EQuIP RUBRIC FOR SCIENCE EVALUATION

Using Our Resources Wisely

DEVELOPER: mySci

GRADE: 5 **|** **DATE OF REVIEW:** August 2022

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OVERALL RATING: E

TOTAL SCORE: 8

CATEGORY I: NGSS 3D Design Score	CATEGORY II: NGSS Instructional Supports Score	CATEGORY III: Monitoring NGSS Student Progress Score
3	2	3

Click here to see the scoring guidelines.

This review was conducted by NextGenScience's cadre of expert reviewers using the EQuIP Rubric for Science.

CATEGORY I CRITERIA RATINGS			CATEGORY II CRITERIA RATINGS			CATEGORY III CRITERIA RATINGS		
A.	Explaining Phenomena/ Designing Solutions	Extensive	**A.**	Relevance and Authenticity	Adequate	**A.**	Monitoring 3D Student Performances	Adequate
B.	Three Dimensions	Extensive	**B.**	Student Ideas	Adequate	**B.**	Formative	Adequate
C.	Integrating the Three Dimensions	Extensive	**C.**	Building Progressions	Inadequate	**C.**	Scoring Guidance	Adequate
D.	Unit Coherence	Adequate	**D.**	Scientific Accuracy	Adequate	**D.**	Unbiased Tasks/Items	Extensive
E.	Multiple Science Domains	Adequate	**E.**	Differentiated Instruction	Inadequate	**E.**	Coherence Assessment System	Adequate
F.	Math and ELA	Adequate	**F.**	Teacher Support for Unit Coherence	Adequate	**F.**	Opportunity to Learn	Adequate
			G.	Scaffolded Differentiation Over Time	Adequate			

Summary Comments

Thank you for your commitment to students and their science education. NextGenScience is glad to partner with you in this continuous improvement process. It is obvious that this unit was thoughtfully crafted with an eye toward NGSS Performance Expectations (PEs). The unit is strong in several areas, including being grounded in a relevant topic (farming) that the majority of students can connect to or be facilitated to see the connection. The unit also provides abundant support for teachers, including lesson level summaries, routines such as Driving Question Boards (DQBs), "Gotta Have It" Checklists, and Student Interactive Journals. During revisions, the reviewers recommend paying close attention to the following areas:

- **All Educators, All Students**. The instructional supports and feedback in the unit are currently generalized with a focus on the Disciplinary Core Ideas (DCIs). Materials don't support teachers with much Crosscutting Concept (CCC)-related learning supports. For example, formative assessments list elements, but do not coach teachers on how to make sure students really learned them.
- **Differentiated Instruction.** Although there currently are some strategies included (e.g., pictures with vocabulary, conversational supports, grouping of students, etc.), the supports are general and focus on generalized groups of students. Consider providing guidance to help teachers recognize and differentiate for individual students in all three dimensions.

Note that in the feedback below, black text is used for either neutral comments or evidence the criterion was met, and purple text is used as evidence that doesn't support a claim that the criterion was met. The purple text in these review reports is written directly related to criteria and is meant to point out details that could be possible areas where there is room for improvement. Not all purple text lowers a score; much of it is too minor to affect the score. For example, even criteria rated as Extensive could have purple text that is meant to be helpful for continuous improvement processes. In these cases, the criterion definitely WAS met; the purple text is simply not part of the argument for that Extensive rating.

This report was revised based on changes relating to Criteria I.A, I.B, I.C, and III.A in the unit. Therefore, page numbers in this report related to those four criteria refer to the current version of the Teacher Guide (TG) unless otherwise stated. Page numbers in the other criteria sections refer to an older version of the unit.

CATEGORY I

NGSS 3D DESIGN

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

I.B. THREE DIMENSIONS

I.C. INTEGRATING THE THREE DIMENSIONS

I.D. UNIT COHERENCE

I.E. MULTIPLE SCIENCE DOMAINS

I.F. MATH AND ELA

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

Making sense of phenomena and/or designing solutions to a problem drive student learning.

i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.

ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.

iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

Rating for Criterion I.A. Explaining Phenomena/Designing Solutions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that learning is driven by students figuring out an anchoring problem (we need farms to grow food, but large farms can produce a large amount of waste that can be harmful to Earth's systems) and a design challenge (use the design cycle to develop wind turbines that can transfer energy). However, there are some missed opportunities in the learning sequence for students to feel as if they are driving the learning, particularly in relation to the design challenge.

The general topic related to the identified phenomenon and problem — livestock waste — is potentially relevant and universal. The definition of the unit's phenomenon and problem most visible in the front matter of the unit somewhat matches the scope of student learning. Related evidence and reasoning include:

- Launching the Unit: "Introduce the Anchoring Problem: Ask students: 'What is your favorite food? Why?' Provide students with the opportunity to think and then have them turn and talk to a partner. Call on students to share and record their responses. Take a poll to indicate common favorite foods in your classroom. Ask students: 'Where does this food come from?' Provide individual think time and then ask students to share with a partner. As they share, circulate, and listen for students' prior knowledge about food and farms. Identify a student or students to share their ideas during the whole class discussion. To begin the discussion, ask these students to share where food comes from. Then say to students: 'Most of the food that we eat comes from a farm. In order to produce the food we eat, farms use resources. Have you ever thought about how farms produce the food we eat? What are the side effects of producing the food? How do you think we could reduce some of the side effects?'" (TG, pages 15–16).
- Launching the Unit: Teachers are told to "Say to students: '*If we want to be able to answer these driving questions, what do you think we need to know about the problem?* (We need to think about how very different locations and parts of Earth are connected, how our use of natural resources affects the environment, and how we farmers can protect the environment. We can use this knowledge to design and test solutions to this problem.)'" (TG, page 18).

- Lesson 5, Elaborate: "Has anyone seen a pond that looks like this before? (Show the photos of dead zones and pond eutrophication In Section 2 Curriculum Slides. Use the descriptions in the slides to provide context for students"…."Say to students: '*There are multiple activities that contribute to these phenomena including deforestation, sewage discharge, fertilizer that is applied to people's lawns or golf courses to maintain green fairways, fertilizer applied on farms, and animal waste. There are many contributing factors to this problem, but we are going to focus on animal waste'"* (TG, page 72). The teacher introduces the investigative phenomenon of a pond, mentions many causes of the phenomenon, and then tells students they will be focusing on one of the causes. This direction to focus on a given cause may seem forced and teacher-directed from the student's perspective.
- Lesson 8: An engineering design task is introduced to students. The teacher is told to ask students "What is the most important problem we've been exploring in this unit?" The given student answer is shown as, "We need energy to live our daily lives, but some sources of energy pollute the Earth more than others" (TG, page 103). This is a different problem than the one introduced in the beginning of the unit as the anchor problem, "We need farms to grow food, but the process of producing food for all of us can harm Earth's systems" (TG, page 15).
- Teacher support for drawing out student questions can be part of determining who is driving the learning. If students feel like the teacher is telling them what to think or ask, then they might feel like the teacher is driving the learning, not the student. For example, Lesson 4, Engage: The materials say for the teachers to tell students, "Today's activity will support us in answering this question (ex: How does our use of natural resources affect the air around us?)" (TG, page 54). However, the teacher is then prompted to, "Ask students: Have you ever heard of asthma, or do you know someone who has asthma?....Have you ever wondered how many people around the USA have asthma?" Some students might not understand that global asthma data has anything to do with the way farms harm Earth, so the activity is unlikely to feel student driven until students make the connection to pollutants.
- A structure (i.e., "farm model") is in place for supporting students with iterative thinking that is predominately related to the stated phenomenon and design challenge, creating opportunities for students to continually apply what they have investigated to revise a progressive model.

Instruction periodically provides opportunities for students to connect to students' personal or prior experiences in order to create a need to engage in sense-making. However, connections are not always made between instructional activities and the anchoring problem. Related evidence is listed below:

- Lesson 1, Explore: A teacher note says, "If you want to change the anchoring problem for your context, keep the following questions in mind:….Is it going to motivate students to want to explain our use of natural resources, how Earth's spheres interact, energy consumption, how humans interact with our environment" (TG, pages 14–15).
- Lesson 1, Explore: "When students go outside, they are considering how their own environment has the same scientific principles as a farm or other parts of the natural world. Students can use self-documentation technique to take photos of the environment around their school or at home to make the experience 'inclusive and meaningful'" (TG, page 21). This experience helps students make connections to their own experiences and environment.

- Lesson 3, Engage: “Say to students: How do you think you are connected to the systems on our planet? Allow students to Turn and Talk, then share a few answers. Let’s collect some data to see how we are connected to the Earth. Using self-documentation technique, ask students to examine their typical day (this could be in their home, at school, and places they go after school or on the weekend) to identify the objects and routines that are important to their lives” (TG, page 43). This experience provides the opportunity for students to make connections to their own lives.
- Lesson 4, Engage: “This lesson includes a chance to value student knowledge if they or someone they know has asthma. By exploring asthma data, students get to figure out a meaningful phenomenon that affects their peers” (TG, page 54). This experience provides an opportunity for students to make connections to their own lives. The teacher then prompts, “Let’s look at some data that shows rates of childhood asthma around our country. You can make observations and ask questions about the maps.”
- Lesson 8, Engage: “Show students a video of wind turbines on farmland from Jeanne Norris. Ask students: ‘What do you observe? Have you ever seen these before?’” (TG, page 102). This prompt has the potential of eliciting students’ prior knowledge, which is in turn used to drive the learning. However, no guidance is provided for students who might not have seen wind turbines.

Teacher support for managing a DQB is included in unit materials, including directions for turning back to it in the beginning of each lesson. This provides an opportunity for students to regularly (almost daily) return to phenomena or problems to add layers of explanation or iterate on solutions based on learning, or regularly build on what they have learned from smaller phenomena or problems to explain a broader science topic. The DQB is used to elicit student questions and encourage return to the unit problem, but student questions are sometimes listed and referenced rather than clearly using them to create a need to engage in learning for the purposes of sense-making from the students’ perspectives. Related evidence includes:

- Teachers are given sample driving questions but are told that, “these questions are provided for you as model driving questions to support categorizing individual student questions and organize the learning progression….You can use these questions to guide your instruction, however, you are encouraged to adapt these questions using the language you develop with your students” (TG, pages 4 and 17).
- Teachers are told to, “Orient students to the categories they developed and explain that these are the Driving Questions for the unit….Say to students ‘If we want to be able to answer these driving questions, what do you think we need to know about the problem?’”….“Say to students: We can use this knowledge to design and test solutions to this problem” (TG, page 18).
- Lesson 1, Engage: “Begin the lesson by revising the Driving Question Board. Highlight questions connected to the learning goals of this lesson by calling attention to questions about what makes up a farm. If no questions directly relate, use prompts to build on student questions, supporting them to think about the components of a farm system” (TG, page 19).
- Lesson 1, Evaluate: after students make a model of a farm, teachers are directed “to support student sensemaking across the unit, orient students back to the DQB. Ask students: ‘What did

we observe during today's activity?' 'How might this help us figure out how our use of natural resources on farms affects Earth's systems?'…. Next, ask students 'What new questions do you have?'" (TG, pages 25–26). This is evidence that student questions are collected, categorized, and generated during the unit.

- Lesson 3, Engage: "Begin the lesson by revisiting the Driving Question Board. Highlight questions connected to the learning goals of this lesson by calling attention to questions about natural resources and how people use them. If no questions directly relate, use prompts to build on student questions, supporting them to think about what they observed on a farm and how farmers might use resources to grow food." (TG, page 43). Students' own questions are therefore connected to the learning. Teachers are directed to revisit the DQB in a similar way in consecutive lessons.
- Lesson 5, Engage: The teacher is told, "Begin the lesson by revisiting the Driving Question Board. Highlight questions connected to the learning goals of this lesson by calling attention to questions about the **use of water on the farm and how it might affect Earth's systems**. If no questions directly relate, use prompts to build on student questions, supporting them to think about what they observed on a farm and pointing out the instances where farmers use water and highlighting examples of how water is used on a farm" (TG, page 66).
- Lesson 6, Engage: "Begin the lesson by revisiting the Driving Question Board. Highlight questions connected to the learning goals of this lesson by calling attention to questions about **animal waste**. If no questions directly relate, use prompts to build on student questions, supporting them to think about what they observed on a farm and pointing out examples of animal waste on farms" (TG, page 79).
- Lesson 7, Engage: "Begin the lesson by revisiting the Driving Question Board. Highlight questions connected to the learning goals of this lesson by calling attention to questions about how people can help the environment. If no questions directly relate, use prompts to build on student questions, supporting them to think about their everyday experiences using resources and questions they might have about reducing their impact" (TG, page 92).
- Lesson 8, Engage: "Begin the lesson by revisiting the Driving Question Board. Highlight questions connected to the learning goals of this lesson by calling attention to questions about how farms might use renewable resources, like wind, for energy. If no questions directly relate, use prompts to build on student questions, supporting them to think about the ways that farms might harness and use energy to do their work" (TG, page 102).
- Lesson 8: Students review a problem, "We need energy to live our daily lives, but some sources of energy pollute the Earth more than others." Students are then told that the solution is to design wind turbines, rather than being facilitated to consider wind turbines as a possible solution: "How could you use the design cycle to develop solutions, using wind turbines, that could help solve this problem?" (TG, page 103).

Suggestions for Improvement

- Students would ideally always feel that it is their questions that are driving the learning. To support the teacher in eliciting student ideas and questions, consider providing specific questions and prompts. For example, consider including lists of "back pocket questions."

- Lesson 4, Engage: The materials prompt teachers to say, “Ask students: ‘Have you ever heard of asthma, or do you know someone who has asthma?’… ‘Have you ever wondered how many people around the USA have asthma? Let’s look at some data that shows rates of childhood asthma around our country. You can make observations and ask questions about the maps.’” Consider ways to support teachers in the framing of this experience and eliciting student questions and connections. For example, the teacher could be prompted to instead say something like: “We have questions about how our use of natural resources affects the air around us. Have any of you ever heard about or experienced problems with something that is in the air?”
- Consider including additional teacher support for leveraging all student voices and establishing the belief that their own questions and their own need to know are leading the learning. For example, when establishing the criteria and constraints for the design project, the teacher could say something like: “We decided that we want to design something that will help farmers use resources wisely to protect Earth's systems. What do we already know about the design process? What criteria and constraints should we have?”
- Consider providing more support to “elicit students’ prior knowledge” in a way that elicits deeper knowledge. For example, when eliciting prior knowledge about energy and energy transfer, consider using prompts such as, “You saw wind turbines in the video. How is energy involved?”

I.B. THREE DIMENSIONS

Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions.

i. Provides opportunities to *develop and use* specific elements of the SEP(s).

ii. Provides opportunities to *develop and use* specific elements of the DCI(s).

iii. Provides opportunities to *develop and use* specific elements of the CCC(s).

Rating for Criterion I.B. Three Dimensions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials give students opportunities to build an understanding of grade-appropriate elements of the three dimensions. Students have opportunities to use elements of all three dimensions, the number and variety of which are sufficient for the unit length. Three-dimensional lesson-level performance expectations are clear and included in the standards section of each lesson.

Quick View Sections in the unit include lesson-level PEs aligned to the dimensions. For example, "Lesson 1: How can we describe the different parts of the Earth? Observe patterns in the environment to describe the components of Earth's major systems. Develop a model to show the different Earth systems present on a farm" (TG, page 10).

Appendix D includes elements of the three dimensions for each lesson. They have crossed out portions of the elements that do not apply to the learning within the lesson. For example, Lesson 3: "DCI **ESS3.A: Natural Resources** Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources ~~are renewable over time,~~ and others are not." "SEP: **Developing and Using Models** Develop a model using an example to describe a scientific principle." "CCC: **System and System Models**: A system can be described in terms of its components and their interactions" (Unit 22, TG Appendix, page 18). This Appendix clearly aligns elements or partial elements for each dimension to specific lessons.

Science and Engineering Practices (SEPs) | Rating: Extensive

The reviewers found extensive evidence that students have the opportunity to use the skill of the SEPs in this unit. On page 5 of the TG, the materials list **Developing and Using Models** and **Obtaining, Evaluating, and Communicating Information** as the two SEP categories that will be intentionally developed during the unit. There is evidence that both of these SEPs are developed and used by students during the unit. The NRC uses the terms "practices" instead of "skills" to emphasize that "engaging in scientific investigation requires not only skill but also the knowledge that is specific to each practice." (NRC Framework, 2012, page 30). It is clear that students are developing knowledge that is specific to the two practices that are being intentionally developed. Related evidence and reasoning include, but are not limited to:

Asking Questions and Defining Problems

- *Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.*
    - This element is not itself claimed in unit materials, but it is the corresponding SEP for **3–5-ETS1-1**, a PE claimed as being built toward in Appendix D but is not made explicit throughout the lesson materials.
    - Students have limited involvement in defining the unit's problems (e.g., "we need farms to grow food but large farms can produce waste that can be harmful to Earth systems"), but they contribute to the design task in the sense that they discuss criteria and constraints. For example:
        - Lesson 8, Explore, Attending to Equity: "In order to allow students to bring their funds of knowledge to the table during engineering design challenges, allow them to help generate the list of criteria and constraints of the challenge" (TG, page 104).
        - Lesson 8, Explore: "Have a conversation about criteria (what the solution must do or be like — In this case the criteria are to design a wind turbine that transfers energy) and constraints (what you are limited by or cannot do — In this case the constraints are time and materials)….Show them the materials they have available to them. Let them brainstorm in their groups how they could use the given materials to build a wind turbine that can harness energy from the wind" (TG, pages 103–104).

Developing and Using Models

- *Develop a model using an example to describe a scientific principle.*
    - Lesson 1: "Create a model farm. Be sure to include the components from the 'Gotta Have It' checklist created with your class. You will revise this model over the next few lessons" (Student Journal, slide 6). This is evidence that students develop a model according to principles of farming systems.
    - Lesson 3: "We've been considering our farm from the perspective of Earth's systems, and how they interact. But humans are using natural resources in certain ways to keep their farm operating smoothly. In the previous lessons we developed a 'Gotta Have It Checklist' to show the components and relationships we needed to include in the models. What would you add to the checklist today to make our models show how natural resources are being used on a farm?" (TG, page 48).
    - Lesson 4, Explain: "Set up the spheres interaction model from Lesson 2"…."You will model the process for students, using the asthma example. Use the flowchart to trace how the human use of energy for driving affects the different spheres" (TG, page 58).

This is evidence of students being shown how a model can be used to describe asthma and students apply that example to model how human energy use can affect Earth's spheres.

- Lesson 6, Explore: "Set up the graduated cylinder demo." The teacher models the world's water distribution of salt and freshwater using a graduated cylinder and then students create a graph showing water distribution on Earth's surface (TG, page 68). This experience includes the teacher showing how the total water in a graduated cylinder can be used to demonstrate water type and having students, "Use the data table to make a pie graph that shows the amounts of different types of water on Earth" (Student Journal, page 12). The data table is provided (Section 2, slide 55) and on slide 57 comments, teachers are told to, "give students time to take data from the chart on the previous slide and make a graph of the data on Types of Water on Earth Student Journal page. There are different ways to approach this. You could have students make a pie chart, but first discuss why this is the best way to represent this kind of data. You could have students graph only the amount of freshwater vs. saltwater, or have them graph the different kinds of freshwater" (Section 2 slide 57 comments). However, a key aspect of the element claimed is having the students develop a model. In this case, the students observe the teacher modeling the location of distribution of water on the Earth's surface and are led to use a pie chart (included in the title of their student journal). Students therefore use graphs to display data but do not necessarily develop models.

Planning and Carrying Out Investigations

- *Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.*
  - Lesson 6, Explore: "Say to the students:… 'Different groups can test different types of bottle environments to see which conditions make the most methane gas to use. Let's brainstorm the different things we could change about the environment of the bottle.' To support this, show students the materials they have available to them. This will help narrow their suggestions. Discuss these as the constraints of their design. Record the different suggestions students come up with on cart paper" (TG, page 81). "Provide students with the first Biodigester Investigation Student Journal page. There are four different types of investigations listed, but students may come up with other ideas that you can approve based on classroom constraints. It is ok if two groups do the same variable – tell students this will just help us get more data. In groups, let them explore the materials and think about what they could investigate, and what that would tell them about using waste as an energy source" (TG, page 82). The teacher is given a "Biodigester Set Up Tutorial" (TG, page 83) but additional clarification may be necessary to ensure teachers do not share the tutorial with students, so students build their own capacity with this element.
  - Lesson 6, Explain: "How will you do your investigation? Write a procedure that lists how you will set up the materials. You will need multiple steps so that any student could pick

up your procedure and repeat it" (Unit 22, Student Journal Interactive, page 14). This will help students develop independence with planning and carrying out investigations.

- Lesson 8, Explore: "Explain to students that they must do a fair test. To do this, show them the fan that will be used for testing and the coins that will serve as the weight in the bucket…Say to students: 'The materials here are what everyone will be able to use for their wind turbines and they are the same for each group. Is there anything else that we should keep the same to make sure it is a fair test?'" Make sure student responses include, "Use the same fan on the same setting, the wind turbine is the same distance from the fan, each team lifts the same amount of coins, each team lifts the same distance, teams have the same amount of time to work." "If students miss any of these variables, prompt them. For example, if they miss 'same distance from the fan' ask if it would be a fair test to place one wind turbine right next to the fan and one far away. As a class, determine the length of the string (40 cm is good), the weight of the bucket (or number/type of coins) and any other variables that would be controlled for a fair test" (TG, pages 105–106). This is evidence that the students are building understanding of planning and carrying out investigations.

Analyzing and Interpreting Data

- *Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.*
    - Lesson 6, Explore: This element Is not claimed, but students are supported to use it. "Have students work in groups to analyze their graphs. To support students to do this, ask: 'Which slice of the pie chart is the biggest? What does that tell you? Which slice of the pie chart is the smallest? What does that tell you?' (The saltwater slice is the biggest. The freshwater slice is the smallest. This means most of the water on Earth is salt water.) Ask students: 'What claim can you make about humans and freshwater on Earth, based on the data table and graph you made?' (Most of Earth's water is found in the ocean. We don't have a lot of usable fresh water on Earth)" (TG, page 70). Students are being asked to make inferences about the data they have graphed in relation to their prior knowledge about human activity.
    - Lesson 6, Elaborate: This element is not claimed, but students are supported to use it. "Have students use the fourth Biodigester Investigation Student Journal page to create their data table" (TG, page 83). "Create a table where you will record your observations from the investigation" (Unit_22, Student Journal Interactive, slide 16). This is evidence of the claimed element because students are creating a data table to display observations.
    - Lesson 9, Explore: This element is not claimed, but students are supported to use it. "'Let's analyze our data to see what conditions met our criteria — making the most amount of gas from waste — given the materials constraints.' Have students get into their groups and finalize the data they will present to the class….As students present their findings, create a class chart that summarizes it" (TG, page 115). This is evidence of the claimed element because students determine the best way to present data.

Using Mathematics and Computational Thinking

- *Describe, ~~measure, estimate, and/or~~ graph quantities such as ~~area,~~ volume, ~~weight, and time~~ to address scientific and engineering questions and problems.*
    - Parts of this element are claimed in the unit. Appendix D lists a truncated version of the element with some words missing (not crossed out), such that readers might be confused about the wording of the original element (Unit 22, TG Appendix, page 18).
    - Lesson 5, Explore: This element is part of a claimed PE for the lesson and this SEP category is claimed on TG, page 63. The teacher is told to "Give students time to take the data from the chart (in Section 2 curriculum slides) and make a graph of the data on the Types of Water on Earth Student Journal page." "There are different ways to approach this. You could have students make a pie chart, but first discuss why this is the best way to represent this kind of data. You could have students graph only the amount of freshwater vs. saltwater, or have them graph the different kinds of freshwater" (TG, page 69).
    - Lesson 9, Explore: This element is not claimed in this lesson, but students use it: "To guide students in determining what to share, tell them they will need to share what conditions they investigated as part of their experiment, qualitative and quantitative data (measurements of balloon inflation which represents the amount of gas produced) they collected, and what claim they can make about which environment has better conditions for the most natural gas to be produced.

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.*
    - Lesson 9: This SEP category is claimed and this element is part of a claimed PE for the lesson. In the lesson, students generate and evaluate prototypes of wind turbines. "Based on their discussions, have groups choose the best ideas from their research and brainstorming. They should then draw a model of their group prototype….After they show you their prototype, they can work together to construct it using the materials they have chosen" (TG, page 105). Students then test and evaluate their designs. "Once all groups are done testing, ask the groups to communicate their design and test results to the class. Ask students 'Why do you think it is important that we share our designs and results with each other? How will this help us improve our designs?' Students can share the design they chose for their wind turbine, and why they thought it would be the most effective at transferring energy" (TG, page 106).

Obtaining, Evaluating, and Communicating Information

- *Obtain and combine information from books and other reliable media to explain phenomena or solutions to a design problem.*
    - Lesson 3, Explain: "Provide students access to one or both of the following resources, as well as the Fossil Fuel Energy Research Journal page….To help students develop the

practice of obtaining information, provide one resource. In the following lesson they will be provided with multiple resources and asked to combine information" (TG, page 46).

- Lesson 4, Explore: "Next, allow students to work in groups to choose another phenomenon related to humans' uses of natural resources, research using text and video resources, and create a flowchart to apply the CCC of cause and effect to other examples" (TG, page 57).
- Lesson 4, Explore: Students look at a map of asthma rates caused by various sources. Students assume these maps to be reliable. In the Explore activity, students obtain information from text resources and Research About Traffic and Asthma and The Air We Breathe Student Journal pages. Students obtain information from media sources that include: *What causes air pollution?* from NASA Climate Kids and *Clean air outdoors* from the American Lung Association. Students are prompted to answer questions that could help establish the reliability of the resources, such as "Who is the author of the article?" "Where can we find the author?" "What is their purpose for writing the article? Is it to inform? To persuade? To sell us something?" (TG, page 58).
- Lesson 5, Engage: This element is part of the corresponding PE (**5-ESS3-1**) claimed for the lesson. The teacher is told to, "Show students the following video The Ogallala Aquifer from the National Science Foundation. After students have observed the video, ask 'What do you observe about water on farms?'" (TG, page 66).
- Lesson 8, Explain: "To further help students explain how wind turbines use technology to harness wind energy and transform it into electricity, show this Energy 101 video (3:16) from the Office of Energy Efficiency and Renewable Energy. Here is a reading that can also help support this topic: How do wind turbines work? from Alliant Energy. Be sure to focus students on the role of windmill technology and how this technology has evolved over time to meet the needs of humans (from windmills to wind turbines)" (TG, page 107).
- There is no evidence that students will identify reliable media as compared to unreliable media, although they begin to build toward this part of the element in Lesson 4.

Disciplinary Core Ideas (DCIs) | Rating: Extensive

The reviewers found extensive evidence that students have the opportunity to use or develop the claimed Earth and space science and ETS DCIs in this unit. There is evidence that students use grade-appropriate elements in service of sense-making or problem solving.

The Teacher Guide lists several DCIs as being developed in the unit. In addition, the following DCIs are referenced as possible prior knowledge (TG, pages 80–82): **5.LS2.A Interdependent Relationships in Ecosystems, 5.LS2.B Cycles of matter and Energy Transfer in Ecosystems,** and **4.PS1.A Structure and Properties of Matter.** The Teacher Guide includes at least one element for each DCI claimed and lists connections to the unit (Unit 22, TG Appendix, pages 16–25).

5.ESS2.A: Earth Materials and Systems

- *Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes.*
    - Lesson 1, Explain: "Say to students: 'Scientists have words to describe the different parts of our Earth. There are five different categories, or systems, that we can use to describe our planet.' Now is a good time to introduce geosphere, biosphere, atmosphere, hydrosphere to students" (TG, page 22).
    - Lesson 2, Explore: "Say to students: 'Let's explore ways that the systems of the Earth interact with each other. We're going to look at examples of things that happen on our planet. Each group will decide which systems are interacting, and pin the card on the string that links the two systems.'….Explain that each student or group will get cards that show spheres interacting, and they should clip it on the correct string with the clothespin you will give them" (TG, page 32).
    - Lesson 4, Explore: "Next, allow students to work in groups to choose another phenomenon related to humans' uses of natural resources, research using text and video resources, and create a flowchart to apply the CCC of cause and effect to other examples." "Examples students could choose from include: Coral Bleaching in Oceans, Oil Spills and Aquatic Life, Earthquakes and Fracking, Flammable Water from Fracking, Increased Wildfires, Coal ash spills, Orange Water from Coal Pollution" (TG, page 57).
    - Lesson 4, Explain: "Show Greenhouse Effect from NASA…After the video, use a student research example (about wildfires, for example) to talk about how greenhouse gases such as carbon dioxide and methane increase the greenhouse effect, or warming of the Earth" (TG, pages 59–60).

5.ESS2.C: The Roles of Water in Earth's Surface Processes

- *Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.*
    - Section 2, Post Assessment II: Students are provided with an image and reading about Lake Mead "the largest reservoir in the US in terms of water capacity." Students are provided with data "Water Source" and "Percent of Total Water" and asked to "create a bar graph" to show "where most of Earth's water is located." The final question on Post Assessment II, "Using the graphs from question 1 and your knowledge of science, explain why it is important to protect freshwater resources on Earth, such as Lake Mead (Unit 22, Assessments, pages 8–10).
    - Lesson 5, Explore: "Use the USGS water cycle maps and have students look at the maps. The focus here is not on the process of the water cycle, but rather to visualize the different places we can find water on Earth….Ask: 'What are the different types of water you see?' 'Is ocean water the same as river or lake water?' 'How are they different?'" (TG, page 68).

- Lesson 5, Explore: “Show the data table of the amounts of types of water on Earth (in Section 2 curriculum slides). Have students make observations and ask questions about the data. Say to students: ‘We noticed that there were big differences in the amounts of types of water on Earth. Let’s make a model to make it easier to understand these differences in amount.’….Give students time to take the data from the chart (in Section 2 curriculum slides) and make a graph of the data on the Types of Water on Earth Student Journal page” (TG, pages 68–69).

4.ESS3.A: Natural Resources

- Grade 4 Element: *Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.*
  - This below grade level DCI element is claimed in Lessons 3, 4, and 7 in the TG Appendix.
  - Lesson 3, Engage: “Using self-documentation technique, ask students to examine their typical day...to identify the objects and routines that are important to their lives....After they compare and sort, ask students: What are the parts of Earth’s systems involved in the things you used and did during the day?” “Make a class chart like the following. As you make the chart, point out that though these objects may be human-made, they are made from natural resources that come from Earth’s systems such as water, air, organisms, minerals and rocks (metals), and soil” (TG, pages 43–45). Students are then asked to complete a “Natural Resources” chart with the columns, “object or routine” “Things we needed from Earth’s Systems to Make Object/Routine” and “Energy Source We Needed for it to Work.”
  - Lesson 4, Explain: “Say to students: ‘We have seen that when we use natural resources, we can cause pollution – adding a harmful or poisonous substance to the environment. Let’s break down how this affects the Earth.’….You will model the process for students, using the asthma example. Use the flowchart to trace how the humans' use of energy for driving affects the different spheres” (TG, page 58).
  - Lesson 7, Engage: “Say to students: ‘We have explored a lot of the harmful effects human activities can have on our planet. What are some of the effects we have when we use fossil fuels and water resources, for example?’….Listen for ideas such as fossil fuels give off pollution, which affects Earth systems, like the air and water; fossil fuels are non-renewable resources, and get depleted over time; water use depletes groundwater; farming can cause animal waste to pollute the water” (TG, page 92).
  - Lesson 7, Explain: After students collect and categorize ideas, they read “Energy Island” watch the video “Island in Denmark Produces More Energy Than it Consumes” and visit the website “Waste Becomes Important Part of Island Circuit.” They display and share information and the teacher is told to, “Say to students: ‘What makes Samso Island so special is that they are using renewable resources. This means that the resources can be replaced by nature faster than they are used. Sun, wind, biofuels, and water are energy sources that can be replaced quickly by nature. Let’s compare non-renewable and renewable energy sources” (TG, page 95).

- Lesson 8, Explore: "Ask students 'What is the most important problem we've been exploring in this unit?' (We need energy to live our daily lives, but some sources of energy pollute the Earth more than others)" (TG, page 103).

5.ESS3.C: Human Impacts on Earth Systems

- *Human activities in agriculture, ~~industry, and everyday life~~ have had major effects on the ~~land, vegetation,~~ streams, ocean, air, ~~and even outer space~~. But individuals and communities are doing things to help protect Earth's resources and environments.*
  - This DCI element is claimed in Lessons 4, 5, and 7 (Unit 22, TG Appendix).
  - Lesson 4, Explain: "Say to students: 'We have seen that when we use natural resources, we can cause pollution — adding a harmful or poisonous substance to the environment. Let's break down how this affects the Earth'" (TG, page 58).
  - Lesson 5, Evaluate: "Ask students: 'How might this help us figure out how our use of natural resources on farms affects Earth's systems?' (Students may say that farms need water to grow food, and that using too much water can deplete the resource. They may also discuss how human activities can cause water pollution. For example, animal waste can be moved by water to different locations on Earth. The nutrients in the waste can lead to dead zones in lakes and oceans)" (TG, page 74).
  - Lesson 6, Evaluate: "Write student responses on the driving question board. (They may have new questions, such as: What other ways can we protect the environment on farms? How can we reduce the amount of fossil fuels we use even more? Are biodigesters the only solution? Do biodigesters have any impacts on Earth systems?) Do not provide these questions for students, instead help them start thinking about these ideas by focusing their attention to the problem that biodigesters are helping to solve to help orient them to thinking about other solutions and how that could relate to the anchoring problem: Farms use a large amount of resources. This can have a negative impact on the environment. Have students place their questions into existing categories, or create new categories" (TG, pages 85–86).

5.LS2.A Interdependent Relationships in Ecosystems

- *Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met.*
  - This grade level-appropriate DCI element is listed as a DCI that could be referenced as possible prior knowledge. "This unit does not develop this DCI, however it can be incorporated if students already had the opportunity to make sense of this DCI through Unit 21. It is not critical that students understand the role of decomposers in an ecosystem to complete Lessons 6 and 9. Guidance is provided for how to proceed in Lesson 6 if students have not had prior experience with this DCI" (Unit 22, TG Appendix, page 24).

    - Lesson 6, Explore: "There are opportunities to bring in life science connections – for example, if you have completed mySci unit 21 you can review the concepts from DCIs LS2.A and LS2.B. However, if you have not completed mySci unit 21 you should skip this section as students have not yet made sense of these concepts. The idea to review is decomposition or decomposers (There are bacteria, both on food and in soil, that help break down the food waste). The living bacteria release gas as a by-produce of their own digestion, or breakdown, of the food (this is above grade level, so it is not crucial that your students understand this process" (TG, pages 81–82).

5.LS2.B. Cycles of Matter and Energy Transfer in Ecosystems

- *Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.*
    - This element is listed as a DCI but not aligned to a specific lesson. "This unit does not develop this DCI, however, it can be incorporated if students already had the opportunity to make sense of this DCI through Unit 21. It is not critical that students understand that decomposers produce gas to complete Lessons 6 and 9. Guidance is provided for how to proceed in Lesson 6 if students have not had prior experience with this DCI" (Unit 22, TG Appendix, page 24).
    - Lesson 6, Explore: "There are opportunities to bring in life science connections – for example, if you have completed mySci unit 21 you can review the concepts from DCIs LS2.A and LS2.B. However, if you have not completed mySci unit 21 you should skip this section as students have not yet made sense of these concepts. The idea to review is decomposition or decomposers (There are bacteria, both on food and in soil, that help break down the food waste). The living bacteria release gas as a by-produce of their own digestion, or breakdown, of the food (this is above grade level, so it is not crucial that your students understand this process" (TG, pages 81–82).

3-5.ETS1.A. Defining and Delimiting Engineering Problems

- *Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.*
    - Lesson 8: This element is claimed. The teacher is told to, "Divide your class into six groups. Tell students that they will take on the role of an engineer as they work in groups to design their own wind turbines. Have a conversation about criteria (what the solution must do or be like - In this case the criteria [sic] is to design a wind turbine that transfers energy) and constraint**s** (what you are limited by or cannot do – In this case the constraints are time and materials)" (TG, page 103). "Decide how you will measure your success as a class….Once all groups are done testing, ask the groups to communicate their design and test results to the class. Ask students: 'Why do you think it is important that we share our designs and results with each other' How will this help

us improve our designs?" (TG, pages 105–106). Students are therefore supported to build toward this DCI understanding.

3–5.ETS1.B. Developing Possible Solutions

- *Research on a problem should be carried out before beginning to design a solution.*
    - This DCI element is claimed in Lesson 8 (Unit 22, TG Appendix, pages 19–20).
    - "Research and Brainstorm" is shown as a step in the Engineering Design Cycle that students discuss (Student Journal, page 19).
    - Lesson 8: The "Design Challenge Rubric" includes a row that says, "I used research to help make a design proposal" (Student Journal, page 20). Students may therefore infer that this must be important if it is included in the rubric.
    - Lesson 8: Students are prompted to research about the wind turbine solution (TG, page 104). However, they only follow the teacher's directions to do the research rather than showing awareness that they need to do research about the problem.
    - Throughout the lesson, students are supported to build toward this element, but do not show evidence of being able to apply it themselves in different contexts.
- *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.*
    - This DCI element is claimed in Lesson 8 (Unit 22, TG Appendix, pages 19–20).
    - "Communicate" is shown as a step in the Engineering Design Cycle that students discuss (Student Journal, page 19).
    - Lesson 8: The "Design Challenge Rubric" includes a row that says, "Our group communicated to our peers the results of our test" (Student Journal, page 20). Students may therefore infer that this must be important if it is included in the rubric.
    - Lesson 8: Students are prompted to discuss their solutions with one another (TG, pages 96–97). "Once all groups are done testing, ask the groups to communicate their design and test results to the class. Ask students: 'Why do you think it is important that we share our designs and results with each other? How will this help us improve our designs?' Students can share the design they chose for their wind turbine, and why they thought it would be the most effective at transferring energy" (TG, page 106).
- *Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.*
    - This DCI element is claimed in Lesson 8 (Unit 22, TG Appendix, pages 19–20).
    - Lesson 8: "Explain to students that they must do a fair test. To do this, show them the fan that will be used for testing and the coins that will serve as the weight in the bucket…Say to students: 'The materials here are what everyone will be able to use for their wind turbines and they are the same for each group. Is there anything else that we should keep the same to make sure it is a fair test?' Keep a list of their responses on the board….If students miss any of these variables, prompt them. For example, if they miss 'same distance from the fan' ask if it would be a 'fair test' to place one wind turbine right next to the fan and one far away. As a class, determine the length of the string (40 cm is good), the weight of the bucket (or number/type of coins), and any other variables

that would be controlled for a fair test….Ask students:….'How will this help us improve our designs?'" (TG pages, 105–106).
- "Test & Evaluate" and "Redesign" are shown as steps in the Engineering Design Cycle that students discuss (Student Journal, page 19).
- Lesson 8: The "Design Challenge Rubric" includes a row that says, "Our group conducted a fair test to determine if the design met the criteria given the constraints, and design should be improved" (Student Journal, page 20). Students may therefore infer that this must be important if it is included in the rubric.
- The idea of failure points is not discussed explicitly in the unit.

3–5.ETS1.C: Optimizing the Design Solution

- *Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.*
  - This DCI element is claimed in Lesson 6 and Lesson 9 (Unit 22, TG Appendix).
  - Lesson 6, Explore: "Say to students: 'The gas captured by the biodigester can be used as a natural gas energy source. We want to figure out how to create a biodigester that creates the most gas from animal waste. These are the criteria for the designs. We know we can't actually use animal waste in the classroom – that would not be safe. What else could we use as a model of animal waste?' (We will use food scraps. Animals eat fruits and vegetables, and this is part of their waste, so it is a good substitute). Say to students 'If we want to make the best use of animal waste, we need the best environment possible to make gas. Different groups can test different types of bottle environments to see which conditions make the most gas to use. Let's brainstorm the different things we could change about the environment of the bottle'" (TG, page 81). Students are therefore building toward an understanding of this element, but do not yet demonstrate understanding of it themselves since it was the teacher who stated the DCI idea.
  - Lesson 8: The "Design Challenge Rubric" includes a row that says, "Our group compared multiple design proposals to determine which design would best meet the criteria given the materials constraints" (Student Journal, page 20). Students may therefore infer that this must be important if it is included in the rubric.

Crosscutting Concepts (CCCs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the CCCs **Cause and Effect**, **Scale, Proportion, and Quantity**, **Systems and System Models**, and **Energy and Matter** in this unit because elements of the CCCs are claimed and sometimes explicitly developed through classroom instruction.

The CCC element being developed in each lesson is listed in the Appendix of the TG. For example, Section 2, Lesson 5 "**Scale, Proportion, and Quantity** Standard units are used to measure and describe physical quantities such as ~~weight and~~ volume. **System and System Models** A system can be described in terms of its components and their interactions." (Unit 22, TG Appendix, page 18). A "Connection to

Unit" section describes some ways students use the focus CCC elements in the unit (Unit 22, TG Appendix, pages 25–26).

Cause and Effect

- *Cause and effect relationships are routinely identified and used to explain change.*
    - This element is claimed in the Appendix: "This crosscutting concept is key to sensemaking[sic] in this unit. In lesson 4, students research the cause and effect relationships between humans using natural resources and their impact on the environment" (Unit 22, TG Appendix, page 26).
    - Lesson 4: This element is claimed. Students create "The Air We Breathe" flow charts. "After students create their flowcharts, create a class flowchart to make sure everyone comes to a consensus about the cause and effect relationship….Highlight the routine nature in which cause and effect is used in these cases to explain changes in the environment. As students work, use these prompts to support student sensemaking: What's going on? Does it always work this way? What is the mechanism that explains this? How can we show this relationship and how does it help us explain what's going on?" (TG, pages 56–57).

Scale, Proportion, and Quantity

- *Standard units are used to measure and describe physical quantities such as weight and volume.*
    - This element is claimed in the Appendix: "This crosscutting concept is key to sensemaking in this unit. In lesson 5, students use a standard unit of volume to describe the amount of freshwater and saltwater available on Earth" (Unit 22, TG Appendix, page 26).
    - Lesson 5: Most of this element is claimed. The teacher is told to, "Ask students: What did you notice about how we measured the amount of water? What is volume? Why is this unit of measure important? Explain to students that volume is a standard unit used to measure the amount of space something takes up. Scientists use standard units, instead of everyone using their own units, in order to measure quantities accurately and communicate with one another" (TG, page 69).

System and System Models

- *A system can be described in terms of its components and their interactions.*
    - This element is claimed in the Appendix: "This unit intentionally develops this crosscutting concept. In this unit students examine Earth Systems and create models for how these systems appear on farms and interact with one another. They revise their models as they learn about more interactions between Earth Systems and figure out the ways farms" (Unit 22, TG Appendix, pages 25–26).
    - Lesson 1: Part of this element is claimed. "Allow students to add in components they may know about that occur on farms, but were not included in the videos. Students should identify each component, and label which of Earth's systems it falls under. For example, a student may observe a cow and categorize this as being part of the

biosphere, while categorizing a farm pond as the hydrosphere" (TG, page 24). Students are asked to label farm components as being associated with a certain system.

- Lesson 2: This element is claimed. The teacher is told to "Highlight questions connected to the learning goals of this lesson by calling attention to questions about the interactions between Earth's systems. If no questions directly relate, use prompts to build on student questions, supporting them to think about how the different parts of their school environment or a farm might interact" (TG, page 30). Later in the lesson, students are asked to explain how parts of a system interact, "Ask students to use the model to explain why these interactions matter. How does one of the systems in your example affect the function of the other system? What would happen if one of the systems was removed?" (TG, page 33).
- Lesson 3: This element is claimed. The teacher is told, "Students have learned about systems and system models, so listen for ideas about the components of Earth's systems that their activities affect and how these components interact. If not, prompt them to consider: What did our observations tell us about our interactions with Earth's systems? How are the components in our models interacting? What questions do you have about these components and their interactions?" (TG, pages 44–45). Later in the lesson the teacher is prompted to, "Say to students 'We've been considering our farm from the perspective of Earth's systems, and how they interact. But humans are using natural resources in certain ways to keep their farm operating smoothly. In the previous lessons we developed a 'Gotta Have It Checklist' to show the components and relationships we needed to include in the models. What would you add to the checklist today to make our models show how natural resources are being used on a farm?' Examples of things the model's 'gotta have' might include: Any natural resources or products made from natural resources found on the farm (For example, did they include any farm equipment, water, fuel for energy, metal for grain silos and fencing, etc.) How energy is used on a farm, and what energy sources are used (For example, if the farmer uses a milking machine, what powers it?)" (TG, page 48). This is evidence that students are told to include components and interactions in their "gotta have" list and included in their models.
- Lesson 4: This element is claimed. The teacher is told, "Highlight questions connected to the learning goals of this lesson by calling attention to questions about how the Earth Systems interact, specifically how the use of natural resources might affect the atmosphere" (TG, page 54).
- Lesson 5: This element is claimed. "Have students share their models with a partner or another group and give each other feedback using the 'Gotta Have It Checklist.' How do their models compare with each other's? What interactions between water, animal waste, and Earth's systems did they identify?" (TG, page 73). However, it is not clear if all students will be developing this element explicitly such that they could use it again in other contexts.
- Lesson 7: This element is claimed. When students revise the farm models they are reminded, "'Just like in our original farm model, we need to use a 'Gotta Have It

Checklist' to show the components and relationships we need to include in the models. What would you add to the checklist today to make our models show how a farm can use natural resources in a way that doesn't harm Earth systems as much?' Examples of things the model's 'gotta have' might include: Renewable fuel sources for tractors and other farm equipment and Renewable energy sources for electric power" (TG, page 96). This is evidence that students are reminded to include renewable energy sources in their system model. However, it is not evidence that students are developing this element such that they could apply it in other contexts in the future.

- Lesson 9: This element is claimed. The teacher is told, "Say to students: 'We need to use a 'Gotta Have It Checklist' to show the components and relationships we need to include in the models. What would you add to the checklist today to make our models show how farmers can use resources in a way that protects Earth's systems?'" (TG, page 118). Later, an expected student response related to how farmers can use resources wisely is, "This is important because Earth systems interact" (TG, page 119). However, this is evidence of student understanding of the K–2-level element *Systems in the natural and designed world have parts that work together*. There is not evidence that students explicitly understand the claimed 3–5-level element.

Energy and Matter

- *Energy can be transferred in various ways and between objects.*
  - This element is claimed in the Appendix: "This crosscutting concept is key to sensemaking in this unit. In lesson 8, students use this crosscutting concept to help make sense of their windmills. Specifically, students think about how energy transfers from the wind to the movement of their bucket" (Unit 22, TG Appendix, page 25).
  - Lesson 7: This element is claimed. The teacher is told to, "Ask students:….How is the energy from the sun transferred in different ways?" (TG, page 95). Note that students are also asked, "What forms of energy are involved in these systems? What energy transformations are taking place as the community uses renewable resources?" Because no note is included to describe a boundary of expectation for all students, these questions might lead some teachers to assuming that students are expected to understand the middle school-level CCC element *Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).*
  - Lesson 8: This element is claimed. When students design, test, and evaluate their wind turbines, they are asked to consider energy transfer. "Students can share the design they chose for their wind turbine, and why they thought it would be the most effective at transferring energy….Have students use chart paper or whiteboards to create a chart. On one side of the chart students can draw a model of their design, and use their data and what they have learned to explain how energy is being transferred. For example, students may say energy was transferred from the fan to the blades. We know this because the blades and dowel rod began to move. They may also notice that the wind turbine makes noise as the wind moves the blades and the basket moves upward. This caused the bucket to lift. On the other side of the chart, students can draw an actual

wind turbine, and show how energy transfer is occurring." (TG, pages 106–107). This is evidence of students understanding this CCC element.

Suggestions for Improvement

Science and Engineering Practices

- When developing models, consider providing additional time for students to develop models individually as a way to build capacity and application. For example, in Lesson 1 consider providing students time to model (draw and label) on their own and then turn and talk, using the model as a guide. Students could then share with the whole group what they feel should be in their group model. If time allows, students could be allowed to create a small group model, followed by a carousel walk to review all models and identify what they want to see on the group model. This could increase ownership of the model and the feeling that the group model is representative of the individual students' understanding.

Crosscutting Concepts

- Consider clarifying the expectations for all students related to energy transformations in Lesson 7.

I.C. INTEGRATING THE THREE DIMENSIONS

Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.

Rating for Criterion I.C. Integrating the Three Dimensions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena and designing solutions to problems because there are opportunities for students to figure something out or solve part of a problem in a way that requires a grade-appropriate element of each of the three dimensions working together.

Related evidence includes:

- Students develop a model of a farm, evaluate each other's models, collect additional information, and revise their farm models. Although the reviewers can see that there is potential for at least one grade-appropriate element from each dimension to be used by students during most of the iterations of the Farm Model, it is not clear that elements from each of the three dimensions would always be *required* or supported for all students as students complete each iteration of the Farm Model. For example, in Lesson 1, Elaborate: "Students will create their models on the Farm Model Student Journal page….Allow students to add in components they may know about that occur on farms….Students should identify each component, and label which of Earth's systems it falls under" (TG, page 24). In Lesson 2, Elaborate: "Show students the following videos of a farm….Have students identify where they observe interactions occurring between the things on the farm. Students may observe cows eating the grass. They may also make note of the farmer who discusses drinking the water and breathing the air on the farm. After watching, say: 'What could we add to our Farm Model to show the interactions of the different Earth systems? Let's develop a 'Gotta Have It checklist' that tells the relationships we want to show on our model. What interactions should we include in our model? Think of all the possible interactions we discussed in this lesson.' Students can refer back to the activity from the Explain phase. 'What else should we include as part of our model so that other people know what we drew?'….'Are there components you could add to your farm model that would help you identify interactions?'" (TG, pages 34–35). In Lesson 2, Evaluate: "Have students share their models with a partner and give each other feedback. Did they have an example of the different sphere interactions? Did they label all parts of their model? How do their models compare with each other's?" (TG, page 35). In Lesson 3, Elaborate: "Say to students 'We've been considering our farm from the perspective of Earth's systems, and how they interact. But humans are using natural resources in certain ways to keep their farm operating smoothly. In the previous lessons we developed a 'Gotta Have It Checklist' to show the components and relationships we needed to include in the models. What would you add to the checklist today to make our models show how natural resources are being used on a farm?'" (TG, page 48). This is an example of students figuring out interactions on a farm using parts of the following elements:

  - **DCI: ESS2.A Earth Materials and Systems:** *Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes.*
  - **SEP: Developing and Using Models:** *Develop a model using an example to describe a scientific principle.*
  - **CCC: Energy and Matter:** *A system can be described in terms of its components and their interactions.*

- Students test and design wind turbines. In Lesson 8, Explore: "Ask students: 'What is the most important problem we've been exploring in this unit?' (We need energy to live our daily lives, but some sources of energy pollute the Earth more than others.) Ask students: 'How could you use the design cycle to develop solutions, using wind turbines, that could help solve this problem?' Next, show students the Design Challenge Rubric Student Journal page. Ask students to compare the rubric to the engineering design cycle. 'How does each category of the rubric relate to the design cycle?'" (TG, page 103). "Have a conversation about criteria (what the solution must do or be like — In this case the criteria is to design a wind turbine that transfers energy) and constraints (what you are limited by or cannot do – In this case the constraints are time and materials). This is a review from Lesson 6. Show them the materials they have available to them. Let them brainstorm in their groups how they could use the given materials to build a wind turbine that can harness energy from the wind" (TG, pages 103–104). "Have students access the Wind Energy Design Challenge Notes Student Journal pages. Individually, students research and brainstorm. Prior to this lesson, students have been provided with resources to research. In this lesson, students will be expected to research on their own" (TG, page 104). "Based on their discussions, have groups choose the best ideas from their research and brainstorming. They should then draw a model of their group prototype. Remind students that it is important to label the parts of the design, the materials they will use for those parts, and how much material will be used. After they show you their prototype, they can work together to construct it using the materials they have chosen. Refer back to the Engineering Design Cycle Student Journal page. After students construct their prototype, they can test and evaluate it. Explain to students that they must do a fair test. To do this, show them the fan that will be used for testing and the coins that will serve as the weight in the bucket" (TG, page 105). "Once all groups are done testing, ask the groups to communicate their design and test results to the class. Ask students: 'Why do you think it is important that we share our designs and results with each other? How will this help us improve our designs?' Students can share the design they chose for their wind turbine, and why they thought it would be the most effective at transferring energy" (TG, page 106). This is an example of designing a wind turbine and requires student engagement in parts of the elements below.

- **DCI: PS3.B Conservation of Energy and Energy Transfer:** *Energy is present whenever there are moving objects, sound, light or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.*
- **SEP: Planning and Carrying Out Investigations:** *Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.*
- **CCC: Energy and Matter:** *Energy can be transferred in various ways and between objects.*

Suggestions for Improvement

- Consider framing these experiences in a way that helps teachers recognize the need to have students engage in the elements working together in service of sense-making as they provide students with opportunities to develop their ability to apply the elements to new situations or related phenomena (such as biodigester and desalinator).

I.D. UNIT COHERENCE

Lessons fit together to target a set of performance expectations.

i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences.
ii. The lessons help students develop toward proficiency in a targeted set of performance expectations.

Rating for Criterion I.D. Unit Coherence	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that lessons fit together coherently to target a set of PEs because each lesson builds on the previous lessons. There are linkages across the unit, but some are not explicit from the student perspective. Students have opportunities to ask questions based on what they have learned so far in the unit and revisit their questions in subsequent lessons. In addition, students are supported in the unit to develop or use more than half of the elements included in the three targeted PE learning goals for the unit.

Related evidence includes:

- There is a common theme in the lessons throughout the unit, but this common theme is not always present throughout each activity. For example, farms are the focus of the anchor problem, but in Lesson 7 students read about Samso Island and how they use renewable energy. A large part of the next content is about the virtues of renewable energy in a way that is not connected to farms. However, at the end of the lesson, renewable energy is linked to farms. Thus, the lesson content flow starts with topics that are largely removed from farms and the anchor problem (the big picture) but later focuses on the content related to farms. Some young students may not be able to anticipate this type of sequencing and therefore might find the beginnings of lessons to feel less coherent.
- The lessons clearly build on one another although each activity might not always seem to be directly connected to the flow of the unit storyline from the students' perspective. For example:
  - Lesson 1: Students are introduced to the anchoring problem, develop a farm model, and are introduced to the Earth's "parts" "systems" and "spheres." However, they are told to go on a nature walk before they see the connection between that walk and the farm that they initially discussed (TG, page 18).
  - Lesson 2: Students learn to name the Earth's spheres and watch four videos, use card and string structure to demonstrate how the spheres interact, and add interactions to their farm models. The activities therefore relate directly back to Lesson 1.

- Lesson 3: Students analyze their daily activities. The teacher connects this activity to the prior lesson by saying, "How do you think you are connected to the systems on our planet?" and "Let's collect some data to see how we are connected to the Earth" (TG, page 38), but many students might be confused about how this self-documentation activity fits together with the previous lessons.
- Lesson 4: The lesson begins with students being provided with asthma data and asked to connect the data to the production of nitrous oxide and particulate matter in different countries, during different years. Students might not therefore immediately understand the connection to the prior lessons.
- Lesson 7: Students consider the wind turbine as an alternative, renewable energy source. They are introduced to examples of alternative energy sources.
- Lesson 8: Students design and test a wind turbine and investigate advantages and challenges of wind energy. Students therefore build on their learning from Lesson 7.
- Lesson 9: Students consider biodigester technology and develop a final farm model.

Students use what they figured out in one lesson to form the next question to ask. For example, in Lesson 6, Evaluate, students design and test a biodigester. At the end of the lesson, the teacher asks, "To support student sensemaking across the unit, orient students back to the DQB. Ask students: 'What did we observe during today's activity?' Record the activity and their observations. Next, ask students: 'What did we learn today?' (We observed that waste can produce gas. We observed this as a balloon inflating.) Record their responses. If students need a reminder, they can reference their student journals. Ask students: 'How might this help us figure out how our use of natural resources on farms affects Earth's systems?' (Students may say that farms use energy from fossil fuels, like natural gas. Waste can produce gas that could be used as an energy resource on a farm.) Next, ask students: 'What new questions do you have?'" (TG, page 77).

Students have opportunities to ask questions and revise based upon new learning, and student questions are often returned to in subsequent lessons. For example:

- Lesson 1: "Next, ask students: 'What new questions do you have?' (They may have new questions, such as: How can animals and plants on a farm affect the different Earth systems? How do the parts of our environment interact with one another? What happens to one part of the environment if there is a change in another? What role do humans play in the environment?)" (TG, page 23).
- Lesson 2: "Ask students: 'What new questions do you have?' (They may have new questions, such as: Are all interactions between Earth systems beneficial? Can some interactions cause problems?)" (TG, page 32).

  Lesson 3: "Ask students: 'What new questions do you have?' Write student responses on the driving question board. (They may have new questions, such as: Can we run out of natural resources? Does our use of natural resources affect Earth systems?)" (TG, page 45).
- Lesson 4: "'What new questions do you have?' Write student responses on the driving question board. (They may have new questions, such as: How can we reduce the effect that the use of

fossil fuels has on the environment? Do other natural resources have an impact on the environment? Are there other ways to get energy instead of fossil fuels?)" (TG, page 56).

NGSS PEs are identified as targeted learning goals in the chart included in the Sections Quick View: Links to Resource for the Unit (TG, page 7). Overall, more than half of the elements required for these PEs are used or developed in the learning sequence:

- **5-ESS2-2.** Describe and graph the amounts of saltwater and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. The CCC from this PE is not explicit in the unit.
- **4-ESS3-1.** Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. The CCC from this PE is not explicit in the unit. Students instead use a related CCC element from the K–2 grade band.
- **3-5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved. The idea of failure points is not explicit in the unit.

The following PEs are listed as "Performance Expectations Partially Addressed," although the meaning of "partially" is not explained, such as which dimensions are partially or fully addressed for each PE:

- **4-PS3-2**. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- **5-ESS2-1.** Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
- **5-ESS3-1.** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- **3-5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Suggestions for Improvement

- Consider supporting student use of a tracker that would allow students to record what they've figured out in relation to the anchor problem. Students could be asked to complete the tracker as they add to their layers of understanding. This could be in students' own words but use similar information to the teacher charts provided in the TG Appendix, pages 9–11.
- Consider leveraging the use of the student journal in a way that provides students opportunities to reflect upon and record connections and questions specific to the anchoring problem. The journal could be used as a tool to help students generate, revise, and share questions and connections.
- Consider providing opportunities for students to build toward all of the elements contained in the targeted PEs.

I.E. MULTIPLE SCIENCE DOMAINS

When appropriate, links are made across the science domains of life science, physical science and Earth and space science.

i. Disciplinary core ideas from different disciplines are used together to explain phenomena.

ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.

Rating for Criterion I.E. Multiple Science Domains	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that links are made across the science domains when appropriate because the related science domains relevant to the explanation are developed or identified as prerequisite learning. Unit materials identify Earth and space sciences (ESS), physical sciences (PS), life sciences (LS), and ETS domains. However, it is not explicitly conveyed to students how the different domains together are required to explain the problem or design the solution. In addition, CCCs are not used explicitly to connect multiple science domains.

Examples of students focusing on more than one domain include:

- Lesson 5: Students investigate water sources, needs, and pollution. Students are asked to consider water as part of the hydrosphere (**ESS2.A**) and that it is essential to life (**LS1.C**) and for the growth of plants (**LS2.A**) and that some farms pump water out of the ground. They are asked to consider how water gets in the ground (**ESS2.C**), and if farms can run out of water (**ESS3.A**). They look at maps (**ESS2.B**) of water distribution and review data that shows only 1% of water is in the ground and that it is that 1% that makes up the majority of water for human use (**ESS2.C**). They are asked to connect the importance of keeping groundwater clean for human use (**ESS3.A**) and consider the negative impact pollution of groundwater (from animal feces) can have on groundwater when organic material decomposes (**LS2.B**). Students are asked to connect their understanding of human water usage, human pollution to "dead zones in lakes and oceans" and the need to have humans reduce waste and resulting water pollution (**ESS3.C**).
- Lesson 6: Students complete a biodigester investigation and they learn gas is released (**PS1.A**) when animal waste is broken down (**LS2.B**). They revisit the concern that farms have a lot of animals and a lot of animals produce a lot of waste that can negatively impact living things including humans (**LS2.D**). They are introduced to examples of humans minimizing harm to the environment (**ESS3.C**). They then consider how a biodigester can be designed for optimal breakdown (measured by the amount of gas released) of organic material (such as animal waste but substituted with fruit and vegetable scraps for safety reasons) (**LS2.B**). In this lesson, the teacher is told explicitly, "There are opportunities to bring in life science connections – for

example, if you have completed mySci unit 21 you can review the concepts from DCIs LS2.A and LS2.B. However, if you have not completed mySci unit 21 you should skip this section as students have not yet made sense of these concepts. The idea to review is **decomposition** or **decomposers** (there are bacteria, both on food and in soil, that help break down the food waste). The living bacteria release gas as a by-product of their own digestion, or breakdown, of the food (this is above grade level, so it is not crucial that you students understand this process)" (TG, pages 74–75).

- Lesson 7: The teacher is told to, "Use this opportunity to develop connections across the science domains using the CCC of energy and matter. Ask students: What forms of energy are involved in these systems? What energy transformations are taking place as the community uses renewable resources?" (TG, page 95). However, guidance is not given for how to connect across science domains, other than referencing energy transformations, a middle school-level physical sciences concept.

Suggestions for Improvement

- Consider including guidance for ways teachers could make the existing connections between the PS, ESS, and LS domains explicit to students. For example, the class could discuss why the interactions on a farm require an understanding of life, physical, and Earth sciences when considering the flow of matter and energy flow within and between systems.
- Consider providing guidance to help teachers leverage the use of CCCs when developing connections across science domains. For example, leveraging student understanding of energy transfer beyond a wind turbine as an essential element of farm interactions such as the transfer of energy from the sun to plants to animals, from wind to movement of material (such as rocks and soil causing erosion on a farm, food produced on a farm to humans).

I.F. MATH AND ELA

Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.

Rating for Criterion I.F. Math and ELA	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics, English language arts (ELA), history, social studies, or technical standards because the materials explicitly state most of the mathematics and ELA standards used throughout the unit. There are some opportunities to incorporate mathematics and ELA skills during the unit instructional activities, and there is some variation in the structure and purpose of students' writing assignments and some opportunities for students to speak and listen to peers in a variety of formats. However, it is unclear if students will explicitly understand the benefit of using ELA/literacy and mathematics for sense-making and problem solving purposes.

Examples of connections to ELA/literacy include:

- Lesson 4: "To support students in identifying reliable resources facilitate a discussion about important things to look for when examining websites: Writing Videos for Kids: How to Evaluate Sources for Reliability. From this video, highlight the following: Identify the author. Who are they? What is their purpose for writing the article? Look for common information between multiple articles on the same topic Look at the date the article was written. Scientific knowledge can change over time" (TG, page 52).
- Lesson 8: Students read, "The Boy Who Harnessed the Wind" by William Kamkwamba and Bryan Mealer. Teachers are provided with a list of suggestions, questions, and connections to the unit "Pages 14–17: Read text as written. 'What do you think the word 'misala' means when they said 'This boy is misala'? What clues does the text give you about the meaning of that word?' Misala means crazy or madness in Chichewa, one of the languages spoken in Malawi. Turn attention back to the Engineering Design Cycle. Ask students: 'How did William research and brainstorm before he started to collect materials?' (He went to the library and found science books with pictures of windmills. He read about engines and windmills" (TG Appendix, page 7). However, connections to ELA/literacy standards (e.g., from lower grade levels) are not made for this lesson.
- Supplemental reading resources are linked to the TG for example: "What is Earth's core made of?" "What is air made of" are linked in Lesson 1 (TG, page 12) and "What are Fossil Fuels?" "What is gasoline made of?" are linked in Lesson 3 (TG, page 37).
- Students are asked to write in their student journal and at various times within the unit. For example:
  - Lesson 1: "Ask students to write down 2 observations and 2 questions from the video before showing it again" (TG, page 14).
  - Lesson 4: "Have students write a list of what types of fossil fuels they use in their home or that they see being used in their neighborhood" (TG, page 47). However, this is listed as a suggestion that is implied to be optional rather than as part of the standard lesson, meaning that it is less likely that all students will be asked to do this writing assignment.
- Teachers are prompted to provide students with opportunities to talk. For example:
  - Lesson 4: "Give students time to talk through system interactions, write them on index cards, then share out to the whole class" (TG, page 53).
  - Lesson 5: "Use your model to talk to a partner about how humans are affecting Earth's systems by using groundwater for farming" (TG, pages 63–64).
- Teachers are provided with guidance for Turn and Talk. For example: "Guidance for engaging students in Turn and Talk: Turn and talks will be used throughout the unit. If students are not already familiar, take time to introduce the Turn and Talk strategy. Emphasize that students should share their ideas, listen carefully to their partner's ideas, and build on each other's ideas. It is also important to stay on topic" (TG, page 15).

Examples of connections to Mathematics include:

- Lesson 5: The teacher is told, “This is an opportunity to integrate math standards. Students can change the decimals to fractions, notice the magnitude of difference between the numbers, compare different numbers on the chart, or make a number line to show the scale of difference between numbers” (TG, page 62).
- Lesson 5: Students graph data. “Give students time to take the data from the chart (in Section 2 curriculum slides) and make a graph of the data on the Types of Water on Earth Student Journal page. Be sure not to show students the student journal page until they discuss which type of graph to make. There are different ways to approach this. You could have students make a pie chart, but first discuss why this is the best way to represent this kind of data. You could have students graph only the amount of freshwater vs. saltwater, or have them graph the different kinds of freshwater” (TG, page 62).
- Lesson 6: Students measure the circumference of balloons to determine gas production by biodigesters. “You may need to scaffold so that students can make the connection that they could take numerical measurements by wrapping string around their balloons as they fill up with gas, and then laying the string on a ruler” (TG, page 75).

Suggestions for Improvement

- Consider providing teachers with activity-level connections to the ELA and mathematics standards so teachers can clearly see where and whether or not students are meeting the standards. The TG Appendix currently includes general comments about use of the standards but doesn’t include specifics.
- Consider providing teachers with guidance for leveraging student use of ELA and mathematics skills to help students explicitly understand the benefit of using them for sense-making. For example, the class could discuss how ELA and mathematics ideas support their refinement and clarification of thinking, their quest for more information, and their sharing of ideas.
- This unit has significant potential for making meaningful connections to the National Council for Social Studies (NCSS) National Curriculum for Social Studies theme, “People, Places, and Environments: The study of people, places, and environments enables us to understand the relationship between human populations and the physical world…They examine the influence of physical systems…and natural resources, such as land and water, on human populations. They…investigate the impact of human activities on the environment. This enables them to acquire a useful basis of knowledge for informed decision-making on issues arising from human-environmental relationships” (National Council for Social Studies). Consider making these kinds of links to specific standards explicit.

OVERALL CATEGORY I SCORE: 3	
Unit Scoring Guide – Category I	
Criteria A-F	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

CATEGORY II

NGSS INSTRUCTIONAL SUPPORTS

II.A. RELEVANCE AND AUTHENTICITY

II.B. STUDENT IDEAS

II.C. BUILDING PROGRESSIONS

II.D. SCIENTIFIC ACCURACY

II.E. DIFFERENTIATED INSTRUCTION

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

II.A. RELEVANCE AND AUTHENTICITY

Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world.

i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).

ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.

iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.

Rating for Criterion II.A. Relevance and Authenticity	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because the anchoring problem authentically affects peoples' lives and the engineering design parts of the unit have the potential to motivate students. Students experience the anchoring phenomenon via video, readings, pictures, and connections to everyday life. There are opportunities to help students connect to the "farm problem" as it relates to personal energy use, but this connection might not seem clear and authentic to students. There is not evidence that students will authentically want to solve the anchoring problem, as students engage in activities as a result of following teacher directions rather than as a result of their own drive to solve the problem.

Materials support teachers in helping students make connections to their own experiences. The materials also regularly support teachers to anticipate difficulties that might come up when students talk about or think about their specific lives. For example:

- Lesson 1: The anchor problem is presented as "We need farms to grow food, but the process of producing food for all of us can harm Earth systems" (TG, page 23). Therefore, the fact that the anchoring problem affects the world is made explicit to students.
- Lesson 1: "We are going to go outside on a nature walk. While we are walking I would like you to record as many observations of natural things as possible. You are going to try to categorize the things you observe. Before we go, let's discuss the observations as a part of science" (TG, page 18). Students use data collected in their neighborhoods firsthand to observe the parts of the schoolyard and are encouraged to connect those parts to the Earth's systems.
- Lesson 1: Students are encouraged to connect what they observe from the walk in their school yard to what they observe on the farm and what they include in their models. "When students go outside, they are considering how their own environment has the same scientific principles as a farm or other parts of the natural world" (TG, page 18). This connection between the school

yard and the farm is included in an "Attending to Equity" sidebar. However, students might not see the need to visit their schoolyard in relation to understanding a farm.

- Lesson 3: Students are asked, "How do you think you are connected to the systems on our planet?" (TG, page 38). The connection between the parts of a farm — Earth's systems — and how students are reliant upon Earth's systems might seem to students to be very teacher directed such that it may not be clear to the students why they are learning about farms in one lesson, spheres of Earth in the next, and then asked to record their actions. It is unclear if students will feel that the activity is authentically connected to sense-making.
- Hands-on At Home Suggestions are provided, allowing students to connect their learning with their home or community. For example, in Lesson 4, "Have students write a list of what types of fossil fuels they use in their home or that they see being used in their neighborhood. Describe how that might be affecting the air where you live" (TG Appendix, page 33).
- A "Parent / Guardian Letter" is included with unit resources (English and Spanish translations) to involve homes and neighborhoods. In the letter, parents/guardians are provided with school-home connections. "During this unit, it is a great time to consider how you use natural resources in your homes such as food, water, wood, rocks, oil, and natural gas. Discuss how many of these resources you use on a daily basis, and where these resources come from. Make connections to the clothes they should wear depending on the weather. Discuss your favorite family activities, and trace all of the materials needed back to a natural product (for example, if you play a board game, the cardboard might have come from plants, and the plastic pieces came from oil). Experiential Learning Ideas: Go outside and make a list of all of the different parts of the Earth you see. Your child can categorize which sphere they belong to" (Unit 22, TG Appendix, page 13).
- Supports are provided for the teacher for issues to consider if they want to change the anchoring problem. "Keep the following questions in mind: Is it going to be relevant to my students' lives and/or particularly engaging to them?" (TG, page 15).
- The teacher is supported in helping students make connections to their own experiences, such as the Lesson 4, Engage prompt, "Do you know someone who has asthma?" (TG, page 49).
- Lesson 5: "People from different cultures across the globe view water as a sacred resource that deserves to be protected. You could read the children's book *We are Water Protectors* by Carole Lindstrom to examine how Indigenous people of North America have rallied to protect the waters of the land. Missouri has many natural springs that have been important to both native tribes and early European settlers" (TG, page 65).
- Lesson 7: "Historically women have been leaders in social and environmental movements, however, their contributions often go unrecognized. You could read the children's book *The Tree Lady* to examine the story of Kate Sessions, a woman who worked to make a positive impact on her community" (TG, page 86).
- Lesson 8: The teacher is supported to think of students' funds of knowledge as assets. A sidebar "Attending to Equity" teacher note says, "In order to allow students to bring their funds of knowledge to the table during engineering design challenges, allow them to help generate the list of the criteria and constraints of the challenge" (TG, page 96).

The reviewers recognized that the intention of the unit is for students to think innovatively about how farming practices may improve. For example, in Lesson 7, Elaborate: “we are going to create a new farm model that includes our vision for what a farm that creates less impacts on Earth systems could look like” (TG, page 88). However, a possible side effect of teaching and learning that asks young learners to think of how a community practice might improve is the implication that the community practice is currently “bad.” Furthermore, when that community practice is associated with a specific identity (e.g., farmers) there is added potential for creating negative bias toward individuals or a group. The unit positions the farming community — especially livestock farmers — as the source of the problem. There is currently no support in the unit to acknowledge this potential conflict for individual students who may be from farming families or to productively navigate it. Classrooms that exist in communities that rely heavily on livestock farming or are made up of predominately farming families may hesitate or opt not to utilize these curricular materials without the addition of a note to both recognize the potential for conflict and guidance on how to navigate the conflict.

Suggestions for Improvement

- Consider connecting the discussion of students’ favorite foods (TG, page 13) explicitly with the discussion of farms. For example, the teacher could be prompted to say something like, “I heard many of you sharing foods that have ingredients produced on a farm” before discussing the anchoring problem and showing the video.
- Lesson 1: Consider helping students further understand the connection between a farm and students’ schoolyard by leveraging a need to visit their schoolyard to better understand the interacting components of a farm system. This could be done by involving students in wondering how they can learn more about interactions between parts of a farm environment without actually visiting one.
- Lesson 5: Water demonstration: Rather than a demonstration, consider having students measure the water themselves or ask a student to add and remove water.
- Parent/Guardian Letter: Rather than including the storyline in this initial letter (“students will figure out key earth science components through the lens of farming. They will consider the animal waste generated on farms, and the effects of all of this waste. Students will first explore the different parts of our planet, such as the atmosphere. They will make a model to show how all parts of the Earth are connected. Students will continue their learning by considering how humans use Earth’s natural resources for daily life and as energy sources. Finally, students will explore how we can understand science ideas in order to use our resources in a way that does not negatively affect the environment. Students will be challenged to design a biodigester that can use food waste to produce gas as an energy source”), consider supporting the inclusion of families in figuring out the anchoring problem so they can experience “ah-ha moments” together with their student (Unit 22, Appendix).
- Consider more explicit connections between the farm and the students’ neighborhoods. For example, consider having students develop a systems interactions model that includes matter and energy transfer in a system model that could be applied to understanding system interactions within any environment.

- Consider including a wider variety (e.g., racial, ethnic, cultural, etc.) of people represented in unit materials. It is essential that students see themselves represented. The article “Cultural Responsiveness of the Next Generation Science Standards” printed in the *Journal of STEM Teacher Education* might be helpful: link.

II.B. STUDENT IDEAS

Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate.

Rating for Criterion II.B. Student Ideas	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas because there are opportunities for students to discuss their own and each other’s ideas in a variety of formats. However, there are few supports to elicit ideas, help address disparate ideas, or help students clarify their ideas.

Students have regular opportunities to share their ideas and thinking in various formats. They also have many opportunities to give and respond to peer feedback. However, teachers are not prompted to provide feedback to students. Related evidence includes:

- Launching the Unit: “To support students to Turn and Talk, consider using: Conversational Support for Sharing and Expanding on Each Other's Ideas from STEM Teaching Tools” (TG, page 15).
- Lesson 1: “When creating groups, we advise that the teacher creates the groups in order to make them more equitable. It is best to have students in groups of 3 or 4 that consist of mixed ability, gender, and cultural background. The article, Designing Group Work, from Ambitious Science Teaching has more information on group arrangements and facilitating discussions” (TG, page 18). Teachers might not have enough support for leveraging student groupings to promote voice and provide opportunities to refine and clarify thinking.
- Lesson 1: “Once students return to class, have them share their observations and the different classifications they made. Push students to provide reasoning for how they categorized the different parts of the environment” (TG, page 19). This is an opportunity for students to refine and clarify their own thinking.
- Lesson 1: “When co-constructing the ‘Gotta Have It’ checklist with your students, actively moderate the discussion using discourse moves such as probing, turn-and-talks, follow-up questions, revoicing, and wait time. During this process, students often challenge or build on a peer’s suggestion so it may be helpful to refer to your classroom norms around how to comment on another’s ideas” (TG, page 21).

- Lesson 1: After creating a farm model, "Have students share their models with a partner and give each other feedback. Did they have something to represent each system? Did they label all parts of their model? How do their models compare with each other's?" (TG, page 22).
- Lesson 1: "Bring the class back together, and ask students to share out the differences and similarities in their models. This supports students to see the different ways you can represent and label things in models. Based on their discussion, students should change their models to reflect feedback" (TG, page 22). Teachers might need additional support on how to leverage student ideas. For example, after sharing, students could be asked to create an entirely different small group model.
- Lesson 2: "Have students share their models with a partner and give each other feedback. Did they have an example of the different sphere interactions? Did they label all parts of their model? How do their models compare with each other?" (TG, page 31).
- Lesson 3, Elaborate: "Ask students: 'Could animal waste be considered a natural resource? Why do you think it might be?' Allow students to share their ideas. Students should use their understanding of what natural resources are, and begin to discuss their rationale for why animal waste should be considered a natural resource, or why it should not be considered a natural resource" (TG, pages 43–44). Some students may not think animal waste is a natural resource, so teachers might need support in how to respectfully address all viewpoints and understandings.
- Lesson 5: "Have students share their models with a partner or another group and give each other feedback using the 'Gotta Have It Checklist.' How do their models compare with each other's? What interactions between water, animal waste, and Earth's systems did they identify? Students will continue to refine this model over time. Bring the class back together, and ask students to share out the differences and similarities in their models. This supports students to see the different ways you can represent and label things in models. Based on their discussion, students should change their models to reflect feedback" (TG, pages 66–67).
- Lesson 8, Explain: "Ask students: 'Why do you think it is important that we share our designs and results with each other? How will this help us improve our designs?' Students can share the design they chose for their wind turbine, and why they thought it would be the most effective at transferring energy. After each group shares, provide space for other groups to give feedback. Tell students that they must provide at least one piece of feedback for each group. Make sure feedback is helpful, specific, and kind. Examples of feedback students may provide: Praise: Tell why you like it/why it is a strength. Questions: Ask questions about components of the plan that are unclear. Polish: Tell what is confusing/provide suggestions for improvement" (TG, page 98).

Suggestions for Improvement

- Consider adding language to prompt educators to provide constructive feedback to students, on which the students then have the opportunity to reflect and act. Consider also providing suggestions about the content and format of that feedback.
- Consider including guidance throughout the learning sequence for eliciting questions and ideas from all students. Including desired student responses in parenthetical notation is helpful for educators, but without guidance on how to draw out those ideas, there is an increased chance

that educators will default to telling students and/or only gather ideas from a limited number of students once the desired response has been stated. Teachers will also need support to help them address responses that are not ideal or scientifically correct.

- The use of the phrase "Discuss with students…" as a directive to educators in the read-aloud guides could be interpreted more as "teacher telling" than as "student-to-student discourse." Consider including student-centered language or educator questions, more explicitly encouraging interaction among students or gathering of student ideas and reasoning.
- Consider providing direction for the implementation of tools strategically to balance variety of modality with repetition with regard to eliciting student ideas. For example, currently, many of the artifacts that demonstrate student ideas are verbal (e.g., turn-and-talk, share, etc.).
- Consider including more consistent and explicit support for the educator on how to encourage the addition of reasoning at most moments of eliciting student ideas.

II.C. BUILDING PROGRESSIONS

Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers:

i. Explicitly identifying prior student learning expected for all three dimensions

ii. Clearly explaining how the prior learning will be built upon.

Rating for Criterion II.C. Building Progressions	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials identify and build on students' prior learning in all three dimensions because the materials sometimes state the expected level of proficiency students should have with the DCIs and there is some guidance to understand the progression of learning via the use of the cross-out tool on portions of elements. However, the expected prior proficiency level students should have with the CCCs and SEPs is vague as is the progression toward learning targets.

Examples of prior learning being addressed include:

- In the introduction to the unit "Summary" section, teachers are provided with the prior understanding that is expected. "Prior to this earth science unit, students may have knowledge that energy makes things happen. Students may understand that energy can move from place to place and be transformed from one form of energy to another (NGSS 4-PS3, MLS 4.PS3). They have considered the environment as an ecosystem of parts that interact" (TG, page 10).

- Lesson 2: "Teaching Tip: If you teach Unit 23 'Our Place in the Universe' first, this will be a review for your students. If they do not remember, you can remind them by giving them an example from Unit 23. One example could be our solar system, which is composed of the different parts including the planets, moons, and the sun" (TG, page 28).
- Lesson 6: "If students have completed Unit 24 the concept of gas particles taking up space is a review (DCI PS1.A). If they have not completed Unit 24, it is okay just to get students thinking that gas is filling up the balloon, but it is not expected that they understand the particle level of the states of matter at this point" (TG, page 73).

Learning progressions are not clearly described for SEP and CCC learning goals:

- The unit materials have several claimed learning goals listed in the Appendix. These are referred to in individual lessons during the formative assessment opportunities in the teacher side bar. However, the specific progression of learning related to these elements (e.g., if they are meant to be just partially understood in one lesson but fully understood in a later lesson) is not indicated for the teacher other than with strikethroughs in some elements. In most cases the SEP and CCC elements do not include strikethroughs, so readers would assume full proficiency in these elements are expected of students the first time they appear in the unit, indicating that there is not a learning progression during the unit.
- In the Storyline (TG, page 5), unit activities are described in a linear fashion (e.g., "First," "Next," "Finally"). This description includes mentions of student learning related to DCIs and use of SEPs, but explicit learning (new development) of SEPs or CCCs is not described.

Suggestions for Improvement

- Consider highlighting expected prior learning in all three dimensions. This will help ensure teachers are aware of previous learning and are able to build on understanding (with support for those who require it). This will allow teachers to make connections and for students to apply the rich learning that they have already developed.
- Consider listing expected prior learning in the Appendix document. This will provide further clarity for building elements as students increase in the complexity and sophistication of element development.
- While it is easiest for teachers to work around gaps in prior understanding, it would be helpful to provide the support needed to ensure all students are engaged in grade-level elements and the teacher is supported in identifying and filling the gaps.

II.D. SCIENTIFIC ACCURACY

Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.

Rating for Criterion II.D. Scientific Accuracy	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials use scientifically accurate and grade-appropriate scientific information because there are only minor issues with the accuracy or clarity of the scientific ideas and representations.

The following are examples of areas of potential confusion pertaining to scientific accuracy:

- There is potential confusion (for the teacher and student) about Earth systems and Earth spheres. For example, in Lesson 1, "Say to students: Scientists have words to describe the different parts of our Earth. There are four different categories, or systems, that we can use to describe our planet" (TG, page 19). The teacher is directed to show two videos "Four Spheres Part 1 (Geo and Bio)" and "Four Spheres Part 2 (Hydro and Atmo). " Teachers are told, "These videos are used to introduce the terms to students. Each video covers two systems" (TG, page 20). Using the terms "spheres" "categories" and "systems" in what appears to be an interchangeable fashion may lead to confusion.
- Some wording is potentially misleading about energy creation (rather than transfer). In Lesson 7: "Revise the class model to include ways to create energy using renewable resources" (TG, page 89). One of the Lesson 7 learning goals also says, "Revise a model of a farm system to explain how farms could create energy in a way that protect's [sic] Earth's resources" (TG, pages 79 and 81).
- Lesson 5, Explain: "Aquifers are large bodies of underground rock that contain fresh groundwater" (TG, page 63). Some aquifers, especially coastal, can contain salt water.
- Renewable/non-renewable energy and renewable/non-renewable resources are used in an interchangeable way that may be confusing. The title of the unit includes "natural resources" and "renewable and non-renewable energy." However, unit material and design challenges require an understanding of non-renewable and renewable natural resources that can be used as energy resources. This distinction is not always clearly made, and it is not clear if it is understood (by teacher and students). For example:
    - Lesson 7: "They will examine a case study of an island in Denmark that changed from using non-renewable to renewable energies" (TG, page 5).
    - Lesson 7: "Key Takeaway" "One way to do this is by using renewable resources such as wind, solar, water, and biofuel" (TG, page 79).

    - Lesson 8: "One of the types of renewable energy we saw used on Samsø Island was wind energy. What do you observe from the video?" (TG, page 94).
- The definitions of "renewable resource" "non-renewable resource" and "natural resource" have been simplified in unit materials, potentially preventing students from fully understanding the ideas:
    - A non-renewable resource is defined in the materials as "resource that is not replaced by nature as fast as it is used" (TG, page 37). However, the full definition includes the idea that non-renewable resources are finite. This latter part of the definition may help students (and teachers) understand that non-renewable resources can be depleted over time.
    - Natural resources are defined as "materials in Earth's systems that are useful to people" (TG, page 37). However, the definition typically includes the idea that the resource is "used to support life and meet people's needs." Including this portion in the definition provided may help emphasize that natural resources are not just available as energy sources but in some instances (water for example) are essential for life.

Suggestions for Improvement

- Consider clarifying definitions and references to key scientific words and principles, including transfer of energy (versus creation).

II.E. DIFFERENTIATED INSTRUCTION

Provides guidance for teachers to support differentiated instruction by including:

i. Supportive ways to access instruction, including appropriate linguistic, visual, and kinesthetic engagement opportunities that are essential for effective science and engineering learning and particularly beneficial for multilingual learners and students with disabilities.

ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.

iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.

Rating for Criterion II.E. Differentiated Instruction	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials provide guidance for teachers to support differentiated instruction. The materials highlight some areas where students might struggle and there are some individualized learning strategies provided and some differentiation strategies to address the needs of struggling students. However, support is generalized and limited in helping teachers anticipate needs of struggling students. Explicit support is rarely provided to connect elements of the three dimensions to these strategies.

Examples of supports for anticipating and addressing gaps in understanding include:

- Launching the Unit: “Students come to the classroom with prior knowledge, or partial knowledge from previous learning as well as life experiences. Use the Driving Question Board to elicit student thinking and access students [sic] prior knowledge” (TG, page 13). However, it is unclear if all student voices will be heard and if teachers will be able to elicit thinking and access prior experience of individual students or just the louder or more assertive students.
- Launching the Unit: “Take notice about what students understand about the DCIs, or how what they know could connect to the DCIs as they progress through the unit. This will help you figure out how to best meet individual student needs as you teach the unit, and gauge how much student knowledge and skills grow as a result of the unit” (TG, page 14). This suggestion is very general. Teachers might need additional support in the identification, interpretation, and response to individual student needs.
- Launching the Unit: “If students aren’t sure what to observe you can ask: ‘What do you notice is happening during this part of the video? What questions do you have about what we just saw?’” (TG, page 14). However, this prompt might only support the students who volunteer their answers first.
- Lesson 2: “If students are struggling to make connections among systems, ask students: ‘Are there components you could add to your farm model that would help you identify interactions?’” (TG, page 31). This prompt might only support the students who volunteer their answers first.
- Lesson 4: “If students provide system interactions that are not correct, ask them to explain their thinking. Then refer to the talk moves and have students agree and/or disagree with their thinking” (TG, page 53).
- Lesson 4: “If students are struggling to obtain information to describe the connections between human events (transportation) and pollution, read the resources as a class, pausing frequently to check if you have come across information needed to fill out the journal page” (TG, page 54). This support is very general and might not address the needs of individual students.
- Lesson 5: “If students are struggling to create their graphs, walk through graphing one data point as a class” (TG, page 63).
- Lesson 5: “If students are struggling to develop their claims, provide them with sentence starters” (TG, page 63). Sentence starters may help some students but may not address the needs of individual students who may be struggling for different reasons. For example, they might not understand the task.
- Lesson 5: “If students are struggling to come up with a procedure, walk a group or the whole class through using one of the experiment options as an example. If other groups finish early, you can use their procedure as an example” (TG, pages 75–76). This general support might need additional scaffolding for individual students.

- Lesson 7: “See the student journal answer key for an example. If students are struggling to apply what they have learned in developing a model, use the class consensus model you created to support students to further develop their models” (TG, page 89). This support might lead to students copying without teachers providing the individualized support that would help students progress in their learning.
- Lesson 8: “Almost every mySci unit incorporates the engineering design cycle. At this point, students should be familiar with the cycle. If not, remind students that engineers are people who work to design and build solutions to problems we face. Say to students: ‘Engineers create new inventions that solve problems.’ Show students the Engineering Design Cycle Student Journal page and talk through each step” (TG, page 95). Some students may need additional and individualized support in implementing the design cycle.
- Lesson 8: “If students are struggling to see how these materials could form a wind turbine, display ‘Bucket Lift Drawing’ (in Section 3 curriculum slides) and point out how the materials are used to make the turbine” (TG, page 96). Students might need additional scaffolds that extend beyond pointing out examples. This guidance has the potential of students mirroring what the teachers do without developing understanding and capacity.
- Lesson 9: “If students are struggling to apply what they have learned in constructing explanations, focus their attention back to the evidence to help them identify how a particular condition meets or does not meet the criteria” (TG, page 108). This general support might not meet individual students’ needs. Additional and varied support suggestions could better help teachers respond to the needs of students.
- Lesson 9: “If students are still struggling with a specific DCI, CCC, and/or SEP consider revisiting the lesson(s) where that concept is covered” (TG, page 111). This general support may not meet individual students’ needs. Additional and varied support suggestions could better help teachers respond to the needs of students.

Examples of support provided for specific subgroups of students include:

- Spanish speaking students and families:
    - The parent letter that introduces Unit 22 is provided in Spanish to ensure that Spanish-speaking parents are included in the communication.
    - Google Slide vocabulary cards are available in English and Spanish.
- Students who need reading support:
    - Lesson 3: Teachers are told, “The ‘Nine Surprising Things Made with Oil’ video does not include narration. You may need to narrate this video while watching if you have students who need support with reading” (TG, page 42).

An “Extend” section is included in Lesson 5: “If students demonstrate success with DCI ESS2.C and begin to wonder about solutions to the problem, you can provide them with this extension” (TG, page 68). Extension activities are not provided for students who already meet or exceed expectations related to SEPs or CCCs.

The "Attending to Equity" comments found in the left-hand column provide some individualized instruction guidance, especially regarding cultural accommodations. However, none of these margin notes provide multiple and varied individualized learning strategies that support three-dimensional sense-making, including specific guidance for all of the critical learning steps.

Suggestions for Improvement

- Consider providing teachers with additional support for identifying areas where individual students may struggle in one of the targeted learning goals, especially for SEPs and CCCs. For example, consider including sample tracking charts in which teachers could insert names of all of the students and track progress to identify struggling students. This kind of chart could be accompanied by a list of possible scaffolds that could be added or removed to meet individual students' needs.
- Consider providing teachers with additional support strategies related to specific elements of all three dimensions aimed at meeting individual students' diverse needs, including learners with disabilities and learners whose home language is other than English or Spanish.
- Consider providing additional extension opportunities, especially those aimed at expanding student capabilities in the SEPs and CCCs.

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

Supports teachers in facilitating coherent student learning experiences over time by:

i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.).

ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions.

Rating for Criterion II.F. Teacher Support for Unit Coherence	**A**dequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials support teachers in facilitating coherent student learning experiences over time because frequent guidance is provided to teachers to support linking student engagement across lessons. However, support might not currently be sufficient for teachers to help students see the connections between phenomena and problems across lessons and to ensure that students see learning in all three dimensions as coherently linked to progress they are making toward explaining the "farm problem."

Teachers are provided with support to help them understand the intended flow of learning across the lessons. For example:

- The unit is divided into sections "How are farms part of Earth's systems?" "How does our use of natural resources on farms affect Earth's systems?" and "How can farmers use resources wisely to protect Earth's systems?" Charts that include "Activities + Observations" "What I learned" and "How it connects to the anchoring problem and driving questions" are provided for each section (Unit 22, TG Appendix, page 9). This layout is clear and assists teachers in linking lessons together.
- The teachers are provided with a "Storyline" (TG, page 5) in which color coding is used to highlight categories (e.g., "**Systems and System Models**") of the three dimensions that are intended to be developed or used in the unit. The Storyline page lists the dimensions intended to be developed or used throughout the unit followed by "first," "next," and "finally" statements. "First, students will explore the four Earth systems (hydrosphere, biosphere, atmosphere, and geosphere) and learn how these systems interact" (TG, page 5). This kind of description can help educators get an overview of the unit's outline.
- Appendix D includes the chart "Progressions of NGSS 3-Dimensions" with a summary of targeted learning for identified DCI, SEP, and CCC elements. For example:
  - **ESS3.A Natural Resources**: *Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.* "In Lesson 3, students research different ways we obtain energy and describe how the different types of energy affect the environment. In Lesson 4, students learn about fossil fuels as non-renewable resources. In Lesson 5, students think about fresh water as a natural resource. They also examine the negative impacts that may result from using these resources in excess in Lessons 4 and 5. In Lesson 7, students read the book Energy Island, an article, and watch a video to learn more about how a community can change the way it uses renewable energy, then develop new ideas about energy choices in their community" (Unit 22, TG Appendix, page 21).
  - **Planning and Carrying Out Investigations**: *Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered*. "This SEP is key to sensemaking in this unit. In Lesson 6, students work in groups to decide which condition they want to test for their biodigester. In Lesson 8, students work in groups to design their wind turbines. They collect data to use as evidence that wind turbines work by transferring energy" (Unit 22, TG Appendix, page 25).
  - **Cause and Effect**: *Cause and effect relationships are routinely identified and used to explain change*. "This crosscutting concept is key to sensemaking in this unit. In Lesson 4, students research the cause-and-effect relationships between humans using natural resources and their impact on the environment" (Unit 22, TG Appendix, page 26). Note however that in relation to the **Cause and Effect** CCC category, reviewers only found evidence of students using a related K–2-level element in the unit. See evidence under Criterion I.B.

The unit materials support teachers in communicating the connections between lessons, referencing the DQB, and helping students link back to the anchor problem. For example:

- Lesson 2: "We are trying to figure out how farms are part of Earth's systems in order to address the anchoring problem that producing food uses a lot of resources and that can harm Earth's systems. In the previous lesson, we described the different parts of a farm environment. We considered what Earth systems these things were part of" (TG, page 27).
- Lesson 3: "Today's activity will support us in answering this question. By answering this question, we will be able to build on our understanding of the anchoring problem" (TG, page 38).
- Lesson 4, Elaborate: "In the last lessons we have used a 'Gotta Have It Checklist' to show the components and relationships we needed to include in the models. What would you add to the checklist today to make our models show natural resources used on a farm affect the environment?" (TG, page 54).

Teachers are provided with questions and guidance for generating student questions. For example:

- Lesson 1: Following guidance to ask students, "What new questions do you have?" and a set of sample student responses, teachers are advised, "Do not provide these questions for students, instead help them start thinking about these ideas by focusing their attention to the different systems that they labeled on their models and how that could relate to the anchoring problem: We need farms to grow food, but the process of producing food for all of us can harm Earth systems. Have students place their questions into existing categories, or create new categories" (TG, page 23).
- Lesson 4: Following guidance to ask students, "What new questions do you have?" and a set of sample student responses, teachers are advised, "Do not provide these questions for students, instead help them start thinking about these ideas by focusing their attention to the different interactions between fossil fuel use and Earth systems that they labeled on their models and how that could relate to the anchoring problem: Farms use a large amount of resources. This can have a negative impact on the environment. Have students place their questions into existing categories, or create new categories" (TG, page 56).
- Lesson 6: Following guidance to ask students, "What new questions do you have?" and a set of sample student responses, teachers are advised, "Do not provide these questions for students, instead help them start thinking about these ideas by focusing their attention to the problem that biodigesters are helping to solve to help orient them to thinking about other solutions and how that could relate to the anchoring problem: Farms use a large amount of resources. This can have a negative impact on the environment. Have students place their questions into existing categories, or create new categories" (TG, page 78).

There is very limited evidence to support that educators are provided strategies for ensuring student sense-making or problem solving is linked to learning in all three dimensions. For example:

- Although lesson level front matter includes a summary that lists the three dimensions that students are "Building Towards" during the lesson, the three dimensions are only listed at the

K–12 category level (e.g., "**Cause and Effect**") rather than the individual element or partial element level, and individual elements are only listed in the Evaluate sections at the end of the lessons and in the Appendix. The Evaluate sections often help students reflect on their learning related to DCI elements, but guidance about reflecting on learning related to SEPs and CCCs is not included.

- The iterative Farm Model experience for students, the most prevalent examples of multi-dimensional integration and demonstration of sense-making in the learning sequence, is evaluated through peer feedback using a co-constructed "Gotta Have" checklist. While educators are given a few suggestions for what those "Gotta Have" checklists might include, no criteria are linked back to specific elements of SEPs and CCCs in a way that would allow students to realize they're learning something that they could apply again in a different context, other than for modeling.

Suggestions for Improvement

- Consider explicitly illustrating how every lesson adds a layer of understanding that will help students design a solution to the anchoring problem. If an activity is not clearly a sense-making opportunity for students or is not explicitly connected to the anchoring problem, consider its removal from the sequence or offering it as an extension activity for students who have demonstrated mastery.
- Consider expanding the information found in Progression of NGSS 3-Dimensions Chart, particularly the CCCs, to make the progressions more explicit. For example, the lesson summaries next to specific elements could connect to specific lesson activities.
- It would be helpful to support educators in conveying to students why each dimension selected — as well as their integration together — is essential for students to sense-make and problem solve.

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.

Rating for Criterion II.G. Scaffolded Differentiation Over Time	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjust supports over time because there is some evidence that scaffolds for developing models are gradually reduced over the length of the unit. However, there are very few supports to help all students explicitly build understanding and proficiency with the targeted SEP elements using a variety of approaches to meet diverse student needs.

Some development of student understanding of **Obtaining, Evaluating, and Communicating Information** appears in the unit, although a large amount of scaffolding is provided for students each time and is only slightly reduced. For example:

- Lesson 3: "To help students develop the practice of obtaining information, provide one resource. In the following lesson, they will be provided with multiple resources and asked to combine information. You can walk through the resource (Coal) and model how to take notes on important information" (TG, page 41).
- Lesson 4: "To support students in identifying reliable resources facilitate a discussion about important things to look for when examining websites: 'Writing Videos for Kids: How to Evaluate Sources for Reliability.' From this video, highlight the following: Identify the author. Who are they? What is their purpose for writing the article? Look for common information between multiple articles on the same topic Look at the date the article was written. Scientific knowledge can change over time" (TG, page 52).
- Lesson 7: "Students will continue to build on the SEP Obtaining, Evaluating, and Communicating information. In Lesson 3, students developed the practice of obtaining information, using only one resource. In Lesson 4, they used multiple resources, and combine information. In this lesson, students will again use multiple resources and combine information. They will use this information to create presentations to communicate this information…. Students will use the Guiding Questions for *Energy Island* Student Journal pages to help them gather information for their presentation. Discuss that a 'claim' is what you think is true, and 'evidence' is an observation or data that supports your claim. Students will make claims based on the book, video, and article and provide specific evidence for each claim. Make it clear that they can have more than one claim and that they can have more than one piece of evidence to support each claim" (TG, page 85).

Support for student use of **Developing and Using Models** is reduced over the length of the unit.

- Lesson 1: Teachers are told, "Modeling is an important science and engineering practice in this unit. This practice is initially done as a whole class, as a scaffold for students to engage in the practice. Students will develop and revise their own models as they progress through the unit" (TG, page 17).
- Lesson 3: "Revise the class model to include the natural resources the students described from their individual models. Ask students what labels you should put on your drawing. This helps scaffold the revision process and provides continuity throughout this unit" (TG, page 44).
- Lesson 5: "Students will continue to refine this model over time. Bring the class back together, and ask students to share out the differences and similarities in their models. This supports students to see the different ways you can represent and label things in models. Based on their discussion, students should change their models to reflect feedback" (TG, pages 66–67).
- Lesson 5: "If students are struggling to apply what they have learned in developing a model, use the class consensus model you created to support students to further develop their models" (TG, page 89).

- Lesson 9: "If students are struggling to apply what they have learned in developing a model, use the class consensus model you created to support students to further develop their models" (TG, page 110). In this case, the supports do not change between Lessons 5 and 9.

Suggestions for Improvement

- Consider adding additional support to provide teachers with guidance for where and when to remove supports to move students toward independence.
- Consider using a format such as "where have we been?" and "where are we going?" in the TG in relation to student proficiency expectations for these two targeted SEP elements. This could help teachers understand where and when students are expected to reach certain steps in their proficiency or independence with the SEP elements.
- Consider providing teacher support to help all students (including those with special needs and abilities) explicitly build proficiency through a greater variety of approaches over the course of the unit. For example, consider including explicit examples of how to recognize and support individual students who are struggling with targeted elements using a variety of approaches.

OVERALL CATEGORY II SCORE: 2	
Unit Scoring Guide – Category II	
Criteria A-G	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

CATEGORY III

MONITORING NGSS STUDENT PROGRESS

III.A. MONITORING 3D STUDENT PERFORMANCES

III.B. FORMATIVE

III.C. SCORING GUIDANCE

III.D. UNBIASED TASK/ITEMS

III.E. COHERENT ASSESSMENT SYSTEM

III.F. OPPORTUNITY TO LEARN

III.A. MONITORING 3D STUDENT PERFORMANCES

Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.

Rating for Criterion III.A. Monitoring 3D Student Performances	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials elicit direct, observable evidence of students using practices with core ideas and CCCs to make sense of phenomena or design solutions. Major assessments and student artifacts require grade-appropriate elements in more than one dimension to be used together to evaluate most targeted learning, and assessments are regularly driven by phenomena or problems. However, most of the post assessment prompts do not require students to use the claimed CCC elements.

Related evidence includes:

- In the unit formative assessments, students sometimes produce individual student artifacts that show their performance in three dimensions in relation to problem solving. For example, in Lesson 7, the teacher tells students, "now, we are going to create a new farm model that includes our vision for what a farm that creates less impacts on Earth systems could look like….Just like in our original farm model, we need to use a 'Gotta Have It Checklist' to show the components and relationships we need to include in the models" (TG, page 96).
- In the Section 1 Post Assessment: Students are asked to develop a model "that describes interactions between two Earth systems during a volcanic event. They are reminded to include "Labels to identify the components of the systems" "Arrows to show relationships between the chosen system" and "Captions that explain the interactions."
    - The questions are driven by the phenomena of Mt. St. Helens erupting and that eruption having an effect on the environment.
    - Students are asked to apply their understanding of an SEP element: *Develop a model to describe phenomena.*
    - Students might demonstrate implicit use of part of a CCC element: *A system can be described in terms of its components ~~and their interactions.~~*
    - Students are asked to demonstrate understanding of part of a DCI element: *Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). ~~These systems interact in multiple ways to affect Earth's surface materials and processes~~*.
- In Section 2 Post Assessment I: "How does our use of natural resources on farms affect Earth's systems?" Students are asked to read a paragraph that tells them, "While meeting the expected increase in demand is an important concern, it's not the only thing that is important. Energy use

can have impacts on the environment. We want to supply energy to people while decreasing the impact we have on the environment." They are provided with a chart with links to resources on geothermal and nuclear energy. Students are asked to fill a table "explaining the resources used for energy and if it is renewable or nonrenewable." They are then asked to fill another table "explaining the positive and negative effects of geothermal and nuclear as energy sources" and then "combining the information you have gathered, explain which resource should be used to support the United States [sic] future energy needs while still protecting the environment."

  - The questions are driven by solving the problem of energy use affecting the environment.
  - Students are expected to demonstrate understanding of the SEP element: *Obtain and combine information from reliable media ~~to explain phenomena~~*.
  - Students are asked to demonstrate understanding of the DCI element: *Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not*.
  - A claim is made that students also apply the CCC element*: Cause and effect relationships are ~~routinely identified and~~ used to explain the change*, but the prompts only require students to use the K–2-level partial element: *Events have causes.*

- In Section 3 Post Assessment: "How can farmers use resources wisely to protect Earth's systems?" Students are provided with a paragraph and two pictures about "plastic pollution." They are asked to apply their understanding of Earth systems to explain the negative effects of plastics on Earth's oceans. They are provided a table "to obtain information to explore different solutions to the problem of ocean plastic pollution", asked to fill in a table to "Describe the three solutions and how they will protect Earth's environment", and answer the question "Which of the solutions from part 1 do you think will do the most to protect the environment?"
  - The questions are driven by the problem of plastics polluting oceans.
  - Students are expected to demonstrate the SEP element: *Obtain and combine information from ~~books~~ and/or other reliable media to explain ~~phenomena~~ or solutions to a design problem*.
  - Students are asked to demonstrate understanding of the DCI element: *Human activities in ~~agriculture~~, industry, and everyday life have had major effects on the ~~land, vegetation,~~ streams, ocean, ~~air, and even outer space~~. But individual communities are doing things to help protect Earth's resources and environments*.
  - Students have the opportunity to apply the CCC element: *A system can be described in terms of its components and their interactions.* However, students are not required to show this understanding of how systems can be described in order to successfully complete the performance in accordance with the answer key responses.

Suggestions for Improvement

- Consider modifying the prompts in the post-assessment to ensure they require grade-appropriate use of CCC elements.
- Consider a greater variety of three-dimensional sense-making or problem-solving-focused assessments. For example, consider using the wind turbine or desalination device as a formative

assessment with clear expectations (rather than directions) as to what students are being asked to figure out. Students could then be asked to apply and demonstrate competency with elements of the three dimensions without being directed which ones to apply.

III.B. FORMATIVE

Embeds formative assessment processes throughout that evaluate student learning to inform instruction.	
Rating for Criterion III.B. Formative	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction because the material explicitly calls out formative assessment opportunities, most formative assessments are tied to multiple dimensions, and there is some support to interpret and respond to student thinking related to the learning targets. However, there is little specific support for modifying or informing instruction based on students' responses and few supports are provided to equitably attend to the needs of individual students.

Materials explicitly call out formative assessment opportunities, and often include instructions that the teacher should provide additional support "if students are struggling." However, the assessment opportunities are typically for the entire group versus individual students, and the instructions for modifying instruction if students struggle are often vague or focused on repeating or scaffolding instruction in the same modalities as the original instruction. For example:

- A green check mark is used to indicate "an opportunity for formative assessment" many times throughout the nine lessons. Distinct formative assessment opportunities are built into the lesson flow.
- Lesson 1: Following the revision of a class consensus model to include the Earth systems students identified, teachers are told, "This activity is a chance to formatively assess students' understanding of the SEP Developing and Using Models, DCI ESS2.A, and the CCC System and System Models. Look for students to have met the criteria of the 'Gotta Have It' checklist. See the student journal answer key for an example. If students are struggling to apply what they have learned in developing a model, use the initial class model you created in the Engage to show students how to further develop a model" (TG, page 22). This is an example of a full group assessment. Note also that the lesson does not describe discussion or prompts indicating that students would need to explicitly understand the CCC in order to participate in this assessment. Students are more likely to show understanding of the K–2-level element *Systems in the natural and designed world have parts that work together.*

- Lesson 3: After the students "Return to the class consensus model that was created in the Engage portion of Lesson 1" and "revise the class model to include the natural resources the students described from their individual models", teachers "ask students what labels you should put on your drawing." Teachers are told, "This activity is a chance to formatively assess students' understanding of the SEP Developing and Using Models, DCI ESS3.A, and CCC System and System Models. See the student journal answer key for an example. If students are struggling to apply what they have learned in developing a model, use the class consensus model you created to support students to further develop their models" (TG, page 44). This is a full group (rather than individual student) assessment. Note also that the lesson does not describe discussion or prompts indicating that students would need to explicitly understand the CCC in order to participate in this assessment.
- Lesson 4: "This activity is a chance to formatively assess students' understanding of the SEP Obtaining, Evaluating, and Communicating Information, DCIs ESS3.A and ESS2.A, and CCC Cause and Effect. You can examine the flow charts students created (see the student journal answer key for an example) as well as observe their discussions about the interactions between Earth's systems using the model from Lesson 2. If students are struggling to obtain information to describe the connections between human events (transportation) and pollution, read the resources as a class, pausing frequently to check if you have come across information needed to fill out the journal page" (TG, pages 53–54). Note that students are not prompted or required to use the claimed CCC element (about the routine nature of identifying cause and effect relationships) in this assessment.
- Lesson 5: Students make a pie chart of water sources on Earth. Students are instructed to make a claim about the chart (TG, page 63). An idealized answer is provided, but it does not include components related to the claimed CCC element.
- Lesson 6: Teachers are told, "The Biodigester Investigation Student Journal pages are a chance to formatively assess students' understanding of the SEP Planning and Carrying Out Investigations and the DCI ETS1.C. If students are struggling to plan and carry out their investigation, pick one investigation that is different from what the student groups choose and develop the procedure as a class to model the process" (TG, page 77). This is an example of individual-level assessment. However, note that students are not prompted to demonstrate understanding of DCI **ETS1.C** in this instance, since they merely follow the teacher's direction in testing multiple different designs.
- Lesson 8: "This activity is a chance to formatively assess students' understanding of the SEPs Planning and Carrying Out Investigations and Developing and Using Models, PS3.A and PS3.B, and CCC Energy and Matter. See the student journal answer key for an example. If students are struggling, develop a class comparison" (TG, page 99). This is an example of three-dimensional assessment.
- Lesson 8, Explore: "Say to students: 'The materials here are what everyone will be able to use for their wind turbines and they are the same for each group. Is there anything else that we should keep the same to make sure it is a fair test?'….If students miss any of these variables, prompt them. For example, if they miss 'same distance from the fan' ask if it would be a fair test to place one wind turbine right next to the fan and one far away. As a class, determine the

length of the string (40 cm is good), the weight of the bucket (or number/type of coins) and any other variables that would be controlled for a fair test" (TG, pages 97–98). This is evidence that the teacher is supported to use formative assessment for the class as a whole related to **Planning and Carrying Out Investigations,** and this is an example of specific (rather than general) guidance provided related to instructional modification.

- Lesson 9: "If students are still struggling with a specific DCI, CCC, and/or SEP consider revisiting the lesson(s) where that concept is covered" (TG, page 111).

There is some variation in the format of formative assessments. For example:

- Gathering and evaluating video information (Lesson 1);
- Drawing a farm model (Lesson 2);
- Completing a worksheet (Lesson 3);
- Small group discussions about information about Earth's systems on index cards (Lesson 4);
- Making a pie chart of water sources on Earth (Lesson 5);
- Developing an investigation plan (Lesson 6); and
- Participating in a class and small group discussion about an optimal wind turbine design (Lesson 7).

Suggestions for Improvement

- Consider including guidance to help teachers understand how they can use student artifacts to determine if students are integrating all three dimensions at a grade-appropriate level in service of sense-making or problem solving.
- Consider adding guidance to help teachers adjust instruction related to all three dimensions in a way that helps students reach grade level learning goals.
- Consider inserting additional formative assessments throughout each lesson to ensure students do not make it to the "Evaluate" stage of the lesson, and teachers do not teach the lesson until the end, prior to recognizing that individual students may have been "lost" along the way. Assessing throughout the lesson would provide teachers with information and the opportunity to adjust instruction prior to the end of the lesson.

III.C. SCORING GUIDANCE

Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.

Rating for Criterion III.C. Scoring Guidance	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials include aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions because assessment targets for grade-appropriate elements of all dimensions being assessed are clearly stated and incorporated into scoring guidance. Exemplar student responses are often provided, and the post assessments explicitly describe how each of the three dimensions is meant to play a role in the student response. However, a range of student responses is not provided, and the scoring guidance rarely includes explicit student use of a CCC. More and clearer scoring guidance is provided for post assessments than for formative assessments and there is little guidance on how to interpret different levels of student performance in relation to all three dimensions.

Related evidence includes:

- The Unit 22, Student Journal Answer Key includes sample student work and some scoring guidance. For example:
  - Slide 6: There is a sample student farm model and teacher guidance. “By the end of this lesson students should have a model similar to this. The model should include different things you may observe on a farm, and identify the Earth system that each component is part of using labels. Students may identify systems by writing directly on their model, or creating a key. Note: At the end of every lesson Evaluate the curriculum, there is guidance for what components students' models should have (Gotta Have It Checklist) as well as questions you can ask students if they are unable to add the components listed. Examples of revisions are provided at the end of the SJ.”
  - Slide 29: There is a sample new model farm and teacher guidance. “By the end of this lesson, students should have a model similar to this. Students should include renewable fuel sources for tractors and other farm equipment and renewable energy sources for electric power. They may include examples from their case study of Samso, including Wind turbines, biodigesters, using the oil of plants for gas, etc. Note: Students will revise this model after they have further explored solutions in Lessons 8 and 9.”

- The Unit 22, Post Assessment Answer Key includes scoring guidance and assignment of point values. For example:
  - Section 1: How are farms part of the Earth's systems? In question 2 students are asked to draw a model. The answer key states to give one point for labels, one point for using arrows to show relationships between systems, and one point for including captions.
  - Section 1: How are farms part of the Earth's systems? In question 2b students are directed to, "Use the model to explain how the Eruption of Mount St. Helens affected the functioning of one of Earth's systems." The answer key provides the following as scoring guidance and assigning points: "Two Point Answer: To earn two points, students must use evidence from the model to provide a detailed and accurate explanation of the systems involved and affected by the eruption of Mount St. Helens. Possible student responses include Volcanoes (events in the geosphere) release hot lava (geosphere). This causes mountain glaciers (hydrosphere) to melt. Volcanoes release gases (geosphere) into the atmosphere. This causes breathing problems in living things (biosphere)." "One Point Answer: Responses show that the student is attempting to explain the effects of the eruption of Mount St. Helens, but the explanations use limited evidence from the model, may be vague about how systems are interacting, lack detail, or include some inaccuracies. A possible student response includes Volcanoes release gas into the atmosphere" (Unit 22, Assessment Answer Key, pages 3–4).
  - Each section includes a section labeled "Standards Addressed," listing a PE and elements of all three dimensions. This section also includes notes about each dimension, such as "Description of Performance for CCC" to help define the part of the performance related to each of the three dimensions. Note, however, that these claims and descriptions don't always match the assessment prompts. For example, in the Section 1 model (Section 1, question 2), the sample student responses do not include information related to the claimed CCC assessment target. They instead relate to the K–2-level element *Systems in the natural and designed world have parts that work together.*
- Information in the sidebar next to each green check mark "formative assessment opportunity" lists the dimensions and elements that are claimed assessment targets. For example:
  - Lesson 4: On the sidebar "Formative Assessment: **ESS3.A: Natural Resources** Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. ~~Some resources are renewable over time, and others are not~~. **ESS2.A: Earth Materials and Systems** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. ~~The ocean supports a variety of ecosystems and organisms, shapes, landforms, and influence climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.~~ **Obtaining, Evaluating, and Communicating Information** Obtain and combine information from books and other reliable media to explain phenomena. **Cause and Effect** Cause and effect relationships are routinely identified and used to explain the change." This alignment is restated within the flow of the lesson without the

element: This activity is a chance to formatively assess students' understanding of the SEP Obtaining, Evaluating, and Communicating Information, DCIs ESS3.A and ESS2.A, and CCC Cause and Effect" (TG, pages 53–54). Note, however, that students are not prompted or required to use the claimed CCC element (about the routine nature of identifying cause and effect relationships) in this assessment.

- Lesson 8, Explore: Students design and construct a wind turbine. They use a teacher-provided rubric to self-evaluate, which is potential evidence of students tracking their own progress. However, there is no explicit guidance on how to interpret progress in all three dimensions as they work together in service of sense-making. This rubric does not reflect the evaluation of student proficiency with the targeted three dimensions.

Suggestions for Improvement

- The end-of-unit assessments list specific elements to be assessed and describe student performance features related to each dimension. Consider adding guidance to help teachers know what to look for during formative assessments to determine whether students are integrating all three dimensions at a grade-appropriate level.
- Consider including more specific guidance for helping teachers assess performance in all three dimensions and explicitly connecting student responses to elements of each dimension.
- Consider scoring guidance (not necessarily assigning point values) to formative assessments. The current guidance includes ideal student responses. Including guidance to help teachers interpret a range of responses that could help them (and students) assess progress specific to each of the three dimensions.

III.D. UNBIASED TASK/ITEMS

Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.

Rating for Criterion III.D. Unbiased Task/Items	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because vocabulary and the amount of text in task items are grade-appropriate and representation or scenarios are fair and provide some scaffolds. However, there is limited support for teacher awareness of the limitations of the scenarios for reaching all students and for providing students' choices of responses across multiple modalities.

Students are allowed to use a variety of modalities in some of their responses. For example:

- Lesson 1: "Students will create their models on the Farm Model Student Journal page. Students can create a digital drawing, a paper-based drawing that is uploaded, or a physical model. They can also represent their ideas through writing" (TG, page 21).
- Lesson 5, Explore: It is implied that students might have a choice in how to make a graph of global water sources (TG, page 62).
- Lesson 6: Students exercise choice in making a biodigester.
- Lesson 8: Students can choose their own wind turbine design.

However, in a large part of the learning sequence, expected responses from students during verbal exchanges are included in parenthetical notes, but only a limited number and variety of "correct" responses are typically listed. This may bias the educator toward specific "look for" phrases and cause other forms of communication to be overlooked.

Materials often include support to ensure vocabulary and content is unbiased and supported for all students. For example:

- Lesson 6: New vocabulary terms are often accompanied by root words. "Say to students: This is a basic model of a biodigester (bio = life, digest = break down) set-up to collect natural gas from waste. The natural gas from the food waste formed in the plastic bottle and collected in a balloon" (TG, page 73).
- The three slide decks include photographs when a new vocabulary term is introduced. For example:
    - Section 1, slide 12: "biosphere: parts of the Earth that contain organisms" includes a photograph of a flower growing amidst a variety of vegetation.
    - Section 1, slide 14: "hydrosphere: liquid water on Earth's surface, in the ground, and in the air" includes a photograph of a water wave.
    - Section 2, slide 8: "natural resources: materials in Earth's systems that are useful to people" includes a photograph of wheat with the sun in the background.
    - Section 2, slide 13: "fossil fuel: a fuel that formed from the decayed remains of ancient plants and animals (coal, oil, and natural gas)" includes a photograph of a person's (dirty) hand holding a piece of coal.
    - Section 3, slide 22: "criteria: what the design must have or be like" includes a picture of two people looking at a paper plan while standing in front of a dam.
- Lesson 6, Elaborate: "You may need to scaffold so that students can make the connection that they could take numerical measurements by wrapping string around their balloons as they fill up with gas" (TG, page 76).
- Lesson 9, Explore: "For example, students might say that the best biodigester is warm, has soil added to it, and is not too acidic" (TG, page 108). This prompt assumes that students will know what acidity is and the factors that will make the biodigester bottles more or less acidic.

Relevant visuals are sometimes included throughout the three slide decks when there is a question for the students to consider. For example,

- Section 1, slide 5: There is a picture of goats in their pen looking at the camera with the question "How are farm's part of the Earth's Systems? How does our use of natural resources on farms affect Earth's systems? How can farmers use resources wisely to protect Earth's systems?" (Section 1, Using Our Resources Wisely Slides, slide 5). Students might not see the connection between the picture and the questions on the slide.
- Section 2, slide 3: There is a picture of a farm with the question, "How does our use of natural resources on farms affect Earth's systems?" On slide 4 there is a picture of a waterfall with the question, "What are natural resources and how do humans use them?" Students are likely to see the connection between these pictures and the questions.
- Section 3, slide 15: There is a picture of a farm building with solar panels on top and three windmills in the background with the question, "How might this help figure out how farmers can use resources wisely to protect Earth's systems?" Students are likely to see the connection between these pictures and the questions.

Brief video introductions are used throughout the unit material. For example:

- Launching the Unit: Students are shown a video "What is Farming?"
- Lesson 1, Elaborate: Students are shown a video "Dairy Farm" showing an Ohio farm with 250 Jersey cows.
- Lesson 7, Explore: Students, are shown a video "Island in Denmark produces more energy than it consumes" that includes testimonials from Samso residents on their journey to using windmills for energy (captions are included).
- Lesson 8, Engage: Students are shown a silent video taken as a vehicle passed by windmills and asked, "Have you ever seen these fan-looking things while driving? What do you observe? What new questions do you have?" (Section 3, slide 18).

Throughout the unit, students perform tasks that draw from different modalities. For example:

- **Talk:** There are multiple opportunities for students to discuss the content and make sense of it through dialogue. For example, in Lesson 1 students discuss natural resources based on the prompt, "Allow students to Turn and Talk, then share a few answers with the whole class. Listen for students discussing ideas from previous grade levels and possibly previous units in your class. They may have ideas about ecosystems, matter, and energy" (TG, page 18).
- **Visual:** There are multiple opportunities for students to use visualization of targeted concepts. For example, the unit asks students several times to draw a farm model. In later revisions, students add to their previous model and discuss why they made changes. In Lesson 5, students use a pie chart to visualize the relative proportions of water sources on Earth.
- **Writing:** The pencil icon is listed as helping teachers know when students have an opportunity to write. However, the icon does not appear in the unit.

Suggestions for Improvement

- There are some areas where students may not have experience with certain amenities referenced (a car, for example) or may not have an adult at home to help them engage in “Hands-on at Home Suggestions” (a neighborhood that is safe to walk in). Consider adding guidance to build teacher awareness and potential limitations in students’ abilities to engage.
- Consider including additional opportunities for students to use variation in the mode they use to express understanding and application of the three dimensions to sense-making.

III.E. COHERENT ASSESSMENT SYSTEM

Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

Rating for Criterion III.E. Coherent Assessment System	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning because assessments connect to at least half of the learning goals and require students to apply some grade-appropriate elements as they make sense of phenomena or solve problems. The unit materials include formative and summative assessments. However, pre- and self-assessments cover very few of the learning goals and there is a significant mismatch between learning goals and assessments in the unit, especially for CCCs.

Assessments often connect to learning goals and align to some of the grade-appropriate targeted elements as students make sense of phenomena or solve problems. For example, the Assessment Answer Key in the Post Assessment document includes an “Assessment Standards Breakdown” for summative assessments in four sections (one for section 1, two for section 2, and three for section 3). This key lists the standards addressed, the elements of the three dimensions that are targeted for assessment, and descriptions of features of the SEP, DCI, and CCC performance for each question and the corresponding lesson where the learning occurred. However, these elements and descriptors do not always align with the actual assessment prompts and sample answers. See examples under Criteria III.A and III.C.

Formal formative assessments are provided at the end of each lesson and are labeled with assessment targets. However, there are few supports to help teachers interpret student responses to the formative assessments as applying the elements of the three dimensions in service of sense-making or problem solving. For example, in Lesson 4, no support is offered to teachers on how to notice whether students applied the cause-and-effect CCC claimed on pages 53–54. Instead, the connection between learning goals associated with the claimed elements and the tasks is left for the teacher to figure out on their own. Additional evidence is described under Criterion III.B.

Pre-assessments are included related to DCI learning. For example:

- Use of DQB: "Students come to the classroom with prior knowledge, or partial knowledge from previous learning as well as life experiences. Use the Driving Question Board to elicit student thinking and access students [sic] prior knowledge" (TG, page 13).
- Launching the Unit: "Take notice about what students understand about the DCIs, or how what they know could connect to the DCIs as they progress through the unit. This will help you figure out how to best meet individual student needs as you teach the unit, and gauge how much student knowledge and skills grow as a result of the unit" (TG, page 14).
- Lesson 1: "Listen for students discussing ideas from previous grade levels and possibly previous units in your class. They may have ideas about ecosystems, matter, and energy" (TG, page 18).
- Lesson 1: "'Have you ever heard these are part of any other words?' (Students may have exposure to these roots as part of words like geode, geology, biology, biography, hydrate)" (TG, page 19).
- Lesson 2: "Now is a good time to introduce or review* what a **system** is with students – a group of related parts that function together as a whole. You may ask them what they think a system is, and what it is like" (TG, page 29).
- Lesson 6: "Ask students: 'What did we learn about in the previous lesson? What do you remember about connections we made between farming and fresh water?' (Freshwater makes up a small portion of the water on Earth and farms use a lot of fresh water. We also know that farms can pollute water when animal poop washes into rivers and streams" (TG, page 72).

Self-Assessment: In Lesson 8, Explore: Students design and construct a wind turbine. They use a teacher-provided rubric to self-evaluate, which is potential evidence of students tracking their own progress. However, there is no explicit guidance on how to interpret progress in all three dimensions as they work together in service of sense-making. This rubric does not reflect the evaluation of student proficiency with the targeted three dimensions.

Suggestions for Improvement

- Consider including more pre-assessment and self-assessment opportunities linked to elements of all three dimensions so students (and teachers) can monitor progression towards meeting the lesson goals.
- Consider expanding upon the rationale for assessments and helping teachers better understand how the assessments (especially pre-, self-, and formative assessments) connect to the elements listed. While this may be intuitive to some teachers, teachers newer to the NGSS or the NRC *Framework* may benefit from additional clarity and support.
- Consider opportunities to understand and allow students to apply prior knowledge in additional ways. For example, when asking students to make a model, consider asking them to draw a model following the introduction of the anchoring problem. This would allow teachers to determine proficiency with modeling and environmental interactions. Another example is when

teachers are told, "Almost every mySci unit incorporates the engineering design cycle. At this point, students should be familiar with the cycle. If not, remind students that engineers are people who work to design and build solutions to problems we face. Say to students: Engineers create new inventions that solve problems" (TG, page 95). Consider changing this to a more individualized assessment of student understanding of the Engineering Design Cycle.

III.F. OPPORTUNITY TO LEARN

Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.

Rating for Criterion III.F. Opportunity to Learn	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide multiple opportunities for students to demonstrate the performance of practices connected with their understanding of core ideas and CCCs because there are iterative student performances that provide students with the opportunity to demonstrate their growth in proficiency over time. Students have some opportunities to apply peer feedback related to key learning to improve their performance in preparation for the next opportunity. However, these opportunities are not provided for all learning goals and there is no guidance to help teachers provide students with growth-oriented feedback.

Related evidence includes:

- Post-Assessments are administered at the end of three unit sections (Section 1: How are farms part of Earth's systems? Section 2: How does our use of natural resources on farms affect Earth's systems? Section 3: How can farmer's use resources wisely to protect Earth's systems?). Each assessment is accompanied by an answer key for teachers to score. Some assessments include questions based upon the same elements across unit sections and it can be assumed that if students receive scores from the first two sections, the student could use those scores to improve their performance on later sections' assessments. For example, the SEP element: *Obtain and combine information from reliable media to explain phenomena or solutions to a design problem* is assessed in Section 2: Assessment I, question 1 (with "to explain phenomena" crossed out) and Section 3: assessment question 1 (with "combine" "books" and "or solutions to a design problem" crossed out) and 2 (with "books" and "phenomena" crossed out). While reduction of the crossed-out portion of the element does not occur, it is reasonable to anticipate and look for student growth in the first part of the element.
- The "Gotta Have It Checklist" is used to add new learning to the revision of farm models, and students have many opportunities to get feedback from peers on their models. For example:

- Lesson 5: "Ask students what they should add to their 'Gotta Have It' checklist so that their models are showing what they want them to show. Their models should show: How water is being used on the farm, Where the water is coming from, Animal waste, something to show how the animal waste is affecting the water, and how the pollution gets from a farm to a water source that is not near the farm" (TG, page 66).
- Lesson 7: "Just like in our original farm model, we need to use a 'Gotta Have It Checklist' to show the components and relationships we need to include in the models. What would you add to the checklist today to make our models show how a farm can use natural resources in a way that doesn't harm Earth systems as much? Examples of things the model's 'gotta have' might include: Renewable fuel sources for tractors and other farm equipment Renewable energy sources for electric power" (TG, page 88).
- Lesson 7: "Have students share their models with a partner or another group and give each other feedback using the 'Gotta Have It Checklist.' How do their models compare with each other? What new resources did they identify? Students will continue to refine this model over time. Bring the class back together, and ask students to share out the differences and similarities in their models. This supports students to see the different ways you can represent and label things in models. Based on their discussion, students should change their models to reflect feedback" (TG, pages 88–89).

Suggestions for Improvement

- Consider including regular opportunities for students to receive feedback from the teacher to support their learning.
- Consider including iterative opportunities for students to show their proficiency, get feedback, make revisions, and show their proficiency again for all targeted learning goals, including CCCs.

OVERALL CATEGORY III SCORE: 3	
Unit Scoring Guide – Category III	
Criteria A-F	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

SCORING GUIDES FOR EACH CATEGORY

UNIT SCORING GUIDE – CATEGORY I (CRITERIA A-F)

UNIT SCORING GUIDE – CATEGORY II (CRITERIA A-G)

UNIT SCORING GUIDE – CATEGORY III (CRITERIA A-F)

OVERALL SCORING GUIDE

Scoring Guides for Each Category

Unit Scoring Guide – Category I (Criteria A-F)	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

Unit Scoring Guide – Category II (Criteria A-G)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

Unit Scoring Guide – Category III (Criteria A-F)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

OVERALL SCORING GUIDE	
E	**Example of high quality NGSS design—**High quality design for the NGSS across all three categories of the rubric; a lesson or unit with this rating will still need adjustments for a specific classroom, but the support is there to make this possible; exemplifies most criteria across Categories I, II, & III of the rubric. (total score ~8–9)
E/I	**Example of high quality NGSS design if Improved—**Adequate design for the NGSS, but would benefit from some improvement in one or more categories; most criteria have at least adequate evidence (total score ~6–7)
R	**Revision needed—**Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5)
N	**Not ready to review**—Not designed for the NGSS; does not meet criteria (total 0–2)