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SCED 549: Methods of STEM Education

### Nature of Science

Research studies have indicated that student interest in STEM in the western world has declined (Kelley & Knowles, 2016). Now more than ever, there is a demand for improving STEM education that would allow students to “live, learn, and work as productive citizens engaging in integrated STEM issues, problems, and projects (Nadelson & Seifert, 2017, p. 222)” to prepare them for the STEM workforce. Integrated STEM education requires a seamless combination of science, technology, engineering, and mathematics, however, content knowledge of these subjects is not enough. Instruction on the nature of the STEM subjects is necessary for students to understand the reasoning of what they learn and provides them with a framework to be successful in each discipline (Peters-Burton, 2014). In my eighth grade physical science classroom, I foster the nature of science with my students. Since physical science consists of chemistry and physics, I support some of the nature of mathematics practices, as well.

One of the nature of science tenets that I focus on is “Scientific Investigations Use a Variety of Methods”. When my students learn a new topic, they interact with the material in multiple ways. For example, before learning about the concept of density, my students complete an inquiry mini-lab in which they determine which objects float or sink in various liquids. The outcomes usually puzzle my students and make them question why certain items float while others sink. We also create density columns to demonstrate further that substances have a unique property that allows them to separate from each other. With my students perplexed, I teach the concept of density and its calculation. Using this knowledge, students complete a variety of hands-on or virtual labs to calculate the density of objects, or identify mystery items based on known densities. By the end of the unit, my students have used a variety of methods to make observations and measurements to gain a conceptual understanding of density, which they are able to apply to real-world situations.

I also focus on the tenet of “Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena”. When teaching, I am very careful about my word choice when describing bodies of scientific knowledge. Although this concept is taught in both sixth and seventh grade, my students enter eighth grade with misconceptions about hypotheses, theories, and laws. Physical science involves many theories, such as the atomic theory or the kinetic theory of gases, as well as many laws, such as the law of conservation of mass or energy or Newton’s laws of motion. Each time we encounter a new theory or law we review the differences between these two concepts. Through labs and applications of theories and laws, my students begin to understand that theories are explanations of observations of the natural world, while laws are statements or mathematical descriptions of the relationship between natural phenomena.

Our continued study of laws and theories throughout the year also helps foster the tenet of “Scientific Knowledge Assumes an Order and Consistency in Natural Systems”. For example, when studying motion and energy, students realize that Newton’s laws govern all motion, and the energy input to cause a motion must be transformed into other forms according to the law of conservation of energy. The same is true for mass due to the law of conservation of mass. Using this law, students understand why chemical reactions must be balanced and understand how phase changes simply transform matter into different forms. Since motion or interactions among matter occur in consistent patterns, students are able to make predictions and apply their knowledge to other scenarios.

As I continue to enhance my teaching and students’ learning, I would like to focus on the tenets of “Science is a Human Endeavor” and “Science Addresses Questions about the Natural and Material World”. Each year my students complete an independent science project in which they pose a question, form a hypothesis, conduct an investigation, collect data, and report their findings as a presentation to the class. The students really enjoy the project because they get to pick their topic and take ownership of their investigation. However, we only do this project once at the beginning of the year. The project is

rather linear and structured with due dates for each component and set requirements for the presentation.

According to Bell and Bang, to make learning relevant and relatable, teachers should “design learning experiences to grow out of the lives of learners (2015).” One way to enhance these tenets in my classroom is to allow my students to research a topic that interests them. Like Ladson-Billings, I could ask my students, “What do you want to know about yourself?” and “What do you want to know about the world?” (2003, p. 4). By formulating their own questions, and finding the answers to their personal questions with teacher support, my students would be engaging in true, authentic science practices.

Larkin (2011) suggests tapping into community resources and educating students about their community to make science education relevant and relatable to students. One way to involve the community is to form partnerships with businesses or industries that could show students how science is applied in their field. I would also like to get my students more involved in the community. Perhaps we could brainstorm a community issue that we could try to solve or improve. Involvement of community members and involvement in the community will help my students realize that science is a human endeavor and used to address questions about the natural and material world.

Although the focus of my classroom is fostering the nature of science, I also help support some nature of mathematics practices. In physical science, we use a lot of math, especially when studying physics. At first, my students moan and groan when they have to do math in their science class, but I explain to them that math is the language of science, and you cannot understand one without the other! My students apply the mathematical practice of “make sense of problems and persevere in solving them” rather frequently. The math teacher and I collaborated to create a common language of problem-solving steps to use in both of our classes. When we solve a math problem in science dealing with density, speed, velocity, kinetic or potential energy, or forces, we approach the problem in the same way. First, we identify given information, then formulate a plan and determine a solution, next explain

why the solution is reasonable, and finally prove how the solution is correct. By teaching problem solving in this manner, students can easily make sense of a problem and check that their answer makes sense.

Using this problem-solving method also helps my students exercise the mathematical practice of “construct viable arguments and critique the reasoning of others.” My students cannot simply solve a problem and be done. They must explain why their answer is reasonable. This explanation piece is key to making arguments in math and science. Another way this practice is enhanced is through error-analysis activities. Various times throughout the year, groups of students are given several samples of lab write-ups, open-ended responses, or math problem explanations and are asked to “grade” each sample in the set. The error-analysis activities help students determine positive and negative qualities of responses and encourages them to improve their own work.

Lastly, the mathematical practice of “model with mathematics” is regularly incorporated into my classroom. Students must be able to determine relationships from diagrams, data tables, or graphs. Additionally, when completing labs, students create their own representations of their data in the form of tables or graphs for their audience. The math teacher and I also collaborated on a graphing rubric to use in both of our classes to ensure that our students can create informative graphs with all necessary components. We hope to continue our collaboration, so more science and mathematical practices can be expressed across both of our disciplines.

To conclude, integrated STEM education requires content knowledge and practices from each of the STEM subjects. Although I currently foster many of the nature of science tenets in my classroom, I continually plan to improve my teaching so science is more relevant and personal to my students. Furthermore, I hope to incorporate more nature of mathematics practices, as well as nature of technology and engineering practices, so my students can be exposed to more STEM in the classroom.

## References

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