEM

a) engage in a critical reflection of how you address the tenet(s) currently in your teaching. Describe how you currently address the tenets. You may talk about one specific lesson or activity that you use to address the tenet. If you do not address any of them, talk about the way that your curriculum treats the nature of science. (about 1 page)

My class, Interdisciplinary Science and Research (ISR), does not follow NGSS as the specialized program focuses instead on prioritizing teaching the nature of science (scientific habits of mind and tenants of a scholar, as opposed to being confined to any one curriculum). Thus, I am perfectly aligned to instilling a deep understanding of the nature of science (NOS) in my students. The NOS encompasses several tenets, including: 1) **the empirical nature of science**, 2) **the idea that scientific knowledge is open to revision with new evidence,** and 3) **the theory-laden nature of observations**. In my teaching, I strive to address these tenets to help students appreciate the complexities and nuances of scientific inquiry. One of my favorite units to teach in my program is the Environmental Toxicology unit, which hits on crosscutting concepts relevant to environmental science and biology. The specific lab I will discuss focuses on the effects of pollutants on Brine Shrimp.

In the Brine Shrimp experiment, ISR juniors engage in hands-on scientific inquiry by designing and conducting experiments to test the impact of various pollutants on Brine Shrimp survival rates. This activity emphasizes the empirical nature of science by requiring students to make observations, collect data, and analyze their findings. Students learn to value empirical evidence as the foundation of scientific knowledge, understanding that observations and experiments are crucial in testing hypotheses and drawing conclusions.

Throughout the experiment, I highlight the tentative nature of scientific knowledge. Students are encouraged to consider how their results might change with different variables, conditions, or more precise measurements. For example, students are instructed to begin the experiment with 5 increasing levels of pollutant concentration: 0% (control), 1%, 2%, 5%, and 10%. However, after completing one trial of the experiment, they have the option to change the concentration amount to see how results might change, or to change the pollutants tested. This allows for things to change and keeps me and everyone else on their toes to read the results. We end the lesson with discussions on how scientific understanding evolves over time with new evidence and perspectives; for example, comparing their findings with historical data on how similar contaminants have hurt native animal or plant populations.

I also address the theory-laden nature of observations by encouraging students to reflect on how their background knowledge and preconceived notions influence their interpretation of data. Before conducting the experiment, students research different types of pollutants and their known effects on aquatic life. This research informs their hypotheses and experimental design, illustrating how scientific observations are shaped by existing theories and knowledge. Through this process, students recognize that scientific observations are not entirely objective but are influenced by the theoretical frameworks that scientists bring to their work.

b) consider how you might enhance your teaching to address the tenet(s) outlined in Appendix H. You may review and cite resources from the course as well as others (please cite them). Discuss specifically how your thinking/understanding of the "nature of" is dynamic. (about 1 page)

For this question, I will choose to address the NOS tenet "Science as a Human Endeavor." This tenant emphasizes that science is conducted by people and is inherently influenced by human experiences, values, and cultural contexts. This perspective recognizes that scientific inquiry is a dynamic, evolving process shaped by the contributions of diverse individuals and communities. I will discuss how I plan to better apply this tenant in a unit on water quality that I plan to teach to my junior ISR-III class in Spring 2025. Specifically, I plan to highlight how human nature and societal influences have driven advancements in the field of water resource management. By doing so, I aim to help students appreciate the human aspects of scientific work and the collaborative efforts that drive scientific progress.

To better illustrate "Science as a Human Endeavor," I might incorporate historical case studies that highlight key figures and milestones in water quality science. I already discuss the work of John Snow, who traced the source of a cholera outbreak to a contaminated water pump in 19th-century London (Johnson, 2006), at the start of a subunit on biological contaminants. This case underscores how human ingenuity and the application of scientific methods can address public health crises. It is a good start and helps to showcase the human challenges and societal impacts that have driven scientific discoveries. However, it is necessary to further emphasize the collaborative nature of water quality science. To that end, I could showcase the contributions of diverse scientists and communities. For instance, I might discuss the role of indigenous knowledge in understanding and managing water resources. Indigenous communities have long practiced sustainable water management, and their knowledge systems have informed modern water quality practices (Berkes, 2018). I believe I would choose to focus on sub-Saharan communities in Uganda, where a partner of mine (Josh Kurtz, with the Ayin Project) works. Highlighting these contributions can help students appreciate the value of diverse perspectives and the collaborative efforts required to address complex environmental issues.

Addressing the ethical dimensions of scientific work is another way to enhance the module. Students could explore how human activities, such as industrialization and agriculture, have impacted water quality. Examining case studies of pollution events, such as the Flint water crisis, would allow students to understand the social and ethical implications of environmental science (Clark et al., 2016).

Discussing these cases would encourage students to consider the responsibilities of scientists and policymakers in protecting public health and the environment. To show how scientific inquiry in water quality is driven by societal needs and priorities, I might highlight how public awareness and advocacy have influenced research agendas and policy decisions. For example, the Clean Water Act of 1972 was a response to widespread public concern about water pollution in the United States. This legislation spurred significant scientific research and technological innovations to improve water quality (Copeland, 2016). By exploring these connections, students could see how societal values and activism shape scientific endeavors.

I could also discuss the role of technology in advancing water quality science. Students might learn about cutting-edge techniques, such as remote sensing and advanced chemical analysis, that have revolutionized water quality monitoring and management. Emphasizing that these technological innovations are the result of human creativity and collaboration would be key. Looking to the future, I could encourage students to consider how emerging technologies and interdisciplinary approaches can address ongoing water quality challenges (Ritter et al., 2002).

By focusing on "Science as a Human Endeavor" in the water quality module, I aim to provide students with a holistic understanding of science as a dynamic, human-centered process. Through historical case studies, recognition of diverse contributions, and exploration of ethical and societal influences, students would gain a deeper appreciation for the collaborative and evolving nature of scientific inquiry. This approach would not only enhance their scientific literacy but also prepare them to engage thoughtfully and responsibly with scientific issues in their own lives and communities.

References

- Berkes, F. (2018). Sacred Ecology. Routledge.
- Clark, A., Brunkard, J., Stiefel, M., Yoder, J., Roberts, V., & Mohammad, Q. (2016). Outbreaks of Waterborne Disease Associated with Drinking Water — United States, 2011–2012. MMWR. Morbidity and Mortality Weekly Report, 63(55), 29-32.
- Copeland, C. (2016). The Clean Water Act: A Summary of the Law. Congressional Research Service.
- Johnson, S. (2006). The Ghost Map: The Story of London's Most Terrifying Epidemic—and How It Changed Science, Cities, and the Modern World. Riverhead Books.
- Ritter, L., Solomon, K., Sibley, P., Hall, K., Keen, P., Mattu, G., & Linton, B. (2002). Sources, Pathways, and Relative Risks of Contaminants in Surface Water and Groundwater: A Perspective Prepared for the Walkerton Inquiry. Journal of Toxicology and Environmental Health, Part A, 65(1), 1-142.

c) read an additional document from the list above that addresses the “nature of” a different discipline. Identify 3 ways in which your content area overlaps with the second area that you selected.
If you teach math, begin the exercise by using the Common Core Mathematics Practices as your primary document and repeat the steps listed above. If you are a technology teacher, use the ITEEA document. Generalists may select any document to begin; the one most relevant to your work.

After reading the ITEEA document to familiarize myself with Technology standards, I see the following specific ways that my content area overlaps with technology:

1) **Design in Technology and Engineering Education:** Integrated within this standard are the practices of communication and collaboration. My content requires a lot of collaboration between students in groups, and I also harp on them presenting their information in a coherent way. Further, I do integrate opportunities for students to build and design their own structures – for example, a protective device to fit over a head and protect a dummy from a concussion.

2) **Nature and Characteristics of Technology and Engineering**: This requires the practices of attention to ethics and systems thinking. Ethics are something that my seniors must adhere to when designing their own independent research projects, and they must get all projects approved by an SRC (scientific review committee). Additionally, I frequently ask them to pull concepts from multiple domains in order to see a concept as an interconnected system.

3) **Impacts of Technology:** Naturally, technology is embedded in today's science classroom. Whether students are integrating GPS data for a unit on water quality, MatLAB for statistics, or PowerPoint for presentations, students must master their use of technology and how it impacts our ability to analyze data and present results.