NGSS Scientific Practices in an Elementary Science Methods Course: Preservice Teachers Doing Science

by Judith Morrison, Washington State University Tri-Cities

Abstract

To engage elementary preservice teachers enrolled in a science methods course in authentically doing science, I developed an assignment focused on the NGSS scientific practices. Unless preservice teachers engage in some type of authentic science, they will never understand the scientific practices and will be ill-equipped to communicate these practices to their future students or engage future students in authentic science. The two main objectives for this assignment were for the PSTs to gain a more realistic understanding of how science is done and gain confidence in conducting investigations incorporating the scientific practices to implement in their future classrooms. To obtain evidence about how these objectives were met, I posed the following questions: What do PSTs learn about using the practices of science from this experience, and what do they predict they will implement in their future teaching relevant to authentic investigations using the scientific practices? Quotes from preservice teachers demonstrating their (a) learning relevant to doing science, (b) their struggles doing this type of investigation, and (c) predictions of how they might incorporate the scientific practices in their future teaching are included. The assignment and the challenges encountered implementing this assignment in a science methods course are also described.

Introduction

With the advent of the *Next Generation Science Standards* (NGSS; NGSS Lead States, 2013), an increased focus on introducing and modeling the practices of science and engineering has occurred. Preparing future elementary teachers with an understanding of and experiences with scientific practices is central to ensuring that elementary students will be engaged in the practices of science. As stated by the National Research Council (NRC) in the *Framework for K-12 Science Education* (2012), students must participate in scientific practices in order to understand them: “Students cannot comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without directly experiencing those practices for themselves” (p. 30).

Preservice teachers (PST) may never have had authentic experiences with the practices of science in their previous education (Kloser, 2017; Tsybulsky & Muchnik-Rozanov, 2019). In past science courses, their experiences may have been “cookbook” in nature, and their own ideas and questions may have never been incorporated or investigated. According to the National Academies of Sciences, Engineering, and Medicine’s (2018) *Science and Engineering for Grades 6–12: Investigation and Design at the Center*, PSTs need to be involved in coursework in which they carry out authentic investigations in order to prepare them to engage their future students in this type of science learning. Direct experiences in authentic inquiry and the practices of science are where deep learning about the practices of science occurs. Research (Chalmers et al., 2017; English, 2017) has shown that engaging in the authentic work of science requires students to think more deeply and struggle with nonroutine problems and challenges. Project-based learning research (Darling-Hammond, 2008) has shown that student-centered, inquiry-based projects enhance student problem-solving skills, motivation, and conceptual understanding.

Project-based learning, involving inquiry and problem-solving, can help fill a critical need for PSTs to experience using higher order thinking skills such as creativity and innovation rather than being limited to lower order skills such as memorizing facts and repeating procedures (Krajik et al., 2008; Lesh & Zawojewski, 2007). As Li et al. (2019) have stressed, applying critical thinking skills when working with information results in more effective learning and application of that information. If PSTs have opportunities to experience this type of thinking through authentic science investigations, with subsequent reflection on their own learning and their future use of similar instruction, they will be better prepared to implement this type of teaching. As Tsybulsky and Oz (2019) found, engaging in authentic science investigations improves PSTs' feelings of satisfaction toward and attitudes about this type of learning. When PSTs in a science methods course carry out their own investigations and experience the NGSS scientific practices in an authentic context, they exhibit growth in understanding what "doing science" entails. As Duschl and Bybee (2014) stated:

> If students only encounter preplanned confirmatory investigations following step-by-step procedures that ensure the desired outcome occurs, then important and relevant thinking and designing practices and struggles that are part of doing science and engineering get stripped away. When the struggle of doing science is eliminated or simplified, learners get the wrong perceptions of what is involved when obtaining scientific knowledge and evidence. (p. 1–2)

My guiding principle in developing an assignment that incorporated the NGSS scientific practices was that unless PSTs engage in some type of authentic science, they will never understand the nature of science and scientific practices, will be ill-equipped to communicate these practices to their future students, and will be unprepared to engage future students in authentic science.

Course Context

In our program for elementary education majors, similar to many across the country, there is one science methods course required. The PSTs in this program take a number of specific content methods courses other than science: mathematics, health and physical education, integrated arts, social studies, and two language arts methods courses. They also are expected to take courses in one area of specialization for their minor (endorsement area): English Language Learning, Special Education, or Middle Level Mathematics. The PSTs in this course are either in their junior or senior year in a bachelor's program at an R1 (very high research activity) university.

The science methods course is all they have to prepare them to teach science, engineering, environmental science, and technology. This course is designed to introduce PSTs to the *Next Generation Science Standards* (NGSS). Because our state adopted the NGSS in 2013, PSTs will be expected to implement and use the standards in their future classrooms. To that end, it is critical that the PSTs in the science methods course know all parts of the NGSS and how to use the various dimensions when planning for and carrying out instruction. What I found early on was that the science and engineering practices were a list of skills that the PSTs read about and possibly memorized. They were able to identify scientific practices when given descriptions from the NGSS; however, they were not able to meaningfully incorporate the practices into lesson plans or model lessons.

In order to immerse the PSTs into the NGSS scientific practices, I designed a science notebook assignment so that they engage in the practices by individually carrying out an authentic science investigation over the course of the semester. Because the science methods course was already quite full of essential topics such as assessment, student learning, the nature of science, integration of science, engineering, sustainability, and curricular materials, it was difficult to find time for a long-term science investigation in which doing "real" science could be modeled. Therefore, this investigation assignment is completed predominantly outside of the methods course on PSTs' own time. Because the assignment is conducted on the PSTs' own time at home, this assignment works very well when conducting classes remotely. All instruction on experimental design and investigation planning can be done in virtual classes, and PSTs are able to work on data collection and analysis on their own time.

Overview of the Science Investigation Assignment

The science investigation assignment occurs throughout the full 15-week semester and immerses the PSTs in a full science investigation. They identify a topic and research question, plan and carry out the data collection, and spend the final 3–4 weeks of the semester analyzing data, generating explanations, and finalizing their presentations. The general timeline for the assignment is provided in Table 1.

Table 1
Science Investigation Assignment Timeline

Week	Individual investigation components
1–3	Introduction, experimental design, and topic selection
2–3	Work on and get instructor approval for research questions
3–11	Investigation set up, data collection, and periodic check-ins
11–13	Finalize collection, carry out analysis, and work on explanations
13–15	Final presentations

PSTs are required to collect data for a minimum of 6 weeks so that they have time to make mistakes and start over if needed or follow tangents in their investigation if they come up. After their data collection is complete, they also need to have time for data analysis, further research, and communication of their results and conclusions (see Supplement 1 for the assignment rubric). The part about making mistakes is critical. I want them to learn that science does not always follow a straight path from question to answer and that there can be a number of failures that scientists use to learn and move forward. I also want them to understand that doing a 45–50 min science activity in a classroom is not really "doing science" but enacting a model of what is already known. I want them to spend a significant amount of time on their investigation in order to learn that gaining scientific knowledge takes time; it is not done in a 45–50 min activity.

I had previously used a version of the science investigation assignment (Morrison, 2008) to introduce students to inquiry science, but I added a focus on the NGSS scientific practices. I introduce the assignment at the beginning of the semester when the PSTs are learning about the nature of science. During the second and third weeks of the course, we discuss formulating meaningful research questions, experimental design, variables, and controls, and the PSTs practice formulating questions and designing and carrying out experiments in which they work with dependent and independent variables (e.g., force and motion or heating and cooling).

The students start their own investigations by identifying a topic that they are interested in and are able to pose questions about. The PSTs are given possible topic areas to use to form their investigation: plant growth, invertebrates, weather, or lunar phases. They may also select another topic area that interests them. After being given a week to consider their area of interest from the four topics provided or suggest their own area of investigation, as a class, we discuss the differences between experimental investigations (e.g., plants or invertebrates) and observational investigations (e.g., weather or lunar phases) and discuss and do an activity on what makes a good research question. The students then identify one or more questions for investigation and share and revise these in small groups. When teaching remotely, the PSTs also submit their topic, potential research questions, any materials needed, and any questions that they might have to the instructor. Feedback is given regarding their question. If they do not start with a valid question, they cannot carry out a meaningful investigation. The criteria specified the following: Questions must lead to long-term data collection (at least 6 weeks), and the questions cannot be so simple that the PSTs already know or can easily guess the answer (i.e., Do plants need light, or do worms need food?).

The class time throughout the semester used to work on the investigations is minimal. The expectation is that the PSTs will carry out their investigations by themselves, at home, on their own time, making this a good assignment for remote delivery of a methods course. PSTs meet in groups of similar research focus for 15–20 min three or four times during the first month to make sure that they have a chance to provide each other support and get help as needed. If teaching the course virtually, this can be done in breakout rooms. We have a class discussion about the ideas that science is a collaborative endeavor and that learning occurs from sharing ideas, accessing resources, and often making mistakes. I make an effort not to provide too much guidance for the PSTs' investigations. I often get questions about whether they are "doing it right" or "is it wrong if…," which I respond to by stressing that science is a way of finding things out. I will not tell them exactly what to do or what not to do. I do encourage the PSTs to try out questions, methodology, and ideas and encourage them to view mistakes as a way to narrow down their investigation. This nonintervention strategy forces the PSTs to do more searching for answers using the Internet or their peers and leads to a more authentic investigation than if they followed a specific set of guidelines predetermined by the teacher.

To ensure that the PSTs do not have to buy materials for these investigations, I provide materials as needed. There is a small course fee associated with the class for consumable materials that I use to purchase materials for the investigations, such as potting soil, cups, and seeds for plant growth investigations or small plastic terraria, thermometers, and crickets or beetles for invertebrate investigations. The PSTs are free to use any materials that they choose; there is no requirement to use the specific materials provided. The majority of the PSTs usually choose plant growth to explore in their investigations. Typically, out of a class of 20 PSTs, I have one person who chooses to do an investigation on invertebrates and five to six people who choose to do observational investigations on lunar phases or the weather. The typical investigation questions that PSTs studying plant growth pose have to do with exploring different substances as fertilizers, differing soil materials, differing amounts or types of light, or temperature variations and their effect on plant growth. PSTs conducting observational studies on the weather typically explore relationships between factors such as temperature, wind, precipitation, or barometric pressure. Those studying lunar phases explore relationships between various aspects of the moon such as phase, height above the horizon, time of day or night, or time of the month. Invertebrate explorations typically involve explorations of activity in response to temperature or light, exploration of food, or environmental preferences.

The Scientific Practices

Based on the practices outlined in the NRC's framework (2012), there are eight Science and Engineering Practices outlined in the NGSS (NGSS Lead States, 2013):

- "Practice 1: Asking Questions and Defining Problems" (p. 51),
- "Practice 2: Developing and Using Models" (p. 53),
- "Practice 3: Planning and Carrying Out Investigations" (p. 55),
- "Practice 4: Analyzing and Interpreting Data" (p. 57),
- "Practice 5: Using Mathematics and Computational Thinking" (p. 59),
- "Practice 6: Constructing Explanations and Designing Solutions" (p. 61)
- "Practice 7: Engaging in Argumentation from Evidence" (p. 63), and
- "Practice 8: Obtaining, Evaluating, and Communicating Information" (p. 65).

In the science methods course, the NGSS Science and Engineering Practices are introduced and described, and examples are provided. The introduction and description involve the PSTs reflecting on activities done in the class during the first 2 weeks (on states of matter and physical and chemical changes) during which they engaged in posing investigable questions, model building, data collection, analysis, and interpretation, and construction of explanations. This provides an introduction to what the eight practices are; however, without actually carrying out a complete investigation, these may not be meaningful. In addition to the eight NGSS scientific practices, I also provide the PSTs with Duschl and Bybee's (2014) 5D model to help them understand the steps in data collection and analysis:

1. Deciding what and how to measure, observe, and sample;
2. Developing or selecting procedures/tools to measure and collect data;
3. Documenting and systematically recording results and observations;
4. Devising representations for structuring data and patterns of observations; and
5. Determining if (1) the data are good (valid and reliable) and can be used as evidence, (2) additional or new data are needed, or (3) a new investigation design or set of measurements are needed. (p. 5)

As a class, we hold a discussion about the 5D model in which I ask the PSTs to discuss in small groups why each component of the model is critical to the completion of an investigation. As PSTs carry out their investigations, I encourage them to use the 5D model as a checklist to help them understand the process of the investigation as a whole.

The science investigations are assessed through the evidence PSTs provide that they have authentically engaged in a science investigation. They submit their science notebooks containing the full investigation, they present a 15–20 min overview of the investigation during the final class sessions (see Supplement 2 for a presentation rubric), and they complete a full reflection paper about their learning and future use of science investigations. In the presentation, they identify their research question and describe how it was formed and developed. They also describe why they chose the topic area and any prior knowledge they held. The PSTs communicate their full investigation plan in a methodology section in which they fully describe questions, predictions, prior knowledge, materials, data collection, and resources utilized. They describe how they analyzed and interpreted the data collected; they are required to display their data in tables, charts, and graphical form, ensuring that they incorporate mathematics. They are expected to use computational thinking as they search for patterns and generally work with data to determine evidence to support their claims. The PSTs write up a formal explanation of their conclusions in which they make a claim based on both the evidence they collected and research they carried out on their topic. The investigations and final presentations are graded on their completeness and how well the PSTs have identified and described the scientific practices they have engaged in. They are also required to provide reflections on how the investigation impacted their learning, both of science content and on their future science teaching. The PSTs do not all complete a well-developed science investigation, and the reasons for and concerns regarding this aspect of the assignment are discussed in a later section.

Evidence of PST Learning

The two main objectives for this assignment are that the PSTs will gain a more realistic understanding of how science is done and gain confidence in conducting an investigation that incorporates the scientific practices to implement in their future classrooms. My hope is that they will see that the NGSS scientific practices are essential parts of even a basic investigation such as exploring plant growth. To obtain evidence about how these objectives are being met, I posed the following questions: What do PSTs learn about using the scientific practices from this experience, and what do they predict they will implement in their future teaching relevant to authentic investigations using the scientific practices? Additionally, I wanted to find out what PSTs said about any struggles they had in carrying out their investigation. According to Duschl and Bybee (2014), when the struggles of science are taken away and the process simplified, learners may get the wrong ideas about how scientific knowledge is generated. To answer all of these questions, I collected data from PSTs' investigation reports in their science notebooks, their reflection papers, and the final presentations of their investigations. In the reflection papers, the PSTs were asked to reflect on their perceived change in understanding of how an authentic science investigation is carried out and to predict if and how they would implement a similar investigation in their future classrooms. The PSTs' responses were categorized into quotes on their (a) learning relevant to doing science, (b) any struggles doing this type of investigation, and (c) predictions of how they might incorporate the scientific practices in their future teaching.

PSTs' Learning About Doing Science

A majority of the responses collected from PSTs over the course of 1 year (42 students) reflected that they felt they had learned about the process and practices of science and also about the science content associated with their investigations. The majority of the PSTs mentioned that they did learn about some aspects of doing science, such as finding patterns, not focusing on one “right” answer, or the inclusion of all critical aspects of an investigation. The following are some characteristic quotes from PSTs.

I think that I learned a great deal when I did my own investigation. It was very hard at first because I was trying to come up with a question, and I wanted to make sure I was doing the assignment right. After a while, I just kept collecting data and started looking for patterns. I think doing this on my own was real science.

I feel that by conducting my individual inquiry investigation, I have learned a lot. The investigation helped me learn that the importance of science is not getting a right answer but rather gaining new information and learning.

Broadly speaking, through conducting an individual inquiry investigation, I found that the overall inquiry process requires attention to detail, precision, and a can-do disposition that is action oriented. Additionally, the process of conducting an individual inquiry investigation has allowed me to understand the procedural elements such as planning, predicting, practice, active investigation, reflection, and re-designing/re-testing.

I enjoyed going through all the parts of an investigation with relative freedom, from finding a question, to conducting the experiment, to collecting and interpreting the data, to presenting the information. In the process, I was able to then go through all components of conducting science and still learning about the world around me and how plants function.

From the PSTs’ responses regarding what they felt they had gained from doing the investigation, the two main areas most often mentioned were an increased understanding and confidence about conducting an investigation and a greater awareness of the many aspects involved.

Struggles Encountered by PSTs

The assignment is difficult and a is new endeavor for most PSTs. I preface the assignment by telling them to expect to have some failures and dead ends and to view these as ways of extending their learning. From their responses and the comments they made throughout the semester, they felt that the assignment was challenging. I realize that many of the PSTs felt that admitting they had struggled and had setbacks was not acceptable; therefore, only a few wrote formal descriptions of their struggles, even though many expressed these verbally. From their descriptions of struggles, the PSTs demonstrated growth in learning that science investigations are typically complicated, often frustrating, and do not usually follow a straight path, thus demonstrating valuable growth in understanding the nature of science. The following are some remarks PSTs' made in their reflection papers about their struggles

I ran into a few obstacles (i.e., one plant not sprouting, my fan dying) which challenged the validity of my investigation. However, this is, I have learned, a much more authentic experience as to what investigations are really like. Of course, in the real world of science, obstacles occur during investigations.

I learned that more research prior to conducting an investigation may help prevent certain obstacles, while others simply become part of the investigation. Overall, it was a bit of an uncomfortable experience, I think, because I was taught the clean cut-version of science, with concise outcomes and clearly formatted investigation processes, this process felt a bit unnatural.

The personal investigation was interesting because the openness with which it was allowed to be designed had me struggling to figure out how I wanted to conduct my research. I am usually a very structured person who enjoys the rigidness of direct and clear instruction. Having the freedom to choose my own focus question, gather my data, and design my presentation really challenged me to think outside my box, and I enjoyed the accomplishment. Through completing my investigation, I feel more connected to the world around me and gave me insight into how complicated, tedious, and rewarding it can be to discover answers to your own curiosities. I can say, with confidence, I felt more successful in completing my investigation than I ever had doing any science project in school before.

From the PSTs' comments about the struggles they encountered, it is clear that many found it difficult to carry out such an open-ended type of assignment, but many said that it was satisfying to complete and that they gained confidence in doing science through this assignment.

The PSTs often struggled when developing an investigation question. Most of the students were able to finalize a valid question and proceed with the investigation, but a few in each class never developed more than a very simplistic question (e.g., How does light affect plant growth?). Even after being pushed to move away from questions for which the answers were common knowledge, some PSTs felt most comfortable using simplistic questions. Many of the PSTs struggled with the openness of the investigation assignment and asked for guidance. I tried to keep guidance to a minimum and encouraged them to be okay making mistakes and learning from those mistakes as they tried out various methods.

PSTs' Predictions for Future Use

In order for PSTs to introduce and engage their future students in the practices of science, they must have exposure to and understanding of the practices. I asked the PSTs to predict how they might use their experiences doing a science investigation and learning about the NGSS scientific practices in their future teaching. The PSTs saw that doing an investigation on their own was valuable and want their future students to have ownership in doing science. They also described how carrying out a full investigation inclusive of all aspects of "doing science" was important. The majority of the PSTs responded that they did want to use some type of investigation and provided responses stressing how important this will be.

For my students, earlier exposure to this creative and open approach to investigations, with a focus on scientific practices rather than outcome, will provide a more balanced and authentic understanding of what science is.

While conducting my investigation, I have accomplished going through the entire scientific process that I will have my future students do. It allowed me to learn about things that I want to ensure that I have my students do. For example, during my investigation, I felt like taking photos during my observations were helpful when I referred back to my observation notes.

Through the investigation, we were able to collect our data in a way that will make sense to us as long as we were able to explain it to others. I find the representation of data to be important too and is definitely something the students could have practice with at an early age. They will have their own investigation question, predictions, observations through writing, drawings, or pictures, measurements, communicating with their own notebook and/or others, and their own data collection they can consider referencing back to.

Many of the PSTs mentioned, as in the quotes above, that experiencing all aspects of an investigation, not just parts of it, was important for their own learning and will be important for their future students' learning.

The Challenges of Implementing Full-Scale Investigations in a Methods Course

One of the main challenges of implementing this assignment is that it requires PSTs to do work outside of class on their own time. Many of the PSTs in my classes are enrolled full time and also have families and jobs that require their time. I have decreased other work required in the course during the times when PSTs are spending the most time on their investigations (setting up and getting started collecting data at the beginning of the course and finishing up and preparing their presentations at the end of the course). I also have stressed that the PSTs should use the scientific knowledge they are gaining in their investigation when completing other assignments. They are encouraged to make connections to other course assignments, for example, using the science content they are investigating as the topic of the interview they conduct with an elementary student or as the basis for the lesson plans that they develop. I have also collaborated with the mathematics methods instructor to design lessons in which PSTs use their data in the mathematics methods class as they are learning about data display. For example, when the PSTs in the mathematics methods course did an activity designing graphs, the mathematics methods instructor and I planned the timing of this activity so that the PSTs in my course were able to use data from their own investigations rather than the data sets typically supplied for this activity. In the mathematics methods course, the PSTs had class time to work on developing data displays and graphs for the data collected in their science investigations, and they also received feedback from the instructor.

From the instructor's perspective, PSTs often have difficulty developing a meaningful and accurate conclusion and explanation of their results. Consequently, I have addressed including scientific explanations in the requirements for the assignment and incorporated more instruction on how conclusions are explanations rather than a restatement of the results.

Based on quotes from the PSTs, I have identified that designing and carrying out a full-scale investigation is supported by providing them with tools such as Duschl and Bybee's (2014) 5D model. The responses from the PSTs showed that they improved in their understanding of the critical parts of an investigation. For example, one PST stated that they "find the representation of data to be important too," and another said that conducting the investigation helped them "to understand the procedural elements." A full-scale investigation may seem overwhelming to many PSTs, but when broken down into steps, as in the 5D model, they are able to tackle one step at a time.

Although it is challenging to implement this complicated assignment, I have learned from the PSTs that what they get out of this experience is a stronger, more accurate understanding of doing science and a desire to implement similar investigations in their own classrooms. The investigation questions that they devise may not always be unique or complex, but to these often science-phobic PSTs, the questions are meaningful and allow them to collect data, organize and display those data, and propose an explanation of their results.

Implications

Engaging in authentic science investigations does not provide full comprehension of how science works or even a complete understanding of the NGSS scientific practices; however, it does provide PSTs an introduction to how scientific knowledge is created and takes a step toward erasing the misconceptions that many PSTs have that “cookbook” or hands-on activities are authentic science investigations (Llewellyn, 2001). As Duschl and Bybee (2014) have stressed, “Students should have several opportunities to engage in practices where they decide what data are to be gathered, what variables should be controlled, and what tools or instruments are needed to gather and to record data with precision” (p. 8) so that they do not develop views of science as “unproblematic.” In order to help PSTs understand that science does not proceed smoothly from a question to an answer, I do not provide answers to their questions about setting up their investigations. For example, a common question from the PSTs investigating plant growth is: “How much should I water my plants?” I answer that it depends on a number of factors that they should identify in order to decide how much to water their plants. I also encourage them to try out a variety of amounts in their process of determining the right amount. This nonintervention strategy is purposeful in order to force the PSTs to make decisions, find out answers on their own, engage in trial and error, struggle with their investigation methodology, and consequently gain more learning. PSTs often feel frustrated when tackling this assignment, and that is one of my objectives. I want them to wrestle with developing a testable research question, try out a variety of methodologies to find the best ones, and know what failure feels like. It is through these experiences that learning occurs.

It is important to provide the PSTs with tools to support them as they plan and carry out their investigations. In previous years, when not focusing on the NGSS scientific practices or using the 5D model, I felt that PSTs had not completely understood how to develop the critical steps of an investigation. Using the 5D model as a guide helps them to (a) decide what to measure, (b) list their procedures, (c) think about data collection and representation, and (d) consider the quality of their results. Following the 5D model helps PSTs understand that their methodology is developed from their question rather than one specific “scientific method.”

As mentioned above, this assignment works well in a virtual methods course. Most of the work done by PSTs is on their own time, outside of class, in a work-from-home situation. Completing the investigation setup and 6 weeks of data collection is less onerous when PSTs do not have to spend all that time on campus. Also, with limited or no chance to engage PSTs in hands-on activities in the virtual methods course, this investigation assignment provides PSTs with exposure to scientific practices.

In addition to introducing PSTs to a realistic experience with the scientific practices, this assignment in the methods course also builds their critical-thinking and problem-solving skills and competencies. One of my goals is to prepare teachers who are able to implement what Grossman et al. (2019) describe as student-centered environments in which “teachers support disciplinary learning, engage students in authentic work, encourage collaboration, and build an iterative culture” (p. 43). In order to create this type of classroom environment, teachers must have experienced the 21st-century competencies of creativity, critical thinking, problem-solving, and communication.

An identified limitation of this assignment is the focus on only one of the NGSS’s three dimensions. The focus on the Science and Engineering Practices is done without an equal focus on the Disciplinary Core Ideas or Crosscutting Concepts in order to keep the assignment from being overwhelming for the PSTs. I focus on the scientific practices in the assignment to improve the PSTs’ understanding of the nature of science and engage and build their confidence in doing science. The Disciplinary Core Ideas and Crosscutting Concepts are addressed in other assignments in the course.

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