

Professional Development Final Report:  
Building a STEM Unit: Understanding how NGSS and 5E fit  
STEM Leadership Seminar  
Allison Olis  
April 2021

## **STEM Leadership Seminar**

### **I. Title of Project**

The Road to Building a STEM Unit: Understanding how NGSS and the 5E Instructional Model Fit

### **II. Curriculum Topics**

Colorado adopted NGSS this year and our district emphasizes initiating STEM practices in K-12 classrooms. Our district views STEM as a vehicle for teaching students 21st century skills and giving students authentic experiences focused on creating, designing, and building. Replacing our Colorado science standards with NGSS this year naturally complements this push. By adopting NGSS, students have a better understanding of the natural laws and systems of science and how they relate to the processes of STEM fields. Additionally, students are able to see how connections, applications, and needs in the real world are approached and solved. While much attention has focused on STEM in the middle and high schools, not enough attention in STEM education has been given to elementary schools in our district.

This professional development series was composed of three parts: a focus on the NGSS, the 5E Instructional Model, and creating a STEM lesson or unit with a grade level team using NASA resources. The development of these sessions was based on a need at the elementary level for a basic understanding of our district's adoption of the NGSS this year. Many teachers in my building are open to implementing STEM lessons in their classrooms but have limited knowledge about 5E and how it relates to NGSS.

### **School Description**

Westridge Elementary School is a public K-5 gifted and talented center school located in Littleton, Colorado, a suburb south of Denver. Center schools in our district have gifted and talented options within a traditional school setting. Each grade level has one gifted and two traditional classrooms. The student population at Westridge is about 400 students with 17% on free and reduced lunch.

### **Participants**

A total of 13 teachers and 3 administrators from Westridge Elementary School participated in at least one of my three professional development sessions. The median educator in attendance has more than 18 years' experience and the attendees represented all grade levels. The attendees included three kindergarten teachers, two 1st grade teachers, a 2nd grade teacher, a 3rd grade teacher, a 3rd grade gifted and talented teacher, two 4th grade teachers, a 4th grade gifted and talented teacher, two 5th grade teachers, the principal, the instructional coach, and the gifted and talented resource teacher. There were 13 females and 3 males who participated.

### **III. Standards Addressed**

Because participants represented a wide range of grade levels and content areas, I focused on the core idea of life science to demonstrate the progression of standards at different grade levels and how children's understanding of these ideas develop over time. I then allowed participants to briefly explore the additional NGSS standards at their grade level. In addition, a fifth grade STEM unit covering Earth Systems content was shared with participants as an exemplar in addressing 5th grade NGSS standards, incorporating the 5E model, and using NASA resources in a STEM unit.

After session two, a schoolwide Engineering Day was discussed as a possible end of the year program for all students. A brainstorming session to plan this day outside of my three professional development presentations resulted in the closer examination of these engineering standards. Colorado has adopted engineering as a science and engineering practice and not as a core idea into our science standards. See Appendix A for a complete list of standards addressed during and after the three-part professional development series.

### **IV. Summary of Project**

I had meetings with my principal about how to make my sessions align with goals for the building, the needs of the teachers, and the requirements for this class. After our discussions, it was clear a foundational understanding of NGSS and the 5E model was necessary for teachers. Sessions one and two focused on these two concepts. Moving forward, the hope is for more people in the building to collaborate and engage in more STEM lessons and units and this was the goal of session three. Ultimately though, my main objective for the three sessions was to build enthusiasm for science teaching, have participants understand the rationale behind the NGSS and 3D model of learning, and engage in conversations about engineering and science practices. I planned three 45 minutes sessions, roughly two weeks apart.

### **V. Pre-Survey Questions**

I asked the PD attendees the following questions before the training. Discussion of the pre- and post-PD survey questions follows in Section IX, Outcomes.

1. How familiar are you with NGSS? (linear scale 1-5, 1 not so much, 5 very familiar)
2. How familiar are you with the 5E Instructional Model? (linear scale 1-5, 1 not so much, 5 very familiar)
3. Have you incorporated an engineering activity or STEM project in your curriculum? (yes or no)

4. How comfortable are you with technology in your classroom? (linear scale 1-5, 1 not so much, 5 very comfortable)
5. What is your biggest technology challenge in the classroom? (short answer)
6. Who is your go-to person for STEM related questions and activities? (short answer)
7. What is your comfort level in planning lessons or units with your colleagues? (linear scale 1-5, 1 not so much, 5 very comfortable)
8. What kind of resources do you think NASA can provide for you as you develop a STEM activity? (short answer)
9. Any feedback for me? (short answer)

## VI. **Brief Description of PD Training**

**Session one: (45 minutes) Zoom meeting** Prior to my professional development series, I heard comments in the hallways about NGSS such as this “I guess I’m not teaching space anymore.” I realized teachers were more focused on content and not the vision of 3D learning that is at the heart of the NGSS. This pedagogical shift in science education helped form my first goal: Provide participants with a basic understanding of NGSS and the integration of the 3 dimensions of science learning. Participants filled out a survey before my session began.

**Session two: (45 minutes) Zoom meeting** Session two focused on the 5E instructional model and how to use this framework to plan instruction aligned with the NGSS. I wanted to open the door to conversations about the nature of science, how it relates to STEM and start to build the foundation for STEM lessons and units. Furthermore, I wanted teachers to consider using less worksheets, focus less on rote memorization of facts, and pose more open-ended questions setting up more inquiry-based activities.

Learning about science phenomena in my first endeavor course stood out to me as a seismic shift in my understanding of what quality science learning is and what scientists and engineers do. There’s a level of depth and sophistication that develops when anchoring a science learning cycle with phenomena and then providing additional learning opportunities to add to students’ understanding. I wanted to make this point during this session. I emphasized how by adding phenomena, we add inquiry, wonder, and experimentation to learning and get students to think about what they are noticing, feeling, smelling, seeing, or hearing. When we ask, *what do you know?* and *what’s causing this?* one can set the stage for deeper conceptual understanding.

**Session three: (informal meetings with individual teachers and teams)** Originally, I had planned a formal session three. Because of conflicts in our school calendar, my third session became more informal. I met with individuals and some grade level teams to help them find resources and build a 5E lesson or science unit aligned to NGSS. Participants were asked to complete a post survey through Google forms. I followed up again with an email to attendees requesting completion of the post survey.

### **Activities in Sessions**

I used Pear Deck for both virtual sessions to monitor discussions and engage the participants in the learning. I found the online tool to be valuable. To start, participants took a quiz about the purpose and misconceptions of science in session one. Then, I had attendees do a notice and note thinking routine about the progression of life science standards from 1st grade to high school. I gave time for participants to explore NASA and JPL resources and then we watched a video, *Why NGSS?* I explained the 3D learning of NGSS and gave time for reflection.

During session two, participants were introduced to the 5E model and how it can be used with NGSS to create a unit plan. Including phenomena to anchor a unit was emphasized and as a group we explored a few I chose. I included a phenomena video on mudslides that connected to wildfires we experienced this fall in Colorado. I stressed how powerful finding phenomena with local context and science that matters to students can be.

I started a Google Classroom with access to many of my NASA resources and STEM materials. Teachers appreciated the ease and availability of using Google classroom. Many of my colleagues requested I share the 5E unit plan I created for our Earth Systems unit so they could get a sense of how to do one themselves. The slide deck includes three NASA lessons taken from the JPL website. I used the My NASA data quite a bit during my sessions to show how to find resources and data to address EARTH and Space science standards and the ease in connecting the data to math lessons.

Links to the training content presentations is provided in the Appendix.

## **VII. NASA and Endeavor Resources**

The following resources were used in the training or shared with attendees:

1. [NASA Resources](#) Basic search tool for finding NASA resources
2. [NGSS Science of Nature Matrix](#)
3. [Why NGSS](#) Video explaining the need for standards
4. [5E lesson template](#)

5. Designing a Musical Instrument Engineering Challenge from Art in STEAM course
6. [Concord Consortium](#) STEM resources from Coding and Robotics course
7. [PhET simulations](#)
8. [NASA Space Math](#)
9. [Water Cycle Overview](#)
10. [Educator Guide: Tracking Water Using NASA Satellite Data | NASA/JPL Edu](#)

### **VIII. Follow Up Activities and Post Survey Questions**

I asked the PD attendees the following questions after the training. Discussion of the pre- and post-PD survey questions follows in Section IX, Outcomes.

1. What is your comfort level in understanding NGSS? (linear scale 1-5, 1 not so much, 5 very comfortable)
2. How likely are you to use NASA resources in the future? (linear scale 1-5, 1 not likely, 5 very likely)
3. How motivated are you in implementing more STEM lessons in your classroom? (linear scale 1-5, 1 meh, 5 Enthusiastic)
4. What do you foresee as the biggest obstacle in developing STEM in your current classroom? (short answer)
5. Were you able to use a phenomena or implement a STEM lesson since the two professional development sessions? (If you answered yes, please answer question 6. If you answered no, please move to question 7.) (yes, no)
6. Did you notice a difference in student engagement as a result of implementing a STEM lesson or using a phenomena to anchor a unit? (short answer)
7. What is your one takeaway from this professional learning experience? (short answer)

### **IX. Outcomes: Final Data Collection and Analysis**

#### **A. Survey Results-Commentary on the Content**

Participants took a pre-survey before my first session on February 12, 2021. The first two questions pertained to comfort level with NGSS and 5E. I found many teachers in my building weren't aware that Colorado had adopted NGSS this year or why CO was adopting these new standards. Over 50% of respondents had little to no familiarity with NGSS and 70% with 5E. Usually our district does a good

job of having systemic PD about new initiatives, however, the rollout of NGSS was not emphasized this year, likely due to COVID-19 disruptions throughout the district.

Participants took a post survey after my second session. When asked about comfort with NGSS after the professional development sessions, 73% felt very comfortable. When asked about implementing STEM lessons, everyone who responded said they were comfortable or very comfortable.

As happy as I was with the results, I realized the word “comfort” can be subjective and have multiple meanings. Being comfortable with something doesn’t necessarily mean you understand or think deeply about it. I knew my two 45-minute sessions didn’t give people enough time to actively engage in deeper conversations about NGSS. I know this is just the start of the learning journey for many. The more important issue, however, is ensuring elementary educators are not intimidated by NGSS, are comfortable taking risks, and start to make science a priority in the classroom. Even though I was too broad in my wording of the question, my results and conversations with others suggest more teachers are headed in this positive direction.

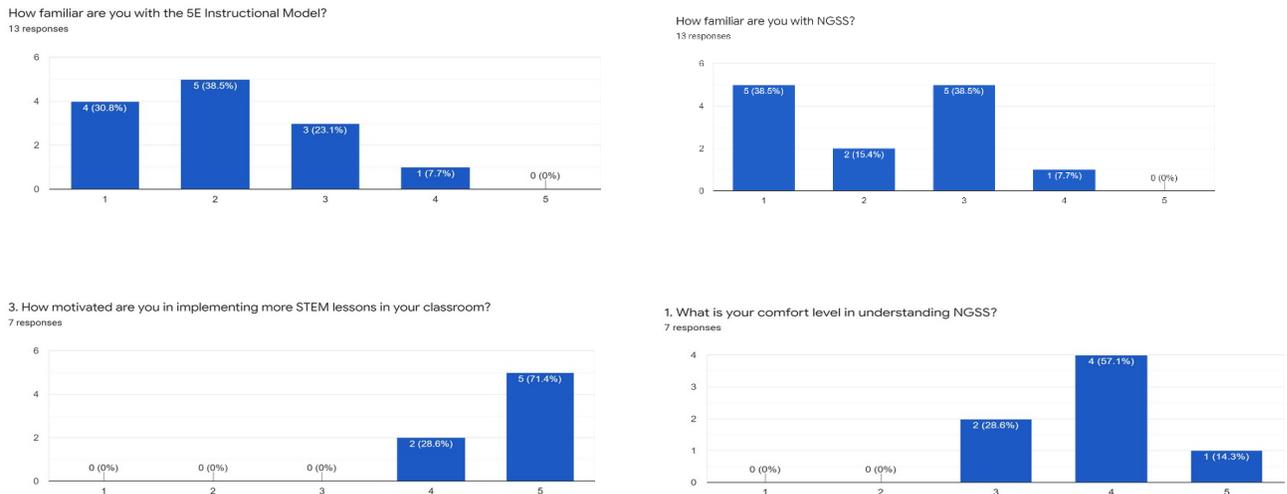


Figure 1. Presentation of some of the Survey Data

## B. Survey Results-Commentary on the Pedagogy

The short answer responses to survey questions were the most revealing and gave me a better sense of what teachers needed and where I needed to adjust my last sessions. The question, *What kinds of additional learning about this topic would you like to see moving forward?* elicited telling responses from the attendees. Here is a sampling. “I would like to see a way to continue the momentum of engagement throughout each lesson and possibly find ways to add a phenomena at

the end of a unit that consolidates and connects learning.” “I’m looking for more ideas and ongoing NASA resources. I’m hooked!” “Our whole staff needs additional training and opportunity for application about science learning.” “Time is always the enemy. We need more of it to develop full grade units.”

The question, *Did you notice a difference in student engagement as a result of implementing a STEM lesson or using a phenomena to anchor a unit?* showed a positive trend in engaging students in science. Here again, is a sampling of responses. “The phenomena I chose made students engage much quicker and they were more excited to learn about forces of nature.” “The more open-ended questions I asked led to more open learners...no fear of right or wrong.” “Yes! My students enjoyed sorting materials based on their physical properties. They also had a richer vocabulary when referring to science words throughout the day.” “Yes. They were SOO excited and the conversations were fascinating. The phenomena led to more awesome questions.”

I shared the professional development results with my school’s administrative team. All agreed the results will serve as a catalyst for a science learning focus next year. We discussed how successful implementation of this pedagogical shift in science will take time and a need for ongoing partnerships and collaboration. Several teachers commented on the constraints and pitfalls of technology. Some were concerned about implementing meaningful use of tech and finding useful online resources that require minimal effort on the teacher’s end. We didn’t have much time to engage in this conversation further. There was a positive response when participants had time to explore resources I provided. Several teachers mentioned the need for more of their own exploration time.

### **C. Success and Reflections of the Professional Development**

It was clear how timely and useful my professional development series was for many people. There has been no training or leadership about science in our building for more than ten years. If my professional development did nothing else, it generated lively discussions about instructional practices in science and enthusiasm for STEM teaching and NASA resources. For that, it was a resounding success. However, my professional development series was only the beginning and unlikely to lead to the kind of systemic change to science teaching needed to support NGSS at the elementary level unless additional training and opportunities are offered for teachers to study instructional practices, analyze science units addressing NGSS, and time to examine student thinking. I simply didn’t have time to do this. Fortunately, my building’s instructional team is energized by my professional development and wants to further teachers’

understanding of science next school year and find ways to support STEM teaching and reading and writing about science.

There was a good representation of grade level teams that attended my professional development. Still, I wish more special teachers like SPED, ELL, Art, Music, and PE were involved. In hindsight, I wonder if I should have put STEAM in the title instead of STEM so I was more inclusive. Next year I know how important collaboration and support among all teachers in the building will be to continue a path of refinement and depth of understanding.

My initial goals for my professional development were lofty. Three sessions were more time than some people could afford, especially this year with high burnout. Instead of a formal third session, I met with individual teachers, and one grade level team to help them find resources and brainstorm ideas. I was tweaking and changing my second and third professional development as a result of my first. And I wish I would have given more thought to the remote teachers. I didn't consider the challenges in access to materials and group projects.

All and all, the professional development series went very well. My principal was extremely supportive and pleased how open teachers were which increased my confidence in taking on more of a leadership role in the building.

Overwhelmingly, teachers expressed positive feedback about my professional development series and commented how much they learned. A few teachers expressed their appreciation in how I involved everyone in the learning process since some were intimidated by the content. Others said my pacing was excellent and activities were engaging. One even said, "Well, that was time well spent!" An instructional coach in another building is using my presentation and notes to present to her staff. While there are still many areas for leadership growth, I did learn and grow a lot as a presenter and leader as a result of this experience.

#### **D. Connections to Readings**

One of the first readings in this course was the Desimone (2011) article which outlined a set of features found in the most promising and effective teacher professional development. I used this comprehensive framework for my own professional development series knowing this was essential in effective implementation of NGSS and 5E in our school. This framework is described in the following bullets.

- **Content focus:** Understanding the philosophy behind the NGSS and shift in science teaching to a 3D model (cross-cutting concepts, engineering and science practices, and disciplinary core ideas) helped participants think

beyond a change in content at their grade level. Using science phenomena during my presentation aided in this shift for teachers. When shown a science phenomena, teachers were asked, *What is going on? How would you explain this phenomena? What other questions do you have?*

- **Active Learning:** Participants were asked to take part in a short quiz, analyze the ways two different classrooms delivered the same content, engage in discussions, and chose phenomena links related to their grade level content during session one and two of my three part series. In session three, participants received support based on need either through a one-on-one brainstorming session or grade-level support from me. I realized there wasn't a one size fits all approach to this learning.
- **Coherence:** To support teacher learning, this professional development aimed to make connections and align to previous learning about math standards and how NGSS and 5E fit in our current understanding. Also, I emphasized how this shift in approach to science is a process and will take time and that teachers need to be willing to refine their approach and expectations as students are able to do more and more in the coming years.
- **Duration:** I purposely planned on three sessions for 45 minutes each knowing that this professional development was intensive and required enough time to understand my goals and apply them in practice. A plan for more extended sessions is scheduled for next year.
- **Collective Participation:** My aim was to have grade level teams create a science unit with NGSS and the 5E model.

The importance of considering all these elements in a professional development cannot be understated. I firmly believe the successful outcomes of this training were the result of including these elements.

Science teacher leadership as explained by Luft et al. (2016) “consists of three categories: Change agent, Professional learning, and Personal learning” (p. 7). I experienced firsthand how the category of change agent fits into leadership. More specifically, I learned how to construct and share an instructional vision and how to work with stakeholders- including teachers, parents, the community, and professionals in STEM fields. After my professional development, several colleagues were enthusiastic and expressed interest in starting a larger schoolwide Engineering Day at the end of the year. Our initial brainstorming session was fantastic and the energy felt awesome. A week later, I wasn't prepared for the roadblocks a few influential teachers in the building threw at the group. A virtual Zoom meeting on a late Friday afternoon doesn't help in these kinds of situations either. I found myself uncharacteristically quiet during the meeting because I was trying to take it all in and understand peoples' perspectives. A seed of an idea got

complicated and messy quickly. As a leader in training, I'm learning on the job. What I have learned recently is the importance of flexible thinking while staying true to a vision in a way that is supportive and encourages collaboration among stakeholders. It's a tricky balance.

#### **E. Next Steps for Educators**

I believe I've laid the fertile ground and set the stage for science learning in our building next year. To maintain the momentum and ensure science education improves in our building, leadership is key. And not just from me. Teachers at different grade levels are sharing resources, successes, and challenges about their lessons with me and will make good candidates for future science leaders at our school. What I would like to see is a collective vision about science education grow in our building.

Two teachers visited my classroom to observe lessons and see what students were doing. An important step moving forward is to continue this practice of watching other teachers' science instruction in action that reflects the NGSS's vision of 3D science. Furthermore, teachers should have opportunities to carefully analyze student thinking and how a teacher helps students do the work of an engineer and scientist.

#### **X. Participant Contact Information**

Jonathan Stein

Principal

Email: [jstein@jeffco.k12.co.us](mailto:jstein@jeffco.k12.co.us)

Phone: 303-982-3975

Jenny Park

5th Grade Teacher

Email: [jpark@jeffco.k12.co.us](mailto:jpark@jeffco.k12.co.us)

Phone: 303-803-7908

Mandi Cummings

3rd grade Gifted and Talented teacher

Email: [acummings@jeffco.k12.co.us](mailto:acummings@jeffco.k12.co.us)

Phone: 303-335-7815

Jenn Westfall

1st Grade Teacher

Email: [jwestfall@jeffco.k12.co.us](mailto:jwestfall@jeffco.k12.co.us)

Phone: 303-905-8805

## References

- AchieveInc, director. *Why NGSS? YouTube*, YouTube, 8 Jan. 2013,  
[www.youtube.com/watch?v=W2yEWyvWznE](http://www.youtube.com/watch?v=W2yEWyvWznE)
- “Concord Consortium.” *STEM Resource Finder*, Retrieved from <https://learn.concord.org>
- Desimone, L. M. (2011). *A Primer on Effective Professional Development*. Phi Delta Kappan, 92(6), 68.
- “Earth Observatory Water Cycle Overview.” NASA, NASA, Retrieved from  
<https://gpm.nasa.gov/education/articles/earth-observatory-water-cycle-overview>
- “Educator Guide: Tracking Water Using NASA Satellite Data.” NASA, NASA, 30 July 2019,  
[www.jpl.nasa.gov/edu/teach/activity/tracking-water-using-nasa-satellite-data](http://www.jpl.nasa.gov/edu/teach/activity/tracking-water-using-nasa-satellite-data)
- “Introduction to the NGSS” *California Academy of Sciences*, Retrieved from  
[www.calacademy.org/educators/introduction-to-the-ngss](http://www.calacademy.org/educators/introduction-to-the-ngss)
- Luft, Julie, Dubois, Shannon, Kaufmann, Janye and Plank, Larry (2016). *Science Teacher Leadership: Learning from a Three-year Leadership Program*. Science Educator: Summer 2016, Vol 25, No. 1 (p. 1-7).
- “My NASA Data.” NASA, NASA, Retrieved from [www.mynasadata.larc.nasa.gov](http://www.mynasadata.larc.nasa.gov)
- Next Generation Science Standards. (2018). *Read the Standards*. Retrieved from  
<http://www.nextgenscience.org/search-standards>
- “PhET Interactive Simulations.” *PhET*, Retrieved from [www.phet.colorado.edu](http://www.phet.colorado.edu).
- “Welcome to Space Math @ NASA !” NASA, NASA,  
<https://spacemath.gsfc.nasa.gov/SpaceMathE.html>

## **Table of Contents for Appendices**

**Appendix A: Standards Addressed ..... 14**

**Appendix B: Links to Presentations and 5E Exemplar ..... 16**

## Appendix A

Life Science standards analyzed and discussed during session one of the three-part series.

- **1-LS1-1.** Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.
- **3-LS4-4.** Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
- **5-LS1-1** Support an argument that plants get the materials they need for growth chiefly from air and water.
- **HS-LS2-2** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Standards addressed in the 5th grade Earth Systems unit are listed below. Shared in session 2.

- **5-ESS2-1** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
- **5-ESS2-2** Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
- **5-ESS3-1** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Engineering standards discussed at Engineering Day brainstorming session.

### **Next Generation Science Standards: Engineering Design**

#### **Science and Engineering Practices:**

##### *Constructing Explanations and Designing Solutions*

- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)

##### *Asking Questions and Defining Problems*

- Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1)
- Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. (3-5-ETS1-1)

#### **Disciplinary Core Ideas:**

##### *Developing Possible Solutions*

- Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

**Crosscutting Concepts:**

*Influence of Engineering, Technology, and Science, on Society and the Natural World*

- The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)
- People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)

**Common Core State Standards:**

**Standards for Mathematical Practice**

CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.

CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.

CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.

CCSS.MATH.PRACTICE.MP4 Model with mathematics.

CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.

CCSS.MATH.PRACTICE.MP6 Attend to precision.

CCSS.MATH.PRACTICE.MP7 Look for and make use of structure.

CCSS.MATH.PRACTICE.MP8 Look for and express regularity in repeated reasoning.

## **Appendix B**

Links to google slide deck presentations and 5E unit exemplar.

[Session 1](#)

[Session 2](#)

[Earth Systems 5E Unit](#)