When I first experienced the shift to NGSS while teaching in Hillsborough county FL, I was unsure of how to teach the nature of science without the "Scientific Method." I am still guilty of overemphasizing the importance of things like isolating variables, mostly to calm my need to organize information. Following our work thus far in this class learning how to create a unit as a "Storyline" using phenomenon, I am feeling more confident and excited to start the new school year! The Goals of NGSS and STEM are the same goals that I have worked to instill in my students every day since I first started undergraduate courses. These goals are to develop scientifically literate citizens who ask good questions and think critically about information as well as collaborate with others to solve problems. Statements I make repeatedly with students are, "You may not love Science and that is ok, but you will develop the skills to understand the information in the world around you. Thinking about what you hear and see every day IS Science. You don't have to like Science or even my class, but you will leave with an understanding of how Science is relevant in everything in you and around you." I spend one day a week teaching Social-Emotional Learning (SEL) and always tie it to Biology, Chemistry and Psychology. Our social and emotional state and overall growth connect to how our body and mind develops. Cultivating scientifically literate citizens is more important now than ever as information bombards us every day at an unprecedented rate. The need to evaluate and critically analyze the information is paramount to making good decisions and forming opinions.

I believe I address the following tenets well. The first tenet: Scientific knowledge changes. Like in life, change is the only constant. This comes up every day when there is a real life example for us to adapt to something changing in our world. Anytime we receive new information about any topic, we practice applying it to what we already think about something. This is especially applicable to the changing social conditions of middle school students. When

drama arises, we can use it to show this process of Science. Take the opportunity to ask kids questions like: How do you currently feel about the person/situation? What new info did you receive? Is it credible? How do you know? What conclusions can you draw? How have your thoughts about this person/situation now changed or not changed and why? Each day when students come in the room saying something about someone or something, I usually try to get them to prove WHY they think/say what they do. “What is your evidence for that?” is a question I ask constantly, just to get them to start identifying how to “prove” what conclusions they have drawn about someone/something. This leads to the second tenet: the empirical nature of Science. Using real-world examples as well as student-generated inquiry, I am able to refer students back to the process of science or the habits of mind. Discussing how scientists collect evidence and design investigations to answer their questions is applicable every day. Schwartz, 2007, reminded me to explicitly define and use correctly terms such as data and evidence, law and theory. Following our class discussion on June 1 with information on the NASA “New” circular model of the “Scientific Method,” I am excited to get more in depth with my students at how scientists answer questions about how the world works using an empirical process. More specifically, how experiments and investigations may differ. This will help with the students who come in everyday and ask to do an experiment.” Using the phenomenon that we are learning about to help develop units that are more like a storyline, I feel confident that I will be able to plan units that provide students with the investigative experience every day in class.

The fourth tenet: Science is subjective in nature, connects well with my SEL units. When the students begin to understand that we are human begins, that this means nature (how biology works) and nurture (how our environments affect us) influence us, then they begin to see that we each have individual filters for how we see life. The connection to STEM is that just by being

human, we can influence the Science we are doing because of how we interpret data and form conclusions to develop evidence. Using the weekly SEL strategies, we often make connections to identify what we perceive versus what is reality. We identify the terms subjective versus objective as well as practice them. We can often connect this tenet with the empirical nature of Science tenet. After asking about evidence/data. Then I ask, "Why?" Why do you think that? This reveals the filters we all have as human beings and opens up for discussion of different interpretations of data.

The fifth tenet: Science is embedded in our society and culture is perhaps the most important in today's world. Using examples from students' everyday lives shows the relevance of Science. As students spend more and more time using technology and devices for learning and everyday life, it is more important than ever to help them see how Science can help understand and evaluate the information they are receiving. We spend time in class learning about how technology affects our brains but also how it helps us grow and advance as a society.

The tenet that needs enhancement in my classroom is the third one: Inferential, imaginative, creative and creative nature of Science. Making the leap from the data to conclusion using evidence is a difficult cognitive activity. It demands higher level thinking skills and effort that most of us in our immediate gratification society are not willing to put forth. It is important to teach our youth to do this as they grow so it becomes second nature to evaluate and synthesize information as they receive it. The IPS (Introductory Physical Science) curriculum design is around this and is the reason it was tougher for most students. They could not look up the answer in text or other sources. Their answer had to come from their evaluation of the evidence after collecting the data. I find this step the most difficult for the younger, more concrete students. At

early to mid-adolescence the brains of students are still developing the ability to be able to make connections, evaluate and synthesize to formulate conclusions.

The other “Nature of” discipline that overlaps well with the nature of science is the Nature of Math. Each “Nature of” discipline connects with Science and I look forward to addressing my weaknesses: connecting technology and engineering to Science. However, I feel confident making connections with Math to start with. I found the document, *NGSS Appendix L: Connections to CCSS Mathematics*, very useful in answering many questions I had throughout this year with integrating math skills into science lessons. This document opened my eyes to how easy it is to see what Math standards align with the NGSS. Table 1 is very helpful to know which grade level that students learn certain concepts. I have found other specific examples in the document that connect with my curriculum and am excited to discuss with my Math teacher in preparation for planning next year. Three specific examples from the Math document that connect to the NGSS standards are:

- MS-ESS3 Earth and Human Activity As part of this work, teachers should give students opportunities to use ratios and proportional relationships and use order of magnitude thinking: Ratios and Proportional Relationships (6–7.RP). Science example: Work with measurement quantities that are formed through division, such as atmospheric concentration of CO2.

- MS-ESS2 Earth’s Systems As part of this work, teachers should give students opportunities to work with positive and negative numbers, and use order of magnitude thinking: The Number System (6–8.NS). Science examples: (1) Use positive and negative quantities to quantify changes in physical quantities such as atmospheric pressure and temperature; for example, if the temperature dropped from 24oC to 11oC, then the temperature change was −13oC.

- The Number System (6–8.NS). Science examples: (1) Use positive and negative quantities to represent temperature changes in a chemical reaction (signs of energy released or absorbed).

References

Tenets of the nature of Science https://www.sciencelearn.org.nz/resources/413-tenets-of-the-nature-of-science

What's in a Word? How Word Choice Can Develop (Mis) conceptions about the Nature of Science. *Science Scope*, *31*(2), 42-47. Schwartz, R. (2007)

NGSS Appendix L: Connections to CCSS Mathematics https://www.nextgenscience.org/sites/default/files/Appendix-L_CCSS%20Math%20Connections%2006_03_13.pdf