EQuIP Rubric for Science

Earth Processes

What causes land and things on it to change? How can we reduce the impacts on humans?

Curriculum Developer: OpenSciEd

GRADE 4 | DECEMBER 2025

nsta
National Science Teaching Association

Category I Rating

A	B	C	D	E	F
Explaining Phenomena/ Designing Solutions	Three Dimensions	Integrating the Three Dimensions	Unit Coherence	Multiple Science Domains	Math and ELA
ADEQUATE	EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE

Score Category I: 2

Category II Rating

A	B	C	D	E	F	G
Relevance and Authenticity	Student Ideas	Building Progressions	Scientific Accuracy	Differentiated Instruction	Teacher Support for Unit Coherence	Scaffolded Differentiation Over Time
EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE

Score Category II: 3

Category III Rating

A	B	C	D	E	F
Monitoring 3D Student Performance	Formative	Scoring Guidance	Unbiased Tasks/Items	Coherent Assessment System	Opportunity to Learn
EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE	EXTENSIVE

Score Category III: 3

UNIT 4.3

Sum Categories	**8**
Rating	**E**

Overall Summary Comments

This unit is designed for the *Next Generation Science Standards* (*NGSS*), including clear and compelling evidence of the following criteria:

- **Integrating the Three-Dimensions.** Students are expected to explain what caused changes to land in Acadia National Park, which requires them to use grade-appropriate elements of the three dimensions simultaneously.
- **Unit Coherence.** The lessons fit together coherently to target a set of performance expectations, as the lessons build on one another, that result in an increased understanding of the science ideas needed to explain the phenomena and design solutions to the engineering problems in the unit.
- **Scaffolded Differentiation Over Time.** Supports are provided to help students engage in the practices as needed, and supports are gradually adjusted over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems for nearly all of the intentionally developed SEP elements.
- **Formative Assessment.** There are opportunities in every lesson to gather, record, and use formative assessment information to inform future instruction.
- **Coherent Assessment System.** The materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

The unit was reviewed to "provide constructive criterion-based feedback and suggestions for improvement to developers" (EQuIP Rubric for Lessons & Units: Science [Version 3.1]). Reviewers recommend focusing on the following criteria during revisions:

- **Explaining Phenomena/Designing Solutions** to ensure that student questions drive the learning
- **Scoring Guidance** to ensure that sample responses are provided for all major summative assessments

Why are there two colors of text in this report?

Black text is used in this report to identify direct quotations or paraphrases of a lesson/unit (the evidence) and why/how this evidence indicates the criterion is being met (the reasoning). (EQuIP Rubric for Lessons & Units: Science [Version 3.1])

Black text is also used for evidence and reasoning that does not affect the rating of the criterion.

Purple text is used in this report to identify direct quotations or paraphrases of a lesson/unit (the evidence) and why/how this evidence indicates that the criterion is NOT being met (the reasoning). (EQuIP Rubric for Lessons & Units: Science [Version 3.1]) The exception to this is when a criterion is rated as "extensive." In those cases, purple is used as a visual cue to "*provide constructive criterion-based feedback and suggestions for improvement to developers*" (EQuIP Rubric for Lessons & Units: Science [Version 3.1]).

CATEGORY I
NGSS 3D Design

I.A. Explaining Phenomena / Designing Solutions

ADEQUATE

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.

The reviewers found **adequate** evidence that making sense of phenomena and designing solutions to a problem drives student learning. Materials are organized so that students figure out how a natural event damaged a road and caused changes to the land in Acadia National Park. Student questions and prior experiences related to the phenomenon or problem adequately motivate sensemaking and/or problem solving. At various points in the unit, the teacher's questions drive the learning instead of student questions. When engineering is a learning focus, it is integrated with the development of disciplinary core ideas from the Earth and space sciences.

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

Student-centered focus on phenomena or problems

The unit is anchored by a series of phenomena that drive student learning in each of the three lesson sets. The phenomenon for the first set of lessons (1-8) is introduced in the first lesson.

- Lesson 1, Explore, Step 3: "Notice and Wonder while going on a virtual field trip. Display slide D, tell students that the class will take a virtual field trip to the park. Tell them that you have a video of someone driving around on one of the roads in the park so that we can see what it is like inside Acadia National Park. Be sure to tell them that the camera is mounted on the car so that the person can still drive safely. Distribute Explore a New Phenomenon and ask students to record what they notice and wonder about as we tour the park. Play the 0:00 - 2:00 of the video linked on the slide. Tell students that you will play the video twice so that they can observe a part of the park. Have students share their observations about the park." (Lesson 1, Teacher Guide)
- Lesson 1, Explore, Step 3, the class views photographs of changes in the road at Acadia National Park.
- Lesson 2, Synthesize, Step 3, Use patterns to identify what type of hazard happened in Acadia. Display slide M. Use the prompts on the slide to work as a class to use the patterns chart to identify that it was coastal storms that happened in Acadia when the damage happened. Celebrate the progress the class has made." (Lesson 2, Teacher Guide)
- Lesson 3, Explore, Step 4: "Discuss a new wave bin model setup. In order to emphasize the purpose of the model, ask students to recall what we are trying to figure out about how waves can move objects. When students say that we are trying to figure out if waves could have caused the rocks to move onto Seawall Road during the storm, display a small group wave bin set up. See Wave Bin Setup for reference. Present slide I and ask students to turn and tell a partner how they think we could use the model to figure out if waves could have moved rocks onto Seawall Road during the storm." (Lesson 3, Teacher Guide)

- Lesson 4, Synthesize, Step 6: "Confirm what we figured out. Present slide K. Ask students if the investigation answered their questions. If students are unsure, use a more specific prompt: What can we now explain about how the rocks got on the road at Acadia National Park?" (Lesson 4, Teacher Guide)
- Lesson 5, Navigate, Step 1: "Recall where we left off. Display slide A. Ask students to recall which images we can explain and which we are still working to explain. Look for students to say that we can not explain the changes to the road that are seen in picture A." (Lesson 5, Teacher Guide)
- Lesson 6, Synthesize, Step 3: "Compare to the Seawall Road model. Display slide I. Put the Seawall Road model from Lesson 5 up alongside the new Thunder Hole model. Ask, How are our ideas about Thunder Hole similar to or different from our Seawall Road model?" (Lesson 6, Teacher Edition)
- Lesson 8, Navigate, Step 8, " Look for and discuss similarities. Ask students to reflect on all of the examples of land change that we have explored together. Display slide O and ask students to turn and talk with a partner about the similarities between all of the land changes that they notice." (Lesson 8, Teacher Guide)

The phenomenon for the second set of lessons (9-12) is introduced in Lesson 9. This lesson set is anchored by the general phenomenon of volcanoes and how they may form.

- Lesson 9, Explore, Step 2: The class observes maps and images of the Hawaiian Islands and observes that the islands have changed over time. (Lesson 9, Teacher Guide)
- Lesson 10, Navigate, Step 1, Students consider the question, "What did you notice about how lava can change land?" (Lesson 10, Teacher Guide)
- Lesson 11, Navigate, Step 6: "Revisit our records to plan where to go next. Tell students that it sounds like even though volcanoes can be very hazardous, they tend to occur in patterns which makes it easier to predict where they might happen. Remind students that volcanic eruptions are not the only hazards that we have been thinking about in this unit. Display slide X and encourage students to look back at our Driving Question Board, our initial model, and/or our "How land and things on it change" chart to recall other hazards we have been wondering about. Ask students to share what some of those hazards are." (Lesson 11, Teacher Guide)
- Lesson 12, Navigate, Step 1: "Return to the Driving Question Board. Display slide A and ensure the Driving Question Board is posted. Remind students that we had some questions at the end of the last lesson, or even from the beginning of the unit, about natural hazards other than volcanoes." The language does not include a connection back to the anchor phenomenon, about how a natural event damaged a road and caused changes to the land in Acadia National Park.

The phenomenon for the third set (places need protecting from natural processes and how can people do that) of lessons (13-16) is introduced in Lesson 13.

- Lesson 13, Connect, Step 2: The class reads about solutions to some of the land changes they have observed in past lessons.
- Lesson 14, Navigate, Step 1: "Recall where we left off. Display slide A and ask students to remind the class the problem the class defined together, and the criteria and constraints the class brainstormed. Reference the Erosion Solution Considerations chart as students share the ideas the class agreed upon in the previous lesson. Have students take out the Solution Brainstorming handout they completed in Lesson 13, and share that the class will continue to work with these possible solution ideas during this lesson." (Lesson 14, Teacher Guide)

- Lesson 15, Navigate, Step 1: "Consider where to go next. Display slide B. Highlight the Erosion Solution Considerations chart showing the agreed upon problem, criteria, and constraints to note this is what the class will use to guide and reflect on their design work." (Lesson 15, Teacher Guide

Consistent student-driven learning over time

Student questions and experiences are sometimes used in the unit to drive student learning. Students create a driving question board, but the support provided to draw out student questions remains teacher-driven instead of driven by student curiosity.

- Lesson 1, Connect, Step 1: "Share experiences with visiting parks. Say something like, 'I recently visited a park. When you hear the word park, what comes to mind?' Invite a few students to share and accept all responses. Display slide A. Ask students to share with a partner ideas about; The types of parks they have heard about, seen in photos or videos, and/or visited themselves. Why people go to parks Why parks are important." (Lesson 1, Teacher Guide)
- Lesson 1, Connect, Step 6: "Transition to asking questions. Point out to students that they have identified related phenomena that are puzzling, and have many areas of uncertainty on the Initial Consensus model. Suggest that the class develop a Driving Question Board (DQB) so that we can start to make a plan for what we want to figure out." (Lesson 1, Teacher Guide)
- Lesson 2, Navigate, Step 4: "Decide where to go next. Display slide P. Use the prompts on the slide to foster a conversation about the mechanisms that happened at Acadia that are most likely to have caused the damage to the road and moved the rocks onto the road. Look for students to highlight wind and waves as two of the most dramatic mechanisms that week in Acadia that seem like they could be related to the damage. Say something like, It sounds like we need to figure out more about wind and waves. Let's start by figuring out more about how waves might have caused these changes next time." (Lesson 2, Teacher Guide)
- Lesson 3, Navigate, Step 7: "As a class, consider whether different waves can affect the shore differently. Recall that we figured out that waves can move things forward when they are near a shore because the water is shallower there. Display slide Q and facilitate a discussion with students about how the size of a wave can impact the way it moves things. Have your class wave bin model in a place where all students will be able to see it." (Lesson 3, Teacher Guide) Students do not have the opportunity to feel as if they are driving the learning sequence through their questions and emerging understanding.
- Lesson 4, Connect, Step 4: "Elicit prior experiences with waves. Display slide F and ask students, Where have you seen waves with big or small amplitudes before? What caused those waves?" (Lesson 4, Teacher Guide) The line of questioning in the materials does not provide structured support for teachers to draw out student questions and prior experiences related to the phenomena.
- Lesson 6, Navigate, Step 6: "What have we figured out about weathering and erosion in different places? What are we still unsure about or need more evidence for?" (Lesson 6 Slides, Slide S)
- Lesson 7, Synthesize, Step 5: "Display slide J and ask students how they think fossils could be visible in the land at that park. Encourage students to reflect on what they just figured out about how the trails at Guadalupe Mountains National Park were washed out when they consider their answers... Tell students that it sounds like we have some ideas about how the fossils could have been uncovered, let's read an article to figure out more about this phenomena." (Lesson 7, Teacher Guide) Student questions or prior experiences do not create a need to read an article to investigate this phenomenon. The teacher determines the need.

- Lesson 8, Navigate, Step 8: "It sounds like so many of the examples of land and things on it changing are pretty destructive (things getting broken or damaged or not working after the changes). Do we think that when land changes, it's always destructive? I am noticing that we have lava as a mechanism on our chart, but we still don't have any examples of how it changes land or things on it. What do you think about lava? Is it always destructive?" (Lesson 8, Teacher Guide) Students are prompted to consider if lava is always destructive, but are not explicitly prompted to consider processes that build up the land.
- Lesson 10, Navigate, Step 1: Students consider the questions, "We know that Hawaii is made of land created by cooled lava, which is rock. Do plants often grow big and tall on rocks? Do you think Hawaii has lots of plants on it or not very many?" The line of questioning does not create an explicit need for students to investigate how and why plants grow in areas with more rainfall.
- Lesson 11, Navigate, Step 6: "After a minute or two of independent work time, ask students to share how they answered our lesson question: How can we predict where other volcanic eruptions might happen around the world?" (Lesson 11, Teacher Guide) The emphasis is on the teacher-determined lesson question, and although students can ask their own questions on the My Growing Ideas chart. This sensemaking does not come from student curiosity; the framing remains teacher - or materials-driven, rather than being rooted in student questions or experiences.
- Lesson 12, Navigate, Step 1: "Return to the Driving Question Board. Display slide A and ensure the Driving Question Board is posted. Remind students that we had some questions at the end of the last lesson, or even from the beginning of the unit, about natural hazards other than volcanoes. Lead a brief discussion using the prompts." (Lesson 12, Teacher Guide)
- Lesson 14, Navigate, Step 5: "Use the Engineering Process chart to consider where to go next. Display slide K and revisit the Our Engineering Process chart. Give students a moment to think about where the class is in the process. Invite a couple of students to share which steps they think the class has completed. As the class agrees on steps they have completed, check those steps off with a marker. Using the process on the chart, let the class know they'll pick up with the Test and Compare phases in the next class." (Lesson 14, Teacher Guide)

When multiple phenomena and /or problems are used

- Lesson 6, Synthesize, Step 3: "Say that scientists have names for these two ideas--weathering and erosion. Say that land is changing in many other places as well, besides Seawall Road and Thunder Hole. Suggest that it might be interesting to look at some places in other National Parks where land is changing." (Lesson 6, Teacher Guide)
- Lesson 8, Navigate, Step 8: "Use the Engineering Process chart to consider where to go next. Display slide K and revisit the Our Engineering Process chart. Give students a moment to think about where the class is in the process. Invite a couple students to share which steps they think the class has completed. As the class agrees on steps they have completed, check those steps off with a marker. Using the process on the chart, let the class know they'll pick up with the Test and Compare phases in the next class." (Lesson 8, Teacher Guide)
- Lesson 9, Navigate, Step 9: "Consider the top layer. Display slide Z and ask students to consider what happens to the things on the top layer of land when lava covers it. Look for students to say things like: they get destroyed, covered up, or burned. Ask students to focus on the image on the slide and consider how Hawai'i can have so many plants if the island had so many eruptions in the past. Accept all responses. Close the lesson by suggesting we find out more about what happens to the top layer of land in our next class." (Lesson 9, Teacher Guide)
- Lesson 11, Navigate, Step 1: "Recall what we figured out about volcanic eruptions in our last lesson. Display slide A and ask students to consider what we figured out about volcanic eruptions in our last lesson that would explain why people would want to predict where they could happen in the future." (Lesson 11, Teacher Guide)

- Lesson 13, Navigate, Step 1: "Put the focus on Seawall Road. Point out that we already know quite a bit about Seawall Road and have experience investigating what happened there using wave bins. Suggest that we design solutions to protect Seawall Road from waves, since those types of solutions could possibly be applied to many other places where roads are near water or lie in places that get flooded." (Lesson 13, Teacher Guide)

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

Close match between the phenomena/problems and the student learning objectives throughout the materials

Lesson 1.A **Develop a model to describe how a natural event can cause a road and the land around it to change suddenly.**

- Lesson 1, Synthesize, Step 4: "Develop an initial model to explain the changes to land and road. Display slide P and arrange students into groups of 4. Pass out the Initial Model handout and a Factors that can change land handout to each group. Ask each student in the group to take one page from the Initial Model handout to work on individually. Explain that for each image, students should focus on explaining the changes to the land and/or road. Remind students that we want to explain: If wind, water, and/or ground shaking were involved in the change. How the wind, water, and/or ground shaking may have changed the land or road. (push, shake, lift, etc.) If the changes were fast (happened suddenly) or slow (gradually over a long period of time). Point out that each group has a set of icons they can cut out and attach with tape to their model to describe the changes." (Lesson 1, Teacher Guide)

Lesson1.B **Ask questions about how natural processes like wind, the movement of water, and/or the ground shaking can cause a road and the land around it to change.**

- Lesson 1, Synthesize, Step 7: "Follow the directions on the slide and help students to group similar questions together as they post them to the DQB. Look for students to ask questions like: How can (natural hazard) change the land? Was this wind or water that changed the land? Does (natural hazard) happen in Maine? How much wind or water is needed to destroy a road? What can we do to prevent this from happening again? Can this happen where we live?" (Lesson 1, Teacher Guide)

Lesson 2. **Analyze and interpret data to make sense of** the **similarities and differences in the patterns** of data during **a variety of hazardous natural processes**.

- Lesson 2, Synthesize, Step 3: "Discuss with your class: Were there any conditions/mechanisms we have on our chart that were not observed in Acadia at all when the road damage and land changing occurred? What type of hazard can that help us eliminate as a possibility for what happened?" (Lesson 2 Slides, Slide J)

Lesson 3. Make observations **that can be used as evidence to explain** that **the depth of the water** (**cause**) affects **the way waves move things** (**effect**).

- Lesson 3, Explore, Step 6: "Use the observations that you recorded while observing the waves to help you answer the question: What caused the gravel in your wave bin to move forward? " (Lesson 3 slides, Slide N)

Lesson 4.A **Use a model that can be analogized** to water waves to identify **patterns** including **wave amplitude and wavelength.**

- Lesson 4, Explore, Step 5: "What did you observe the water doing in the Wind Investigation? Describe the patterns of waves in terms of amplitude and wavelength." (Lesson 4 Handout, Wind Investigation Reflections)

Lesson 4.B **Make observations to produce data** of **cause and effect relationships** to explain **how storms cause waves.**

- Lesson 4, Synthesize, Step 6: "Confirm what we figured out. Present slide K. Ask students if the investigation answered their questions. If students are unsure, use a more specific prompt: What can we now explain about how the rocks got on the road at Acadia National Park? Ideas to listen and look for: Wind can cause big waves that traveled toward shore. Near the shore, the wave was able to push the rocks (from Lesson 3). These big waves were able to apply a force that could push rocks toward and onto the shore." (Lesson 4, Teacher Guide)

Lesson 5 Make observations to produce data that can be used as evidence **to explain how water waves (cause) can break land and things on it. (effect).**

- Lesson 5, Explore, Step 4: "Allow students to make observations about what happens to the rocks. Invite other students to continue making waves until a large portion of the rocks have been removed from where they started." (Lesson 5, Teacher Guide)

Lesson 6. **Make observations** of **patterns to use as evidence** for **how water, ice, wind, and living things break land into smaller pieces and move it around at different rates** to **change physical characteristics of the region**.

- Lesson 6, Explore, Step 5: "How did the land change quickly? How did the land change slowly? Mechanism(s) that caused the changes. How do we know which mechanism caused the changes? What evidence do we have?" (Lesson 6 Slides, Slide Q)

Lesson 7.A **Use a model to explain** the **mechanisms of erosion** that **caused change to land over time at different rates.**

- Lesson 7, Synthesize, Step 5: The class creates a Timescale of Land Changes.

Lesson 7.B **Obtain and communicate information about** how **fossils found in rock layers reveal patterns of changes to landscape over time.**

- Lesson 7, Connect, Step 6: "Read the article in pairs. As students work together to read the article, circulate to offer feedback using prompts such as these: How would you describe the landscape of Guadalupe Mountains National Park today? (Use what we know from the infographics and posters.) How are the fossils fourth graders have seen at Guadalupe Mountains National Park similar? What pattern are they noticing about the fossils there? What evidence does that pattern give us about what this land used to be like very long ago? How is it that people are able to see these fossils now? Why aren't they still buried deep underground?" (Lesson 7, Teacher Guide)

Lesson 8. **Make observations of changes to a bridge and the land around it** in order to provide **evidence** that **heavy rainfall caused the changes**.

- Lesson 8, Synthesize, Step 7: "What changes to the Carbella Bridge and the Yellowstone River did you observe? What caused those changes? What evidence do you have to support your answer?" (Lesson 8 Slides, Slide M)

Lesson 9. Identify evidence in the **patterns** of **rock layers to explain how Hawai'i has changed over time due to volcanic eruptions.**

- Lesson 9, Connect, Step 6: "Circulate as students read and use the sample questions below to probe students' thinking. Each layer of rock represents a different volcanic eruption. Do you think rock from a recent eruption would be found closer to the surface, or deeper in the Earth? Why? Imagine that Hawai'i formed from one single eruption. If that happened, what would you expect scientists to see when they dug underground? Where might we find rock from an older eruption that happened long ago? Why do you think that?" (Lesson 9, Teacher Guide)

Lesson 10.A **Make observations to serve as evidence** that **more rainfall in an area** can **cause more plants to be able to live in the area** and that **plants can cause land to be broken into smaller pieces**.

- Lesson 10, Synthesize, Step 4: "Explain how Hawaii can have so many plants growing on it even though there are frequent volcanic eruptions there" (Lesson 10 Slides, Slide R)

Lesson 10.B **Identify the patterns** in location of **tree molds and lava trees** that **support the explanation** that **the landscape of the area has changed over time**.

- Lesson 10, Explore, Step 5: "How do tree molds and lava trees tell us about what the landscape of different areas of Hawaii were like in the past?" (Lesson 10 Slides, Slide X)

Lesson 11. **Analyze and interpret data presented in maps** in order to **identify patterns in the locations of Earth's features in order to predict** the locations of potential future volcanic eruptions.

- Lesson 11, Synthesize, Step 5: "Predict which location is more likely to experience a volcanic eruption. Display slide U and point out to students that now that we can identify the patterns in the locations of volcanoes, we can use them to predict which areas of the world would be more likely to experience a volcanic eruption. Explain to students that they will be working in pairs to analyze a map that includes volcanoes, volcanic islands, and mountain ranges. There are two locations on the map. Point out where the two locations are on the map on slide U. Ask students to work with their partner to determine which area would be more likely to experience a volcanic eruption and support their thinking with evidence from the maps." (Lesson 11, Teacher Guide)

Lesson 12. **Analyze and interpret data** from **maps** for **patterns of change** (emergence of natural hazards) **in order to predict** future hazards including **earthquakes in relation to land and water features.**

- Lesson 12, Synthesize, Step 3: "Which places seem to be most at risk from hazards around the world?" (Lesson 12, Teacher Guide)

Lesson 13. **Generate and compare (using patterns) solutions to reduce the impact of natural hazards, leveraging research on the problem**

- Lesson 13, Explore, Step 3: "Set up the task. Ask students how we could use what we have figured out, and listen for responses that suggest designing some of our own solutions. Display slide E and distribute Solution Brainstorming to each student. Have students pair up. Tell students that they will have 15 minutes to use the handout to clarify the exact problem at Seawall Road they want to address, brainstorm solution ideas, compare these ideas, and sketch a couple favorite ideas. Emphasize to students that in the brainstorming phase at the start of this activity, the goal is to think of as many ideas as possible and they should take some time to list multiple ideas." (Lesson 13, Teacher Guide)

Lesson 14. **Improve engineering designs based on peer comparisons** about **how well designs attend to criteria and constraints generated** to minimize the **effects of weathering and erosion**.

- Lesson 14, Synthesize, Step 4: "What changes do you want to make to your design based on peer feedback?" (Lesson 14 Slides, Slide I)

Lesson 15. Observe **how multiple solutions affect erosion caused by coastal storms under a range of likely conditions to compare how well they meet the criteria and constraints.**

- Lesson 15, Synthesize, Step 4: "Which designs seemed to attend to the criteria and constraints best? What were features of the designs that worked best that they had in common? What can our investigation tell us about protecting Seawall Road? What about other places near us that are at risk of weathering and erosion?" (Lesson 15, Teacher Guide)

Lesson 16. **Compare multiple solutions to the problem of wind erosion** to **determine how well they meet the criteria of reducing the movement of the sand (effect) due to wind (cause).**

- Lesson 16, Synthesize, Step 4: "Compare solutions for the problem at Indiana Dunes. Display slide F. Help students to recall that wind was causing erosion in Indiana Dunes National Park in Michigan. Support students in remembering that the dunes were moving and eroding away. Suggest we use what we figured out from the book and the investigation results to consider solutions that could reduce the erosion of the dune." (Lesson 16, Teacher Guide)

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

When students are designing solutions to problems (with or without connections to ETS DCIs)

- Lesson 13, Synthesize, Step 4, the class creates an Erosion Solutions Considerations Chart. Question: "What does a solution need to do?" Ideas to look for: "Prevent the road from breaking from waves. Prevent water from washing rocks out from under and around the road." (Lesson 13, Teacher Guide)
- Lesson 14, Explore, Step 3: "Invite students to share their thoughts with their table group, and then ask what proposed changes or clarifying questions students have. If any questions come up, ask the class what they think. If the idea of cost hasn't come up, introduce this or expand upon this constraint by sharing the supplies the class has for the designs. Let groups know the class will represent the constraint of cost by limiting the amount of materials each design can use to ensure there are enough supplies for all of the designs. If the class hasn't added the idea that the design should protect the road from small, everyday waves as well as the big ones from the storm, you may want

to propose that idea to the class. At the end of this discussion, there should be a clear, updated list of criteria and constraints identified." (Lesson 14, Teacher Guide)

- Lesson 15, Explore, Step 3: "Compare designs in a gallery tour. Point out step 4 on the slide. Once all groups are done testing the first round, have the class move around carefully so they don't bump into the wave bins. You might designate someone in the class to take pictures of the results of the large waves for all the bins before they get reset. As the class moves around to look at all of the bins, they should record observations on the back of their handout, and ask students to think about: What effects do they notice? Are there certain materials or characteristics of the designs that seemed to work better or not work as well?" (Lesson 15, Teacher Guide)

Criterion-Based Suggestions for Improvement

- Ensure that "[s]tudents regularly return to the 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." [Detailed Guidance, p. 7]
  - For example, when introducing Lesson 12, consider adding an opportunity for students to reconnect with the anchoring phenomenon of how natural hazards can change the land.
- Ensure that "[s]tudent questions or prior experiences related to the phenomena and problems consistently create an explicit need, from the students' perspective, for the students to engage in learning throughout the materials." [Detailed Guidance, p. 7]
  - For example, in lesson 7, consider how to create an explicit need for students to investigate the fossil phenomena.
  - For example, in lesson 10, consider how to create an explicit need for students to investigate how and why plants grow where there is more rainfall.

I.B. Three Dimensions

(All 3 dimensions must be rated at least "adequate" to mark "adequate" overall)

EXTENSIVE

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.*

Document evidence and reasoning, and evaluate whether or not there is sufficient evidence of quality for each dimension separately.

Evidence needs to be at the *element level* of the dimensions (see rubric introduction for a description of what is meant by "element")

The reviewers found **extensive** evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because students regularly engage in elements of all three dimensions to make sense of the anchoring or lesson-level phenomenon. The unit centers on students using targeted elements of all three dimensions, which are clearly identified and addressed throughout the unit, to explain how a natural event damaged a road and caused changes to the land in Acadia National Park.

Rating for Criterion: SEP

EXTENSIVE

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

The reviewers found **extensive** evidence that the materials provide opportunities to develop and use specific elements of the SEPs. Students use and develop grade-appropriate SEP elements to make sense of the phenomenon. The SEPs—Developing and Using Models, Planning and Carrying Out Investigations, Analyzing and Interpreting Data, and Constructing Explanations and Designing Solutions —are labeled as intentionally developed. Students have the opportunity to practice the SEPs: Asking Questions, Defining Problems, and Obtaining, Evaluating, and Communicating Information.

MOD: Developing and Using Models

Claimed Element: **MOD-E3: Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.** Claimed in Lessons 4 and 5. Evidence was found in 4 and 5, examples include

- Lesson 4, Explore, Step 2: "Remind students that we use models to explain something and review what we are trying to explain with this model: How can we describe different kinds or sizes of waves? Elicit ideas about what different parts of the model might show. Remind students of play parachutes that they may have seen before and point out that a bedsheet can be used similarly. Ask, If we are waving the bedsheet, what does the bedsheet represent from what we have been thinking about at Seawall Road? What does it mean if there is a wave in the bedsheet? Lead students toward general agreement that the bedsheet represents the surface of the water and a wave in the bedsheet represents a water wave." (Lesson 4, Teacher Guide)

- Lesson 5, Synthesize, Step 7, Student Assessment 1, "Use words, symbols, and/or drawings to explain how the pattern of motion of a boat on top of the water is different far from the shore and close to the shore" (Lesson 5, Student Assessment 1)

Claimed Element: **MOD-E4: Develop and/or use models to describe and/or predict phenomena.** Claimed in Lessons 1, 7, and 9. Evidence was found in 1, 7, and 9, examples include

- Lesson 1, Synthesize, Step 4: "Develop an initial model to explain the changes to land and road. Display slide P and arrange students into groups of 4. Pass out the Initial Model handout and a Factors that can change land handout to each group. Ask each student in the group to take one page from the Initial Model handout to work on individually. Explain that for each image, students should focus on explaining the changes to the land and/or road." (Lesson 1, Teacher Guide)
- Lesson 7, Explore, Step 2: "Provide time for small groups to investigate their mechanisms. Give students time to use their model to investigate their site." (Lesson 7, Teacher Guide)
- Lesson 9, Synthesize, Step 3: "Develop a model to explain how an island can form. Pass out one Initial Model to each student. Display slide M. Encourage students to use words, symbols, and/or drawings to explain how an island can form in the ocean." (Lesson 9, Teacher Guide)

INV: Planning and Carrying Out Investigations

Claimed Element: **INV-E3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.** Claimed in Lessons 3, 4, 5, 6, 7, 8, 10. Evidence was found in 3, 4, 5, 6, 7, 8, and 10, examples include

- Lesson 3, Synthesize, Step 6: "In small groups, discuss what caused some gravel to move onto the road. Direct students to the bottom of Wave Bin Observations. Display slide N and ask them to recall what they observed the gravel doing in their wave bin when they made waves. Encourage them to use the observations they recorded during their investigation to support their thinking. Ask students to discuss why they think the gravel moved." (Lesson 3, Teacher Guide)
- Lesson 4, Explore, Step 5: "Carry out the investigation. Present slide H. Have students gather around the wave bin. Test the "wind" by turning on the fan, directing it across and in parallel to the surface of the water. Make sure to show a couple different "wind speeds" by adjusting the fan speed. Elicit students' observations. Repeat as needed so that all students are able to see what their peers noticed." (Lesson 4, Teacher Guide)
- Lesson 5, Explore, Step 4: "Carry out the investigation. Display slide F. Have students gather around the wave bin and carry out the investigation using the following procedure: Place the mix of pea gravel and aquarium on the bricks in a long pile like the road. Draw a reference line on the bricks to indicate where the gravel started. Invite a student to come up and make waves. Allow students to make observations about what happens to the rocks. Invite other students to continue making waves until a large portion of the rocks have been removed from where they started." (Lesson 5, Teacher Guide)
- Lesson 6, Explore, Step 5: "Give time for exploration. Display slide Q and the Thunder Hole, Acadia National Park" chart from earlier in the lesson. Tell students they will have 12 minutes to examine the data for their site and complete their poster. Encourage students to leave room in each box to add more later on." (Lesson 6, Teacher Guide)
- Lesson 7, Explore, Step 3: "Add evidence to our National Park site posters. Display slide E Explain that now that we have gathered data from our investigations, we can use it as evidence to support our predictions about how

mechanisms caused the changes to the land at our National Park site. Adding that evidence to our National Park site posters will support our explanations when we share them with the class." (Lesson 7, Teacher Guide)

- Lesson 8, Explore, Step 8, "Observe photographs and video of the Carbella Bridge and Yellowstone River. Display slide H and introduce students to the Carbella Bridge and the Yellowstone River in Gardiner, Montana. Ask students what they notice about the Carbella Bridge and the Yellowstone River." (Lesson 8, Teacher Guide)
- Lesson 10, Explore, Step 3: "Observe photos of plant roots breaking things. Display slide O and explain that we have some photos of the roots of plants that we can observe. Pair students up and distribute the Plant Roots Breaking Things images. Ask students to observe the photos and look for evidence that plant roots can break rocks. Encourage students to circle and annotate areas of the photos that could be evidence of plant roots breaking rocks." (Lesson 10, Teacher Guide)

DATA: Analyzing and Interpreting Data

Claimed Element: **DATA-E2: Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.** Claimed in Lessons 2, 11, and 12. Evidence was found in 2, 11, and 12, examples include

- Lesson 2, Explore, Step 2: "Analyze data from Acadia. Use the prompts on the slide to guide students in working with a partner to read and annotate the data card. Give pairs about 6 minutes to complete this task. As they work, circulate around the room and help students navigate how to annotate the cards." (Lesson 2, Teacher Guide)
- Lesson 11, Synthesize, Step 5: "Explain to students that they will be working in pairs to analyze a map that includes volcanoes, volcanic islands, and mountain ranges. There are two locations on the map. Point out where the two locations are on the map on slide U. Ask students to work with their partner to determine which area would be more likely to experience a volcanic eruption and support their thinking with evidence from the maps." (Lesson 11, Teacher Guide)
- Lesson 12, Explore, Step 2: "Dig into the earthquakes map. Use these prompts to guide students through making sense of the earthquake map alone and in conjunction with other layers." Students engage with the following question prompts: What patterns do you notice about where earthquakes occur? (If needed: Do earthquakes tend to cluster or be separate from one another?)" and "Where do earthquakes occur compared to other land or ocean features?" (Lesson 12, Teacher Guide)

CEDS: Constructing Explanations and Designing Solutions

Claimed Element: **CEDS-E3: Identify the evidence that supports particular points in an explanation.**Claimed in Lessons 9 and 10. Evidence was found in 9 and 10, examples include

- Lesson 9, Synthesize, Step 7: "As students are sharing their models, circulate and use the following questions to probe students' thinking. What new ideas are you adding to your model? What evidence caused you to add that idea? What did you see with the wax or in the reading that made you think that? How does this compare to what you originally thought? What made you change your mind?" (Lesson 9, Teacher Guide)
- Lesson 10, Explore, Step 5: "Construct an explanation. Tell students that it sounds like we have figured out another form of evidence that can tell us about how the landscape of Hawaii has changed over time. Display slide X and ask students to explain how lava trees and tree molds tell us about what the landscape of different areas of Hawaii were like in the past on their Lava Trees handout." (Lesson 10, Teacher Guide)

Claimed Element: **CEDS-E5: Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.** Claimed in Lessons 13, 14, 15, and 16. Evidence was found in 13, 14, 15, and 16, examples include

- Lesson 13, Explore, Step 3: "Display slide E and distribute Solution Brainstorming to each student. Have students pair up. Tell students that they will have 15 minutes to use the handout to clarify the exact problem at Seawall Road they want to address, brainstorm solution ideas, compare these ideas, and sketch a couple favorite ideas." (Lesson 13, Teacher Guide)
- Lesson 14, Explore, Step 3: "Compare solutions. Each person will have 1-2 minutes to share their design idea. After each person shares, the group should take about three minutes to discuss and capture how well that design attends to each criteria/constraint. They do not need to write complete sentences in each box, but the group can develop a system (i.e., symbols, ratings, bullet points, etc.) to capture their thoughts." (Lesson 14, Teacher Guide)
- Lesson 15, Explore, Step 3: "First groups test and compare designs. When the class feels comfortable with how they will test, display slide E. Point out that one group will test at a time while the other group observes and takes notes. Distribute a copy of Collaborator Group Notes to each student, and point out that the Collaborator Group will be looking at the design for both the small waves and big waves." (Lesson 15, Teacher Guide)
- Lesson 16, Synthesize, Step 4: "Compare solutions for the problem at Indiana Dunes. Display slide F. Help students to recall that wind was causing erosion in Indiana Dunes National Park in Michigan. Support students in remembering that the dunes were moving and eroding away. Suggest we use what we figured out from the book and the investigation results to consider solutions that could reduce the erosion of the dune." (Lesson 16, Teacher Guide)

The SEPs are listed as Opportunities to Practice in the Unit Front Matter. The elements are claimed on the 4.3 Earth Processes SEP-DCI-CCC-ELA-Math-Matrix:

Asking Questions and Defining Problems

Claimed Element: **AQDP-E3: Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.** As claimed in Lesson 1, evidence includes:

- Lesson 1, Connect, Step 3: Students are engaged in an "I noticed, I wonder" activity. They raise questions about their observations of the changes in the road. "Explore a new phenomenon. "As you observe these pictures of Seawall Road, record what you notice and wonder." Students make connections to what might have caused the changes in the road to happen. (Lesson 1, Teacher Guide)
- Lesson 1, Connect, Step 6: "Transition to asking questions. Point out to students that they have identified related phenomena that are puzzling, and have many areas of uncertainty on the Initial Consensus model. Suggest that the class develop a Driving Question Board (DQB) so that we can start to make a plan for what we want to figure out." (Lesson 1, Teacher Guide)
- Lesson 1, Synthesize, Step 7: "Write questions individually. Pass out a few sticky notes and dark markers to each student. Ask students to write one question on each sticky note." "Share and organize questions." "Invite students to form a scientist circle around the Driving Question Board. ... Suggest that as we share questions we group them together to help us see if any patterns emerge in what we wonder about." (Lesson 1, Teacher Guide)

Obtaining, Evaluating, and Communicating Information

Claimed Element **INFO-E1: Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.** As claimed in Lesson 7, evidence includes:

- Lesson 7, Connect, Step 6: "Read the article in pairs. As students work together to read the article, circulate to offer feedback…Debrief students' takeaways from the article. Display slide L and bring the class back together for a brief discussion about what they figured out from the article." (Lesson 7, Teacher Guide)

Criterion-Based Suggestions for Improvement: N/A

Rating for Criterion: DCI **EXTENSIVE**

ii. Provides opportunities to develop and use specific elements of the DCI[s].

The reviewers found **extensive** evidence that the materials provide opportunities to develop and use specific elements of the DCIs. Students have multiple opportunities to build the following science ideas:

- **ETS1.B-E1: Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.**
- **ETS1.B-E3: 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.**
- **ESS1.C-E1: Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.**
- **ESS2.A-E2: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.**
- **ESS2.B-E1: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features of Earth.**
- **ESS2.E-E1: Living things affect the physical characteristics of their regions.**
- **ESS3.B-E1: A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.**
- **PS4.A-E1: Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach.**
- **PS4.A-E2: Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).**

ETS1.B: Developing Possible Solutions

Claimed Element: **ETS1.B-E1: Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.** Claimed in Lessons 13, 15, and 16. Evidence was found in Lessons 13, 15, and 16, examples include

- Lesson 13, Connect, Step 2: "In this lesson the class starts brainstorming ideas for different solutions to protect Seawall Road. They read a book that gives them examples of what others have done to protect the land and people. "While we read, think about how these communities might help us think about protecting Seawall Road." (Lesson 13, Teacher Guide)
- Lesson 15, Explore, Step 3: "Distribute a copy of Collaborator Group Notes to each student, and point out that the Collaborator Group will be looking at the design for both the small waves and big waves. Direct students' attention to the first column. Reference Point out that there is space at the bottom to capture notes about how the group shows the classroom agreements while they test their design. Suggest each group make the small waves then pause for the observers to write or sketch their observations. The testing group can discuss their observations at the same time. After a minute or so, the first group can test for the big waves." (Lesson 15, Teacher Guide) Research was conducted in a previous lesson.
- Lesson 16, Connect, Step 2: "Read the book aloud with students and use the sample prompts to support students in figuring out how scientists can use plants to reduce the impacts of erosion from wind and water." (Lesson 16, Teacher Guide)

ETS1.B: Developing Possible Solutions

Claimed Element: **ETS1.B-E3: 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.**Claimed in Lesson 14. Evidence was found in Lesson 14

- Lesson 14, Explore, Step 3: "Come to consensus and develop the group's revised solution. Let the class know that groups will now build on the discussion they just had about the initial solution ideas to reach consensus around a design they think will best attend to the criteria and constraints. Display slide F, and let groups know they will have ten minutes to agree upon and draw a model showing their consensus design. This may have elements of a few different group members' initial designs or they may want to start with one initial design and make some modifications." (Lesson 14, Teacher Guide)

ESS1.C The History of Planet Earth

Claimed Element: **ESS1.C-E1: Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.** Claimed in Lessons 7, 9, and 10. Evidence was found in Lessons 7, 9, and 10; examples include

- Lesson 7, Connect, Step 6, Students read an article and engage in the following discussion questions, "How are the fossils fourth graders have seen at Guadalupe Mountains National Park similar? What pattern are they noticing about the fossils there?" and "What evidence does that pattern give us about what this land used to be like very long ago?" (Lesson 7, Teacher Guide)

- Lesson 9, Synthesize, Step 8, "Consider what else scientists can learn from rock layers. Display slide X and have students Think, Pair, Share about the two prompts on the slide, which are similar to the ones they considered with their reading partner on the Volcanoes and the Island of Hawaii. Which layer of lava would have been the oldest in the image? Which layer of lava is probably the most recent? Bring students together after a few minutes of sharing with a partner, and use the prompts below to add additional ideas to the model." (Lesson 9, Teacher Guide)
- Lesson 10, Explore, Step 6, Students explore the phenomena of lava trees and engage in the questions, "Observe the photo of an area on Kilauea on slide W. Do you notice any lava trees in the area? What does that tell you about what the landscape of this area was like in the past?" and "What pattern do you notice between where the tree molds and lava trees are and what the landscape of those areas were like in the past?" (Lesson 10, Teacher Guide)

ESS2.A Earth Materials and Systems

Claimed Element: **ESS2.A-E2: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.** Claimed in Lessons 1, 5, 6, 7, 8, and 10. Evidence was found in Lessons 1, 5, 6, 7, 8, and 10, examples include

- Lesson 1, Synthesize, Step 4: "Explain that for each image, students should focus on explaining the changes to the land and/or road. Remind students that we want to explain: If wind, water, and/or ground shaking were involved in the change. How the wind, water, and/or ground shaking may have changed the land or road. (push, shake, lift, etc.) If the changes were fast (happened suddenly) or slow (gradually over a long period of time)." (Lesson 1, Teacher Guide)
- Lesson 5, Synthesize, Students debrief their investigation and reflect on the following question: "How could the waves have made the road sink? What ideas do we have about that?" They provide possible answers like, "The waves took the rocks away from under the road" (Lesson 5, Teacher Guide)
- Lesson 6, Explore, Step 5: "After students have had 5-7 minutes to read and annotate, discuss as a class. Present slide M and ask, What new or surprising ideas did you underline? Look and listen for these ideas: Sediment is a word for little pieces of land. Weathering and erosion happen all the time, not just during storms. Anytime sand or any other land move is a sort of erosion. Weathering and erosion can happen without waves. There are lots of different types of erosion--from ice, flowing water, wind, and living things." (Lesson 6, Teacher Guide)
- Lesson 7, Synthesize, Step 5: "Students have a discussion where they discuss the different mechanisms that cause change at different National Park Sites. They engage with the following discussion questions, "Wow! We noticed so many changes to land in these different places. What did we find out about the mechanisms that cause these changes?" and "What evidence do we have to support that these are the mechanisms that caused the changes at these sites?" (Lesson 7, Teacher Edition)
- Lesson 8, Explore, Step 6: The class examines rainfall and snowmelt amounts to understand the mechanisms behind the erosion of the Yellowstone River. (Lesson 8, Teacher Guide)
- Lesson 10, Explore, Step 2: The class discusses the relationships between rainfall and the number of plants. "Are the areas with high amounts of rainfall the same as the areas with a lot of plants? Are the areas with low amounts of rainfall the same as the areas with fewer plants?" (Lesson 10, Teacher Guide)

- Lesson 10, Explore, Step 3: "Discuss the evidence we gathered from the plant root photos. Display slide P and ask students to consider the observations they made of the plant root photos and make a decision about whether or not they think plant roots can break rocks. Ask students who think that plant roots can break rocks to go to put a thumb up and students who think that plant roots cannot break up rocks to put a thumb down. Facilitate a discussion about the observations of plant roots we made and what evidence they may provide that plants can break rocks. Encourage students to reference the annotations on their plant root photo cards as they discuss the evidence they observed." (Lesson 10, Teacher Guide)

ESS2.B Plate Tectonics and Large-Scale System Interactions

Claimed Element: **ESS2.B-E1: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features of Earth.** Claimed in Lessons 9, 11, and 12. Evidence was found in Lessons 9, 11, and 12, examples include

- Lesson 9, Explore, Step 2: "Observe different maps of Hawai'i. Suggest that we become more familiar with the Hawai'ian Islands by looking at a few different maps. Display slide C and support students in locating Hawai'i relative to the continental United States. Display slide D and ask the students to share what they notice. Support students in understanding that the state of Hawai'i is a chain of islands, each island has a name, and one of the islands is named Hawai'i. Suggest that we look at a few other different maps and images to see what else we notice and wonder." (Lesson 9, Teacher Guide) In this lesson, students observe a volcano that is not associated with mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and other volcanoes. No explanation is provided for why this volcano was chosen over others located along the boundaries of continents and oceans. The mechanism that causes the volcanoes present in the Hawaiian Islands is different from the mechanism that causes volcanoes to occur along continental boundaries.
- Lesson 11, Explore, Step 4: "Explain that there are so many seamounts in the ocean, and this map only shows the large ones. If we looked at a map with the seamounts, volcanic islands, and trenches, there would be so much to analyze at once. Display slide M and tell students that we have a map that shows the locations of volcanic islands and ocean trenches that we can analyze more easily for patterns." "Describe patterns in the locations of mountain ranges and volcanoes. Display slide S and tell students that we have a map that shows the locations of major mountain ranges and volcanoes around the world." (Lesson 11, Teacher Guide)
- Lesson 12, Explore, Step 2: Students examine maps to find the location of earthquakes. Question: "Where do earthquakes occur compared to other land or ocean features?" Ideas to look for: "Sometimes they are in or near mountains. They are often at the edges of continents, especially along the Pacific Ocean." (Lesson 12, Teacher Guide)

ESS2.E Biogeology

Claimed Element: **ESS2.E-E1: Living things affect the physical characteristics of their regions.** Claimed in Lessons 6 and 10. Evidence was found in Lessons 6 and 10; examples include

- Lesson 6, Explore, Step 5: "Introduce the book. Display slide L. Read the *Changes to the Land: Weathering and Erosion* book aloud to students. Ask students to remember or jot down any ideas that are new or surprising to them." The final chapter is *Weathering and Erosion and Living Things*. The chapter describes how some plants change the earth." (Lesson 6, Teacher Guide)

- Lesson 10, Explore, Step 3: "Observe photos of plant roots breaking things. Display slide O and explain that we have some photos of the roots of plants that we can observe. Pair students up and distribute the Plant Roots Breaking Things images. Ask students to observe the photos and look for evidence that plant roots can break rocks. Encourage students to circle and annotate areas of the photos that could be evidence of plant roots breaking rocks. As students are observing the photos circulate the room and ask questions like: What do you see that could be evidence of plants breaking rocks? Can you tell me about this part of the picture? Why do you think that?" (Lesson 10, Teacher Guide)

ESS3.B Natural Hazards

Claimed Element: **ESS3.B-E1: A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.** Claimed in Lessons 1, 2, 13, 15, and 16. Evidence was found in Lessons 1, 2, 13, 15, 16, examples include

- Lesson 1, Explore, Step 3: "Repeat the same process for wonders. As students share wonderings, take note of when they mention a natural hazard. Say something like, I hear us wondering about events that could have caused what we noticed - that's an important thing scientists do - we wonder about why things happen. Each time a student brings up a natural hazard, underline, highlight, or circle those ideas and poll the class to see how many others have similar thinking." (Lesson 1, Teacher Guide) The 4.3 Earth Processes SEP-DCI-CCC-ELA-Math-Matrix indicates that this lesson does not include how humans can reduce the impacts of natural hazards.
- Lesson 2, Explore, Step 2: "Prepare to look at data from natural hazards. Display slide E and tell students that you have a collection of natural hazards data cards that includes the possible causes students suggested and some additional ones that students might find interesting. Point out the example card on the slide (consider reading the information aloud and describing the photos). Ask how the data on that card could help us figure out what happened in Acadia. Establish that students will need to analyze the data from the new cards to see what kinds of data points are associated with the natural hazard on the card. Then we can match what we find out with the data points from Acadia when the land changed and the road broke to figure out what caused those things." (Lesson 2, Teacher Guide) 4.3 Earth Processes SEP-DCI-CCC-ELA-Math-Matrix indicates that this lesson does not include how humans can reduce the impacts of natural hazards.
- Lesson 13, Connect, Step 2: Students discuss how different communities have responded to different natural processes. Question: "Which community is able to stop the impact of Earth's processes on its land? Can any of Earth's processes be stopped?" Ideas to look for: "None of them were able to entirely stop the impacts of Earth's processes. You might be able to prevent landslides for a while, but eventually all places change." (Lesson 13, Teacher Guide)
- Lesson 15, Synthesize, Step 4: Question: "What can our investigation tell us about protecting Seawall Road? What about other places near us that are at risk of weathering and erosion?" Ideas to look for: "It is possible to slow down weathering and erosion. Different solutions might work better in different places or situations. (Lesson 15, Teacher Guide)
- Lesson 16, Connect, Step 2, the class discusses how plants can affect coastal erosion. They evaluate the effectiveness of three methods for reducing coastal erosion. (Lesson 16, Teacher Guide)

PS4.A: Wave Properties

Claimed Element: **PS4.A-E1: Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach.** Claimed in Lessons 3, 4, and 5. Evidence was found in Lessons 3, 4, and 5; examples include

- Lesson 3, Explore, Step 6: "Participate in a discussion." In this sense-making part of the lesson, students compare the wave action in both wave bin set-ups. "Did we observe waves pushing rocks forward in both versions of our wave bin models? How did we change our models? How did the change impact the way the waves moved the gravel? Do waves always push things forward? What evidence did we observe in our wave bin models that would support that answer? (Lesson 3, Teacher Guide)
- Lesson 4, Navigate, Step 1: "As the class reviews the previous lesson, they discuss the differences between the wave bin without a beach or shore and the wave bin with a beach. "Prompts to use: What did we investigate last lesson? What did we notice about the waves as we made changes to the wave bin?" (Lesson 4, Teacher Guide)
- Lesson 5, Synthesize, Step 7: "Normally, ships do not get too close to shore, but on that night in 1911, the Tay got too close to the shore and crashed. Use words, symbols, and/or drawings to explain how the pattern of motion of a boat on top of the water is different far from the shore and close to the shore." (Lesson 5, Student Assessment)

Claimed Element: **PS4.A-E2: Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).** Claimed in Lessons 4 and 5. Evidence was found in Lessons 4 and 5; examples include

- Lesson 4, Synthesize, Step 3: "Debrief the Bedsheet 'Parachute' Investigation. Display slide C. Gather students in a Scientists Circle to discuss what we figured out how different types of waves and how they might be able to move things." Students discuss the question, "Using our new science words, what kind of waves do you think most likely moved the rocks onto Seawall Road? What kinds of waves worked to move the rocks in your wave bins?" (Lesson 4, Teacher Guide)
- Lesson 5, Synthesize, Step 7, Student Assessment 1, "On that night in 1911, there was a large storm that produced strong winds. Use words, symbols, and/or drawings to explain how the pattern of waves in the ocean was different before the storm than during the storm. Include the word amplitude in your comparison. (Lesson 5, Student Assessment 1)

Criterion-Based Suggestions for Improvement:

- For ESS2.B-E1—Consider using a volcano that is associated with the other geologic occurrences mentioned in the DCI (mountain ranges, deep ocean trenches, earthquakes, and other volcanoes) so students will not form misconceptions.

Rating for Criterion: CCC **EXTENSIVE**

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

The reviewers found **extensive** evidence that the materials provide opportunities to develop and use specific elements of the CCCs. Students use and develop grade-appropriate CCC elements to make sense of the phenomenon; however, they do not engage in the full **PAT-E1—Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products**—because they do not analyze simple rates of change. In the unit as written, students consistently leverage **PAT-E3—Patterns can be used as evidence to support an explanation.** Students have multiple opportunities to build the following crosscutting concepts:

- **PAT-E2: Patterns of change can be used to make predictions.**
- **PAT-E3: Patterns can be used as evidence to support an explanation.**
- **CE-E1: Cause-and-effect relationships are routinely identified, tested, and used to explain change.**

PAT: Patterns

Claimed Element: **PAT-E1: Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products.**Claimed in Lessons 2, 4, 5, 6, 13. Evidence was found in Lessons 2, 4, 5, 6, and 13. Students only engage with the full element of PAT-E1 in Lesson 6. Although the 4.3 Earth Processes SEP-DCI-CCC-ELA-Math Matrix states that Lessons 2, 4, 5, and 13 do not support the analysis of rates of change, the materials still claim that this CCC element is used. Because students are not engaging with the full element as claimed, the evidence more accurately aligns with PAT-E3. The purple here indicates that while the original claim was inaccurate, the lessons do support meaningful engagement with PAT-E3.

- Lesson 2, Synthesize, Step 3: "Using the evidence we collected from the data cards: Which types of hazards can we rule out as what happened in Acadia to cause the damage? Which types of hazards are most similar to what was happening in Acadia that week? Does our evidence answer our question? What type of hazard do we think happened in Acadia that week?" (Lesson 2 Slides, Slide M) The 4.3 Earth Processes SEP-DCI-CCC-ELA-Math-Matrix notes that this lesson does not support analysis of rates of change. This is evidence of students engaging with PAT-E3.
- Lesson 4, Explore, Step 3: The class discusses the activity with the bed sheet. Question: "What patterns did you notice in the waves?" Expected responses: "Some waves were bigger. Sometimes there were more, or they were closer together. The bedsheet moved a lot more sometimes. (Gestures of any of the above)" (Lesson 4, Teacher Guide). The 4.3 Earth Processes SEP-DCI-CCC-ELA-Math-Matrix notes that this lesson does not support analysis of rates of change. This is evidence of students engaging with PAT-E3.
- Lesson 5, Synthesize, Step 7: "On that night in 1911, there was a large storm that produced strong winds. Use words, symbols, and/or drawings to explain how the pattern of waves in the ocean was different before the storm than during the storm. Include the word amplitude in your comparison." (Lesson 5, Student Assessment, Explaining the Tay Shipwreck). The 4.3 Earth Processes SEP-DCI-CCC-ELA-Math-Matrix notes that this lesson does not support analysis of rates of change. This is evidence of students engaging with PAT-E3.
- Lesson 6, Synthesize, Step 3: "At this point, post the 'Timescale of Land Changes We Observe' chart. Draw a two-ended arrow with Thunder Hole (slow) on one end and Seawall Road (fast) on the other. Suggest that lots of other land changes we see in the future might fall between those two extremes. As a starting point, ask students where the

covering up of the Tay shipwreck might fall. Listen for the idea that it is closer to Seawall Road and Thunder Hole." (Lesson 6, Teacher Guide)

- Lesson 13, Connect, Step 2: "What patterns of similarities and differences do we see in the problems?" (Lesson 13, Teacher Guide)

Claimed Element: **PAT-E2: Patterns of change can be used to make predictions.** Claimed in Lessons 11 and 12. Evidence was found in Lessons 11 and 12, examples include

- Lesson 11, Synthesize, Step 5: "After students have had an opportunity to work with their partners, display slide V and ask students to share which area they predicted would be more likely to experience a volcanic eruption by holding up 1 finger if they thought it was area 1 and 2 fingers if they thought it was area 2. Ask students to share the patterns they noticed that would support their choice." (Lesson 11, Teacher Guide)
- Lesson 12, Explore, Step 2: Prompts to use/ideas to look and listen for: What patterns help predict where these hazards occur? How can we use what we figured out last time to help us answer our questions this time? We can look for patterns like whether they tend to occur together.
- Lesson 12, Synthesize, Step 3: Identify patterns in many hazards. Gather students into a Scientists Circle and display slide F. Lead a Building Understandings discussion in which groups (pairs of pairs) volunteer to share about their hazard. (Lesson 12, Teacher Guide)

Claimed Element: **PAT-E3: Patterns can be used as evidence to support an explanation.** Claimed in Lessons 1, 6, 7, 9, and 10. Evidence was found in Lessons 1, 6, 7, 9, and 10 as well as in Lessons 2, 4, 5, and 13. Examples include

- Lesson 1, Synthesis, Step 5, the class first brainstorms ideas about the road and then creates a model to answer the question of what caused the changes to the land and road in Acadia National Park. (Lesson 1, Teacher Guide)
- Lesson 6, Explore, Step 5: "Finally, if students are confident in their explanations, be prepared to seed some uncertainty around whether we have experimental evidence that the patterns students identified connect to the physical features. (Lesson 6, Teacher Guide)
- Lesson 7, Connect, Step 6, students discuss the fossils found at Guadalupe National Park. Question: "How do we know the land has changed so much? What evidence do we have?" Ideas to look for: "They said in the article that people have found fossils there of animals that used to live underwater! There are seashell-kinds of fossils in the rock layers from long ago - there's a picture in the article. Animals got buried after they died underwater and their shells and bones turned into parts of the rocks." (Lesson 7, Teacher Guide)
- Lesson 9, Connect, Step 6: "Read with a partner. Display slide T and pass out 1 copy of Volcanoes and the Island of Hawaii handout to each student. Tell students to take turns reading each paragraph with their partner. Ask students to stop after each paragraph to summarize what they read with their partner. Encourage students to underline or circle main ideas as they read. Circulate as students read and use the sample questions below to probe students' thinking." The class reads an article, "Volcanoes and the Island of Hawaii," and obtains information about the rock layers discovered in Hawaii. Students discover the pattern in the layers that supports the idea of how the island formed over a long period of time in layers. They make connections to the wax model. (Lesson 9, Teacher Guide)
- Lesson 10, Explore, Step 2: Students compare a photo map with the rainfall data map and gather evidence that supports their claim that the areas with more rainfall have more plants. They discover a pattern in their observations. Prompts to use/Ideas to look and listen for: "Are the areas with high amounts of rainfall the same as the areas with a lot of plants?" "Are the areas with low amounts of rainfall the same as the areas with fewer

plants?" Explore, Step 3: Students make observations of lava flows of varying ages. "Have photos of lava flows from volcanic eruptions that happened at three different times on the rainy side of Hawaii that we can observe. Explain that we are going to work with a partner to observe the lava flows and record what we notice about the plants and rocks on each flow." (Lesson 10, Teacher Guide)

CE: Cause and Effect

Claimed Element: **CE-E1: Cause and effect relationships are routinely identified, tested, and used to explain change.** Claimed in Lessons 1, 3, 4, 5, 8, 10, 14, 15, 16. Evidence was found in Lessons 1, 3, 4, 5, 8, 10, 14, 15, 16, examples include

- Lesson 1, Explore, Step 3: "How could the wind cause changes to the land and things on it?" (Lesson 1, Teacher Guide)
- Lesson 3, Navigate, Step 1: "How could either of these mechanisms have caused the tree branches to come off of the trees and into Seawall Road?" (Lesson 3 Slides, Slide C)
- Lesson 3, Synthesize, Step 6 Sidebar: "Support students in identifying that waves near a shore can cause rocks to move forward. Encourage them to explain that this cause and effect relationship is why the rocks on the shore in Acadia to move onto the Seawall Road during the coastal storm. Students will get multiple opportunities to further develop this cross cutting concept in future lessons in this unit." (Lesson 3, Teacher Guide)
- Lesson 4, Synthesize, Step 6: The class discusses what causes waves. "Rain or other objects falling into a body of water. Hitting the surface of water. Shaking a bedsheet or parachute. Waves happen when something can move up and down or back and forth. (Lesson 4, Teacher Guide)
- Lesson 5, Synthesize, Step 5: The class revises their model, explaining how the road got cracked. Question: "Can someone share an idea they said or their partner said about how we could explain how the road got cracked?" Ideas to look for: "We need to put (or change it to) a wave icon there. The waves were so big and had a lot of force. The big waves smashed the road and cracked it." (Lesson 5, Teacher Guide)
- Lesson 8, Explore, Step 3: "What did we observe that made us think the land (and/or something on it) changed? What mechanism do we think caused the change? Why do we think that is the cause? What evidence do we have?" (Lesson 8 Slides, Slide E)
- Lesson 10, Explore, Step 3, the class discusses images of older and newer lava flows. Question: "What do you think happened to the layers of rock in order for plants to be able to grow there?" Ideas to look for: "They needed lots of time to grow. It doesn't look like there are many places for the plants to grow on the newest layer. The rock needed to get weathered so more plants could grow there. Most plants can't grow on shiny hard rock like the kind in the newest layer. Plants need a place for seeds to grow and for roots to be able to take hold. I bet the layers of lava get broken up by wind and water so more plants can start growing." (Lesson 10, Teacher Guide)
- Lesson 14, Lesson Assessment Guidance, "What to look and listen for: name how peer feedback and criteria and constraints had an effect on design revisions." (Lesson 14, Teacher Guide) This would be how it "affected" design revisions, not "effect." On the exit ticket, students answer the question, "How did the criteria and constraints affect your decisions about the solution?"
- Lesson 15, Explore, Step 3: Question: "What do you notice about what is happening to the rocks on the road?" Ideas to look for: "(Points at part of the design) Did the waves move those pebbles out of the road? (Shows their paper with a drawing) Their design stopped the water from hitting the road with the small waves but the big waves hit the rocks and moved them more." (Lesson 15, Teacher Guide)

- Lesson 16, Explore, Step 3: "Observe results from tests. Display slide D and pass out a copy of the Student Design Test Results handout to each student. Give students 5 minutes to look over the results and discuss what they notice and wonder about the testing procedure and results from the student tests...Share notices and wonders from the results. Bring students together and invite students to share what they notice and wonder about the results. Accept all responses. Look for students to notice that some solutions seem to work better than others and that students tested the solutions with a fan on low setting." (Lesson 16, Teacher Guide) Students do consider which design may be the best to control erosion, but students are not prompted to consider cause and effect.
- Lesson 16, Navigate, Step 5: "Return to the What Causes Land and Things on it to Change chart. Display the How Land and Things on it can Change chart (refer to slide I). Celebrate the learning that was often situated in National Parks throughout this unit. Help students to recall the different parks that we investigated and connect those investigations to what we have on our How Land and Things on it can Change chart. (Lesson 16, Teacher Guide) "Cause" is more prominent throughout the unit than the effect and its relationship to the cause.

Criterion-Based Suggestions for Improvement

- Ensure that "[t]here is a close match between the SEP, CCC, and DCI elements that are claimed and evidence of their development and use in the materials." [Detailed Guidance, p. 10]
  - Consider how students can examine the "effects of weathering" as opposed to the "effects on design" in Lesson 14.
  - Consider listing PAT-E3—Patterns can be used as evidence to support an explanation—in Lessons 2, 4, 5, and 13 instead of PAT-E1.

I.C. Integrating the Three Dimensions

EXTENSIVE

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

The reviewers found **extensive** evidence that student sensemaking of phenomena and designing solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs. In the unit, students are expected to explain what caused changes to land in Acadia National Park, which requires them to use grade-appropriate elements of the three dimensions simultaneously. The three dimensions are not used in isolation. There are many strong instances of integration of the three dimensions throughout the unit. In most activities in the unit, students are expected to figure out something that requires the use of three dimensions working together at grade level.

Learning is integrated

Throughout the unit, learning is integrated, and the integration is used to support students making sense of the phenomenon.

- Lesson 1, Synthesize, Step 4, students integrate the use of the elements when they develop an initial model to explain the changes to land and road in the three dimensions **CE-E1: Cause and effect relationships are routinely identified, tested and used to explain change, DCI ESS3.B-E1: A variety of natural hazards result from**

natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. and **MOD-E4: Develop and/or use models to describe and/or predict phenomena.**

- Lesson 4, Synthesize, Step 6: Students integrate the use of the elements when discussing their observations from the Wind Investigation in the three dimensions. **CE-E1: Cause and effect relationships are routinely identified, tested and used to explain change. PS4.A-E1 Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. INV-E3 Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.**
- Lesson 6, Explore, Step 5, students integrate the use of the elements when they observe patterns of evidence in images and data from National Park sites in the three dimensions **PAT-E1 Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products ESS2.A-E2 Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. INV-E3 Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.**
- Lesson 7, Synthesize, Step 5: Students integrate the use of the elements when the class adds to a chart displaying information about how the land can change slowly and quickly, as well as the mechanisms that can cause the change. **SC-E2 Some systems appear stable, but over long periods of time will eventually change. ESS2.A-E2 Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.MOD-E4 Develop and/or use models to describe and/or predict phenomena.**
- Lesson 10, Synthesize, Step 4: Students integrate the use of the elements when they use their observations and gathered evidence to construct an explanation of how Hawaii has so many plants. **CE-E1: Cause and effect relationships are routinely identified, tested and used to explain change. ESS2.A-E2 Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.. INV-E3 Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.**
- Lesson 11, Synthesize, Step 5: Students integrate the use of the elements when they predict which location is more likely to experience a volcanic eruption using patterns from a map they analyze. **PAT-E2 Patterns of change can be used to make predictions. ESS2.B-E1The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features of Earth. DATA-E2: Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.**
- Lesson 13, Explore, Step 3: Students integrate the use of the elements when they clarify the exact problem at Seawall Road they want to address, brainstorm solution ideas, and compare these ideas in the three dimensions. **PAT-E1 Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. ESS3.B-E1A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. CEDS-E5 Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.**

Integration to support student sense-making over time

- Lesson 8, Synthesize, Step 7: Students integrate the use of the elements of the three dimensions when they observe additional photographs of the Carbella Bridge before, during, and after June 13th in order to determine what could have caused the changes to the bridge **CE-E1 Cause and effect relationships are routinely identified, tested, and used to explain change.ESS2.A-E2 Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. INV-E3 Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.**
- Lesson 16: Students integrate the use of the three dimensions when they individually **take an assessment that compares multiple solutions to a problem of wind erosion. CE-E1Cause and effect relationships are routinely identified, tested, and used to explain change. ESS3.B-E1A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. CEDS-E5 Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution**.

Criterion-Based Suggestions for Improvement: N/A

I.D. Unit Coherence

EXTENSIVE

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.

The reviewers found **extensive** evidence that the lessons fit together coherently to target a set of performance expectations, as the lessons build on one another, resulting in an increased understanding of the science ideas needed to explain the phenomena and design solutions to the engineering problems in the unit. The lessons help students develop proficiency in a targeted set of performance expectations.

- 4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.
- 4-ESS1-1: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.
- 4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features.
- 4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
- 4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

- 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.

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.

- Lesson 1, Synthesize, Step 7: "Follow the directions on the slide and help students to group similar questions together as they post them to the DQB. Once all students have posted their questions to the DQB, explain that the class will work to answer these questions throughout the unit, and when we discover we have more questions (because that's what scientists do), we can add them to our DQB, as well." (Lesson 1, Teacher Guide)
- Lesson 2, Explore, Step 2: "What new questions do you have? Write these on sticky notes for our DQB!" (Lesson 2 Slides, Slide I)
- Lesson 3, Navigate, Step 7: "Move to the next lesson by pointing out that we have been talking about different sizes or amounts of waves and how we could make them, but wonder aloud about how a storm could have made such big waves. If students have ideas about the causes of big waves, allow them to share, but plan to investigate waves further next time." (Lesson 3, Teacher Guide) Students do not have an opportunity to generate new questions.
- Lesson 4, Navigate, Step 1: The class discusses ideas from the previous lesson. Question: "What did we investigate last lesson?" What to look for in student responses: "We were trying to figure out if waves could have made the rocks end up on the road at Acadia National Park. We played with a water tank/wave bin. We used a board to make the waves. We tried to see if we could make waves that make stuff move. We added a beach or shore to see if that made waves that could move rocks. (Gesturing to show the shape of the bottom of the wave bin)" (Lesson 4, Teacher Guide)
- Lesson 4. Navigate, Step 7: "Partners discuss what we have figured out. Present slide M. Students should discuss which of the pictures we can now explain, and share that explanation with a partner using evidence from the last two lessons. Discuss what we can and cannot explain as a class. Display slide N. Ask, Which of these pictures can we explain? What do we know about how and why they happened?" (Lesson 4, Teacher Guide) Students do not have an opportunity to generate new questions.
- Lesson 5, Navigate, Step 8: "Re-visit the DQB. Display the Driving Question Board and give students a few minutes to remove questions that the class has made progress on. Invite students to read the question and then share what the class figured out about that question. Encourage students to connect the answer to that question to a particular lesson or moment in a lesson." (Lesson 5, Teacher Guide)
- Lesson 6, Navigate, Step 6: "What have we figured out about weathering and erosion in different places? What are we still unsure about or need more evidence for?" (Lesson 6 Slides, Slide S)
- Lesson 6, Explore, Step 2 Sidebar: "Students may raise questions about what happens to the material that is broken off and carried away. Record these questions and ideas and consider using the extension around this process, called deposition, in Lesson 7." (Lesson 6, Teacher Guide)
- Lesson 8, Navigate, Step 1: "Recall the changes to land we wanted to figure out about next. Display the "How land and things on it change" chart (see slide A). Ask students to recall what initial ideas we had about changes to land and things on it in our community. Ideas to listen and look for: We have figured out about a lot of changes to land in National Parks, but we started wondering about the kinds of changes to land there are in our community. We shared some examples of changes to land near us that we have seen. We wondered which mechanisms of erosion can cause changes to land and things on it in our community." (Lesson 8, Teacher Guide)

- Lesson 9, Explore, Step 2: "Recall our question about new land forming. Display slide J Remind students that we were curious if lava could create new land. Ask students if they think the Hawai'ian Islands were always there. Accept all responses." (Lesson 9, Teacher Guide)
- Lesson 11, Navigate, Step 6: "Revisit our records to plan where to go next. Tell students that it sounds like even though volcanoes can be very hazardous, they tend to occur in patterns which makes it easier to predict where they might happen. Remind students that volcanic eruptions are not the only hazards that we have been thinking about in this unit. Display slide X and encourage students to look back at our Driving Question Board, our initial model, and/or our "How land and things on it change" chart to recall other hazards we have been wondering about. Ask students to share what some of those hazards are." (Lesson 11, Teacher Guide)
- Lesson 12, Navigate, Step 1: "Return to the Driving Question Board. Display slide A and ensure the Driving Question Board is posted. Remind students that we had some questions at the end of the last lesson, or even from the beginning of the unit, about natural hazards other than volcanoes." (Lesson 12, Teacher Guide) "Consider where to go next. We have questions about where people might experience natural hazards other than volcanoes. What hazards do we still have questions about? How might we go about figuring this out using strategies and tools that have worked in the past?" (Lesson 12, Slides Slide A)
- Lesson 12, Connect, Step 4: "Re-visit the DQB. Display the Driving Question Board and give students a few minutes to remove questions that the class has made progress on. Invite students to read the question and then share what the class figured out about that question. Encourage students to connect the answer to that question to a particular lesson or moment in a lesson." (Lesson 12, Teacher Guide)
- Lesson 13, Navigate, Step 5: "Consider where to go next. Reflect on how to use criteria and constraints. Display slide I. Celebrate students' progress so far and problematize how the pieces fit together. Ask, How might we use criteria and constraints to move forward with our ideas for solutions?" (Lesson 13, Teacher Guide)
- Lesson 14, Navigate, Step 5: "Use the Engineering Process chart to consider where to go next. Display slide K and revisit the Our Engineering Process chart. Give students a moment to think about where the class is in the process. Invite a couple students to share which steps they think the class has completed. As the class agrees on steps they have completed, check those steps off with a marker. Using the process on the chart, let the class know they'll pick up with the Test and Compare phases in the next class." (Lesson 14, Teacher Guide)

ii. The lessons help students develop toward proficiency in a targeted set of performance expectations.

The lessons help students develop toward proficiency in a targeted set of performance expectations. Six target Performance Expectations are

4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

- Lesson 3, Synthesize, Step 6: Students engage in a discussion of their new model and consider why the gravel moved differently this time. Students conclude that "Waves don't move things forward unless they are close to the shore." (Lesson 3, Teacher Guide)
- Lesson 4, Synthesize, Step 3: "Debrief the Bedsheet 'Parachute' Investigation. Display slide C. Gather students in a Scientists Circle to discuss what we figured out how different types of waves and how they might be able to move things." Students discuss the question, "Using our new science words, what kind of waves do you think most likely moved the rocks onto Sea. (Lesson 4, Teacher Guide)

- Lesson 5, Synthesize, Step 7, Student Assessment 1, "Use words, symbols, and/or drawings to explain how the pattern of motion of a boat on top of the water is different far from the shore and close to the shore" (Lesson 5, Student Assessment 1)

4-ESS1-1: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

- Lesson 7, Connect, Step 6, Students read an article and engage in the following discussion questions, "How are the fossils fourth graders have seen at Guadalupe Mountains National Park similar? What pattern are they noticing about the fossils there?" and "What evidence does that pattern give us about what this land used to be like very long ago?" (Lesson 7, Teacher Guide)
- Lesson 9, Synthesize, Step 8, "Consider what else scientists can learn from rock layers. Display slide X and have students Think, Pair, Share about the two prompts on the slide, which are similar to the ones they considered with their reading partner on the Volcanoes and the Island of Hawaii. Which layer of lava would have been the oldest in the image? Which layer of lava is probably the most recent? Bring students together after a few minutes of sharing with a partner, and use the prompts below to add additional ideas to the model." (Lesson 9, Teacher Guide)
- Lesson 10, Explore, Step 6, Students explore the phenomena of lava trees and engage in the questions, "Observe the photo of an area on Kilauea on slide W. Do you notice any lava trees in the area? What does that tell you about what the landscape of this area was like in the past?" and "What pattern do you notice between where the tree molds and lava trees are and what the landscape of those areas were like in the past?" (Lesson 10, Teacher Guide)

4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features.

- Lesson 9, Explore, Step 2: "Observe different maps of Hawai'i. Suggest that we become more familiar with the Hawai'ian Islands by looking at a few different maps. Display slide C and support students in locating Hawai'i relative to the continental United States. Display slide D and ask students to share what they notice. Support students in understanding that the state of Hawai'i is a chain of islands, each island has a name, and one of the islands is named Hawai'i. Suggest that we look at a few other different maps and images to see what else we notice and wonder." (Lesson 9, Teacher Guide)
- Lesson 11, Synthesize, Step 5: "After students have had an opportunity to work with their partners, display slide V and ask students to share which area they predicted would be more likely to experience a volcanic eruption by holding up 1 finger if they thought it was area 1 and 2 fingers if they thought it was area 2. Ask students to share the patterns they noticed that would support their choice." (Lesson 11, Teacher Guide)
- Lesson 12, Explore, Step 2: "Explore where other hazards occur. Distribute Natural Hazards Mapping and tell students it will help them orient to another natural hazard. Give each pair of students one of the additional hazards maps: hurricanes, tsunamis, thunderstorms, tornadoes, landslides, or floods. Display slide D and give students 10 minutes to use this map and the land and ocean features map, boundaries map, and population map to complete the row on Natural Hazards Mapping." (Lesson 12, Teacher Guide)

4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

- Lesson 1, Synthesize, Step 4: "Explain that for each image, students should focus on explaining the changes to the land and/or road. Remind students that we want to explain: If wind, water, and/or ground shaking were involved in the change. How the wind, water, and/or ground shaking may have changed the land or road. (push, shake, lift, etc.)

If the changes were fast (happened suddenly) or slow (gradually over a long period of time)." (Lesson 1, Teacher Guide)

- Lesson 5, Synthesize, Students debrief their investigation and reflect on the following question, "How could the waves have made the road sink, what ideas do we have about that?" They provide possible answers like, "The waves took the rocks away from under the road," (Lesson 5, Teacher Guide)
- Lesson 6, Explore, Step 5: "After students have had 5-7 minutes to read and annotate, discuss as a class. Present slide M and ask, What new or surprising ideas did you underline? Look and listen for these ideas: Sediment is a word for little pieces of land. Weathering and erosion happen all the time, not just during storms. Anytime sand or any other land move is a sort of erosion. Weathering and erosion can happen without waves. There are lots of different types of erosion--from ice, flowing water, wind, and living things." (Lesson 6, Teacher Guide)
- Lesson 6, Students read about how Alligators can cause changes to the land in the book "Changes to the Land and Erosion." (Lesson 6, Changes to the Land)
- Lesson 7, Synthesize, Step 5: Students engage in a discussion to explore the various mechanisms that cause change at different National Park Sites. They engage with the following discussion questions, "Wow! We noticed so many changes to land in these different places. What did we find out about the mechanisms that cause these changes?" and "What evidence do we have to support that these are the mechanisms that caused the changes at these sites?" (Lesson 7, Teacher Edition)
- Lesson 8, Explore, Step 6: "Make sense of rainfall and snowmelt data. Tell students that you have some data that can help us determine if that is where the water came from. Display slide K and invite students to work together to make sense of the data." (Lesson 8, Teacher Guide)
- Lesson 10, Explore, Step 2: "Display slide J and distribute the transparency of the Hawaii photo map and tell students that they can place the transparency of the Hawaii photo map on top of the rainfall data map and work with a partner to answer these questions based on our predictions: Are the areas with higher amounts of rainfall the same as the areas with fewer plants? Are the areas with lower amounts of rainfall the same as the areas with fewer plants? Display slide K and ask students to consider what they figured out from the maps that they observed. Facilitate a discussion about the data comparison. Encourage students to reference the evidence they have to support their claims." (Lesson 10, Teacher Guide)
- Lesson 10, Explore, Step 3: "Observe photos of plant roots breaking things. Display slide O and explain that we have some photos of the roots of plants that we can observe. Pair students up and distribute the Plant Roots Breaking Things images. Ask students to observe the photos and look for evidence that plant roots can break rocks. Encourage students to circle and annotate areas of the photos that could be evidence of plant roots breaking rocks. As students are observing the photos circulate the room and ask questions like: What do you see that could be evidence of plants breaking rocks? Can you tell me about this part of the picture? Why do you think that?" (Lesson 10, Teacher Guide)

4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

- Lesson 1, Synthesize, Step 7: "Follow the directions on the slide and help students to group similar questions together as they post them to the DQB. Look for students to ask questions like: How can (natural hazard) change the land? Was this wind or water that changed the land? Does (natural hazard) happen in Maine? How much wind or water is needed to destroy a road? What can we do to prevent this from happening again? Can this happen where we live?"(Lesson 1, Teacher Guide)
- Lesson 2, Synthesize, Step 3: "Organize our Acadia data. Propose using a data table to compare the Acadia data to what we've figured out about various hazards. Display slide K and work with the class to list the categories of data

and mechanisms that do apply to Acadia across the top of the chart, including the specific details from Acadia that week across the top row of the Comparing Mechanism Patterns to Acadia chart. Use the prompt on the slide to have students review their Acadia data cards and work together to fill in information about what happened in Acadia with each data point or mechanism." (Lesson 2, Teacher Guide)

- Lesson 13, Connect, Step 2, Students read about what communities are doing to reduce the impacts of natural hazards in the book, "Natural Processes in Our Communities." They engage with the following reflection question: "Which community is able to stop the impact of Earth's processes on its land? Can any of Earth's processes be stopped?" (Lesson 13, Teacher Guide)
- Lesson 13, Connect, Step 2: "Read about Earth Processes in Our Communities. Connect to students' suggestions that we read or research possible options to protect Seawall Road and places like it. Display Slide B and do a class read-aloud of the Natural Processes in Our Communities book. Encourage students to think about what the communities in the book tell us that might help us think about protecting Seawall Road." (Lesson 13, Teacher Guide)
- Lesson 15, Students make sense of their designs to prevent erosion when they engage in the following questions: "What do you notice about how the design is working? What do you notice about what is happening to the rocks on the road? What do our observations of our model tell us about possible solutions for Seawall Road? (Lesson 15, Teacher Guide)
- Lesson 15, Explore, Step 3: "Identify conditions for testing. Have the class gather around one wave bin. Remind students about one of the criteria for the designs being that their designs should protect the road from smaller, everyday waves as well as the larger waves Seawall Road encountered during the coastal storm. Briefly ask students what the different parts of the system represent in the real-world phenomenon: The bin represents the part of the ocean around Seawall Road.The small container represents the land that is slightly above the water where Seawall Road is. The acrylic sheet represents the coastline getting shallower as the ocean gets closer to the shore. The 2 lines drawn with markers across the plastic container and the mixture of gravel (pea gravel and aquarium gravel) represent the rocks underneath the road. The second acrylic sheet represents the wind that causes waves." (Lesson 15, Teacher Guide)
- Lesson 16, Connect, Step 2: "Connect solutions in the reading to other locations. Point out that scientists were interested in reducing coastal erosion using plants to keep the land in place. Ask students to consider if this solution could work for other places. Accept all responses. Tell students that you heard that another 4th-grade class did something similar to what we did with Seawall Road, but for Indiana Dunes National Park." (Lesson 16, Teacher Guide)
- Lesson 16, Explore, Step 3: Students explore the research and testing done by another fourth-grade class to solve the problem of erosion in the Indiana Dunes National Park. (Lesson 16, Teacher Guide)

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.

- Lesson 13, Connect, Step 2: "Read about Earth Processes in Our Communities. Connect to students' suggestions that we read or research possible options to protect Seawall Road and places like it. Display Slide B and do a class read-aloud of the Natural Processes in Our Communities book. Encourage students to think about what the communities in the book tell us that might help us think about protecting Seawall Road." (Lesson 13, Teacher Guide)
- Lesson 14, Explore, Step 3: "Come to consensus and develop the group's revised solution. Let the class know that groups will now build on the discussion they just had about the initial solution ideas to reach consensus around a design they think will best attend to the criteria and constraints. Display slide F, and let groups know they will

have ten minutes to agree upon and draw a model showing their consensus design. This may have elements of a few different group members' initial designs or they may want to start with one initial design and make some modifications." (Lesson 14, Teacher Guide)

- Lesson 15, Explore, Step 3: "Identify conditions for testing. Have the class gather around one wave bin. Remind students about one of the criteria for the designs being that their designs should protect the road from smaller, everyday waves as well as the larger waves Seawall Road encountered during the coastal storm. Briefly ask students what the different parts of the system represent in the real-world phenomenon: The bin represents the part of the ocean around Seawall Road.The small container represents the land that is slightly above the water where Seawall Road is. The acrylic sheet represents the coastline getting shallower as the ocean gets closer to the shore. The 2 lines drawn with markers across the plastic container and the mixture of gravel (pea gravel and aquarium gravel) represent the rocks underneath the road. The second acrylic sheet represents the wind that causes waves." (Lesson 15, Teacher Guide)
- Lesson 16, Explore, Step 3: Students explore the research and testing done by another fourth-grade class to solve the problem of erosion in the Indiana Dunes National Park. (Lesson 16, Teacher Guide)

Criterion-Based Suggestions for Improvement

- Ensure that "[s]tudents have regular opportunities to engage in asking questions based on what they have learned so far in the unit and revisit their questions in subsequent lessons." [Detailed Guidance, p.15]
  - For example, in Lessons 3 and 4, consider inserting more opportunities in which student questions are used to authentically transition from one lesson to the next, including instances when students can generate questions and reflect on which of their questions have been answered.

I.E. Multiple Science Domains

EXTENSIVE

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.

The reviewers found **extensive** evidence that links are made across the science domains when appropriate, as the unit incorporates ideas from both the physical and Earth science domains. These ideas are used together to help make sense of what caused the changes to the land in Acadia National Park.

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

The following DCIs are used in this unit.

- **ETS1.B-E1 Developing Possible Solutions: Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.**
- **ETS1.B-E3: Developing Possible Solutions: 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.**
- **ESS1.C-E1: The History of Planet Earth Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.**
- **ESS2.A-E2: Earth's Materials and Systems: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.**
- **ESS2.B-E1: Plate Tectonics and Large-Scale Interactions. The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features of Earth.**
- **ESS2.E-E1: Biogeology: Living things affect the physical characteristics of their regions.**
- **PS4.A-E1: Wave Properties: Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach.**
- **PS4.A-E2: Wave Properties: Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).**

The unit uses science ideas from both the physical science domain and the earth science domain to explain "How land and things on it change".

- About the Science, "This unit focuses on developing the foundational science idea that Earth's landscape changes over time. Students figure out that land changes over time (at different rates, usually very slowly) because of natural processes such as volcanoes, earthquakes, and weathering and erosion (from water, ice, wind, and living organisms). These processes and hazards do not cause changes consistently in all regions, so students also spend time in this unit using maps to identify patterns in where they are more likely to occur, related to Earth's land and water features. Along coasts, waves cause significant weathering and erosion, so students investigate wave patterns and the motion of waves. As land changes happen, rock formations and fossils provide evidence of those changes. Students also investigate how these Earth processes affect humans when land or things on it are changed. Students use their understandings to design, test, and evaluate solutions to prevent (but not stop) damage from weathering and erosion." (Unit 4.3, About the Science)
- Unit Overview, there is a section titled "Which Performance Expectations does this unit build toward?". In this section, there is a description for teachers about where the DCIs for the 6 performance expectations that are addressed in this unit. For example, "Students investigate the properties of waves as they consider how waves could have moved rocks onto a road during a storm. They observe deep waves in a wave bin and notice that the waves do

not move the pebbles in the bin forward. They wonder if deep waves would move things that are on the surface of the water forward. They place an object on top of the water and see that it also does not move forward in the deep waves. They notice that the deep water does not represent the area that they are investigating well, so they add a shoreline to their wave bin model. They notice that when the rocks are near the shore the waves do move them forward. This makes them wonder if the size of the waves impacts how they move things. They investigate how waves move through another medium and notice that waves can have different amplitudes and wavelengths, which can impact what they are able to move forward." and "Throughout the unit, students investigate various places that have experienced changes to land. They work to determine the mechanisms that cause those changes. Students figure out that water in the form of waves can break and move rocks when they investigate the causes of the changes to Seawall Road in Acadia." (Unit 4.3, Unit Overview)

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

The focal CCCs for the unit are Patterns and Cause and Effect. Patterns and Cause and Effect are used to make sense of phenomena where linking understanding of both physical science and earth science is required.

- Lesson 4, Synthesize Step 6, the class discusses observations from their investigation. "Ideas to listen and look for: Wind can cause big waves that traveled toward shore. Near the shore, the wave was able to push the rocks (from Lesson 3). These big waves were able to apply a force that could push rocks toward and onto the shore." (Lesson 4, Teacher Edition)
- Lesson 5, Synthesize, Step 5, the class revises their model, explaining how the road got cracked. Question: "Can someone share an idea they said or their partner said about how we could explain how the road got cracked?" Ideas to look for: "We need to put (or change it to) a wave icon there. The waves were so big and had a lot of force. The big waves smashed the road and cracked it." (Lesson 5, Teacher Guide)
- Lesson 6, Explore, Step 5, students are asked to gather information about different mechanisms that cause erosion. "What could cause changes to the land and the things on it? Mechanisms. How could it have caused the land and things on it to change?" (Lesson 6 Slides, Slide N) Teachers are given support for this task. "If they struggle to make observations or identify patterns in them, use sentence starters such as 'I notice…' and '___ could be connected to ___ because…'" (Lesson 6, Teacher Guide)

Criterion-Based Suggestions for Improvement: N/A

I.F. Math and ELA

EXTENSIVE

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.

The reviewers found **extensive** evidence that the materials provide grade-appropriate connections to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects because the materials explicitly state the mathematics and ELA standards that are used in the unit, and in the case of ELA and Math standards, support students to see the connections between content areas (Math and ELA) and science.

ELA

CCSS.ELA-LITERACY.RI.4.2 Determine the main idea of a text and explain how it is supported by key details; summarize the text. Claimed in Lessons 2, 9, 10, and 13.

- Lesson 2, Explore, Step 2: "Literacy Supports Support students as they annotate the cards and find key details (i.e., data points). Learners might already be familiar with strategies for annotating text. Encourage students to use their existing annotation strategies (e.g., circling, underlining, highlighting, jotting notes in the margins) to point out important information on the hazard cards. This work supports RI.4.2 as students find the main ideas about each hazard and identify key details via annotation." (Lesson 2, Teacher Guide)
- Lesson 9, Connect, Step 6: "Literacy Supports. As students read with their partner, they are pausing to summarize each paragraph. Unlike storybooks which typically have one main idea, informational texts often convey multiple main ideas in different paragraphs, sections, or pages. Encourage students to underline or circle a main idea in each paragraph. Summarizing and identifying main ideas supports standard RI.4.2." (Lesson 9, Teacher Guide)
- Lesson 10, Explore, Step 5: "Literacy Supports: Support students' understanding of the infographic by reminding students that informational texts and infographics can have more than one main idea. Encourage students to identify main ideas and key details for the formation of lava trees and tree molds (RI.4.2)." (Lesson 10, Teacher Guide)
- Lesson 13, Connect, Step 2: "Also, encourage students to notice key details in the text that could be related to ways that people develop solutions for land changes (RI.4.2)." (Lesson 13, Teacher Guide)

CCSS-ELA-LITERACY.RI.4.6 Compare and contrast a firsthand and secondhand account of the same event or topic; describe the differences in focus and the information provided. Claimed in Lesson 14

- Lesson 14, Connect, Step 6: "Literacy Supports Encourage students to notice the different accounts of the engineering process presented in the book. Students can make multiple comparisons between the ways that engineers, children in the book, and your class engage in the engineering process. This supports RI.4.6 and provides students with an opportunity to make connections between their engineering work and the work of real engineers." (Lesson 14, Teacher Guide)

CCSS-ELA-LITERACY.RI.4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. Claimed in Lessons 1, 8, and 10.

- Lesson 1, Explore, Step 1: "Literacy Supports Maps are a visual type of text that students can engage with in science time to support their sensemaking. Remind students that engaging with texts, like maps, can help readers understand more about where places and things (features) are on Earth. Encourage students to notice and explain the labels, colors and icons on the map of the US and Maine to make sense of where this place is in the world (RI.4.7)." (Lesson 1, Teacher Guide)
- Lesson 2, Explore, Step 2: "Literacy Supports As students investigate the data cards, prompt students to notice and explain visual components (e.g., photographs, maps) alongside the words in the text. Interpreting information presented visually supports RI.4.7. Considering strategies for interpreting written and visual components of text further supports this standard." (Lesson 2, Teacher Guide)
- Lesson 8, Synthesize, Step 7: "Literacy Supports: Encourage students to paraphrase what they read after reading each paragraph of the article with a partner. This supports SL.4.2, ensures that students comprehend the text, and helps students integrate information from the article into their developing understanding of the different ways that land can change." (Lesson 8, Teacher Guide)
- Lesson 10, Explore, Step 2: "Literacy Supports Maps are a visual type of text that students can engage with in science time to support their sensemaking. Remind students that engaging with texts, like maps, can help readers understand more about where places and things (features) are on Earth. Encourage students to notice and explain the labels, colors and icons on the rainfall map and the images of Hawaii (RI.4.7)." (Lesson 10, Teacher Guide)

CCSS-ELA-LITERACY.RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. Claimed in Lessons 6 and 11.

- Lesson 6, Explore, Step 5: "Literacy Supports As students use the information they gathered from the read aloud about weathering and erosion to help them explain the impact of weathering and erosion in a National Park, they are addressing RI.4.9. Integrating information across two texts on the same topic also supports students' generalization of mechanisms of weathering and erosion to specific contexts." (Lesson 6, Teacher Guide)
- Lesson 11, Connect, Step 3: "Literacy Supports. As students compare images and data on maps and diagrams, they are working to integrate information from both texts. This supports RI.4.9 and this work prepares students for identifying patterns in the ocean floor." (Lesson 11, Teacher Guide)

CSS-ELA-LITERACY.W.4.2D Use precise language and domain-specific vocabulary to inform about or explain the topic. Claimed in Lessons 5 and 16.

- Lesson 5, Synthesize, Step 7: "Literacy Supports. As students complete this assessment, they will be using precise language and domain-specific vocabulary to explain what happened to the Tay (W.4.2D). You can direct them to the word wall to encourage them to use some of these words (e.g., wave, amplitude) to explain the events leading to the shipwreck." (Lesson 5, Teacher Guide)
- Lesson 16, Synthesize, Step 4: "Literacy Supports. As students complete this assessment, they will be using precise language and domain-specific vocabulary to explain different engineering solutions (W.4.2D). You can direct them to the text Natural Processes in Our Communities, the class poster, or word wall to encourage them to use some of these words (e.g., criteria, constraint) to explain erosion solutions for Indiana Dunes National Park." (Lesson 16, Teacher Guide)

CCSS-ELA-LITERACY.SL.4.2 Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally. Claimed in Lessons 6 and 7.

- Lesson 6, Navigate, Step 1: "Literacy Supports. As students discuss the postcard and photograph (and optionally the video as well), they are paraphrasing information presented in diverse media and formats. This work supports standard SL.4.2. This skill is extended as they continue to discuss how to quantify the change to Thunder Hole, integrating information presented in another format to their developing explanation of the formation of Thunder Hole." (Lesson 6, Teacher Guide)
- Lesson 7, Connect, Step 6: "Literacy Supports Encourage students to paraphrase what they read after reading each paragraph of the article with a partner. This supports SL.4.2, ensures that students comprehend the text, and helps students integrate information from the article into their developing understanding of the different ways that land can change." (Lesson 7, Teacher Guide)

CCSS-ELA-LITERACY.SL.4.4 Report on a topic or text, tell a story, or recount an experience in an organized manner, using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace. Claimed in Lessons

- Lesson 12, Connect, Step 4: "Literacy Supports Help students prepare for sharing their findings with the class. Encourage students to share their ideas in an organized manner by emphasizing main ideas or explaining the natural hazard in their place using cause and effect language. This supports SL.4.4 and helps students include relevant facts and details in their oral explanation." (Lesson 12, Teacher Guide)
- Lesson 13, Connect, Step 2: "Literacy Supports Prior to reading, prepare students for their forthcoming discussion about solutions for protecting Seawall Road. Students will need to be able to paraphrase information in the text with their peers after reading (SL.4.4)." (Lesson 13, Teacher Guide)

CCSS-ELA-LITERACY.L.4.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking. Claimed in Lesson 6.

- Lesson 6, Explore, Step 5: "Literacy Supports. Support students' use of the varying forms of "weathering" and "erosion" while reading the text and afterwards in class discussions. Encourage students to notice that the words "weather" and "erode" are verbs and their usage differs from the words "weathering" and "erosion". "Weather" and "erode" refer to the action of breaking rock apart and carrying it away, whereas "weathering" and "erosion" refer to natural processes. Model and support correct usage of these terms in students' oral and written language (L.4.1)." (Lesson 6, Teacher Guide)

CCSS-ELA-LITERACY.L.4.4B Use common, grade-appropriate Greek and Latin affixes and roots as clues to the meaning of a word (e.g., telegraph, photograph, autograph). Claimed in Lesson 2.

- Lesson 2, Explore, Step 2: "Literacy Supports. 'Mechanism' is likely a new word for learners. It might be helpful to point out the Greek root "mech" and tell learners that this root means "instrument, tool, or machine". This root can be found in related words like mechanic and mechanical. Children may know someone who works as a mechanic or might have experience with mechanical things. In the context of this lesson we are interested in storms and how certain processes, or mechanisms, that happen during a storm change the land. Instruments, tools, and machines are used by people to do things (e.g., a shovel is used to move dirt). Similarly, mechanisms that happen during storms do things to the land (e.g., waves move rocks) (L.4.4B)." (Lesson 2, Teacher Guide)

CCSS-ELA-LITERACY.L.4.5C Demonstrate understanding of words by relating them to their opposites (antonyms) and to words with similar but not identical meanings (synonyms). Claimed in Lesson 4.

- Lesson 4, Explore, Step 2: "Literacy Supports As students use a variety of adjectives to describe the waves it might be helpful to clarify when these adjectives are antonyms with opposite meanings (e.g., big and small, fast and slow) and when words have similar or related meanings that need to be differentiated (e.g., harder versus faster) (L.4.5C)." (Lesson 4, Teacher Guide)

Mathematics

CCSS-MATH-Practice.MP2 Reason abstractly and quantitatively. Claimed in Lessons 2 and 10. Examples include:

- Lesson 2, Explore, Step 2: "Math Supports. While students make sense of the data cards, they reason quantitatively and qualitatively by associating wind speed with specific conditions (e.g., wind speeds between 45 and 74 miles per hour cause branches to break and large trees to blow over). Remind students to think about what the recorded wind speeds mean about what is happening during the natural hazard (MP2)." (Lesson 2, Teacher Guide)
- Lesson 10, Explore, Step 2: "Math Supports: Students will make sense of the amount of rainfall in different parts of Hawaii using the map and the key. As they explore, they will reason both abstractly and quantitatively about what the colors represent and how they help determine how much rain different parts of the island get in one year (MP2)." (Lesson 10, Teacher Guide)

CCSS-MATH-Practice.MP4 Model with mathematics. Claimed in Lesson 6. Examples include:

- Lesson 6, Explore, Step 2: "Math Supports Students will use the bricks and clay to model erosion at Thunder Hole. To support students in making sense of how their model relates to the measurements of Thunder Hole, encourage the use of both the references such as buses, people, or other objects and the measurements in meters (MP4)." (Lesson 6, Teacher Guide)

CCSS-MATH-Practice.MP6 Attend to precision. Claimed in Lesson 2. Examples include:

- Lesson 2, Synthesize, Step 3: "Math Supports To help students attend to the precision of the rainfall measurements in an hour from the Acadia data compared to an hour from coastal storms, thunderstorms, and hurricanes, take out an inch-ruler. Then, as the rainfall data is shared, have students locate ¼ inch, 1 inch, and 6 inches on the ruler (MP6)." (Lesson 2, Teacher Guide)

CCSS-MATH-4.NF.C.7 Compare two decimals to hundredths by reasoning about their size. Recognize that comparisons are valid only when the two decimals refer to the same whole. Record the results of comparisons with the symbols >, =, or <, and justify the conclusions, e.g., by using a visual model. Claimed in Lesson 2. Examples include:

- Lesson 8, Explore, Step 6: "Math Supports As students compare the typical average amount of rainfall and snowmelt to the daily values, prompt them to consider how the decimal numbers in the table relate to their understanding of money and/or fractions. For example, 0.8 is the same as eight tenths and/or 80 cents. Students can use different representations (decimals, fractions, money) to make sense of which value is greater. (part of 4.NF.C.7)" (Lesson 8, Teacher Guide)

Criterion-Based Suggestions for Improvement: N/A

CATEGORY II

NGSS Instructional Supports

II.A. Relevance and Authenticity

EXTENSIVE

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.

The reviewers found **extensive** evidence that the materials engage students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world, as students have opportunities to explain the phenomena of how natural hazards caused changes to Acadia National Park. Students experience phenomena or design problems as directly as possible when they observe videos and images of the changes to different landforms throughout the unit. The materials include suggestions for connecting instruction to students' experiences, such as their experiences with land changes and prior experiences with waves. The materials provide opportunities for students to connect their explanation of a phenomenon and/or their design solution to questions from their own experiences when they examine natural hazards in their own places and reflect on how to prepare for natural hazards.

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

- Lesson 1, Explore, Step 3, the class is introduced to the phenomenon through video and photographs. "Introduce a puzzling phenomenon. Display slide I. Explain to students that you have some photos of the same road from the video that were taken about a year later. Ask students to draw a line under the notice and wonders they recorded on their Explore a New Phenomenon handout from the video. Display the image on slide J and pause for 30 seconds to allow students to record notice and wonders. Repeat for slides K-M." (Lesson 1, Teacher Guide)
- Lesson 5, Navigate, Step 8, "Introduce Thunder Hole. Display slide M and share with students that you found an interesting phenomenon that people love to visit while in Acadia National Park. Explain that there is a place where ocean waves rush in, and when they hit the rock, it makes a sound like thunder. Tell students this feature is called Thunder Hole. Show the video that is linked on the slide. Invite students to share what they notice and wonder. Accept all responses. Look for students to notice that its shape is long and narrow, the surrounding rock seems to be "chunky" or in layers, and it looks different than the cliffs on either side. Look and listen for students to wonder about how this rock formation came to be here like this." (Lesson 5, Teacher Guide)
- Lesson 8, Synthesize, Step 4 Sidebar: "Encouraging all students to share their ideas and experiences can help bring in valuable knowledge from their families and communities — especially about how land changes in places they know well. Students might share observations of things like construction, erosion, flooding, wildfires, or new plant growth in their neighborhoods, parks, or places they visit often. These personal connections can diversify classroom discussions about Earth's processes and make science more relevant and meaningful to all learners." (Lesson 8, Teacher Guide)

- Lesson 9, Explore, Step 2: "Observe different maps of Hawai'i. Suggest that we become more familiar with the Hawai'ian Islands by looking at a few different maps. Display slide C and support students in locating Hawai'i relative to the continental United States. Display slide D and ask students to share what they notice. Support students in understanding that the state of Hawai'i is a chain of islands, each island has a name, and one of the islands is named Hawai'i. Suggest that we look at a few other different maps and images to see what else we notice and wonder. Display slides E-I, pausing on each for 1-2 minutes to allow students to turn and talk about what they notice and wonder. See the sample list below for possible student responses." "Consider if the island of Hawai'i was always there. Display slide K and ask students to share what they notice about the age of rocks in various parks. Look for students to say that the rocks on the island of Hawai'i are much younger than the other parks. Ask students to consider if this supports the idea that Hawai'i was always there. Look for students to suggest that this means the island of Hawai'i was not always there, and it is younger than some of the other parks highlighted. Suggest we try to explain how an island like Hawai'i could form." (Lesson 9, Teacher Guide)
- Lesson 10, Navigate, Step 1: "Display slide B and ask students to observe the lava flow in a video from an eruption of Kīlauea, one of the volcanoes in Hawaii Volcanoes National Park, and be ready to share what they notice about the lava flowing over the land." (Lesson 10, Teacher Guide)
- Lesson 12, Connect, Step 2, students read a book about various types of natural hazards and how communities can mitigate the harm caused by these events.

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

- Lesson 1, Connect, Step 6: "Consider our experiences with land changing. Remind students that we have been thinking about how the land and the road on it changed in Acadia, what kinds of other natural changes to land and things on it have you noticed? Encourage students to consider times that they have seen land and things on it changing in person, in books, or in videos or pictures from reliable sources. Support students in thinking about a wide variety of changes to land and things on it that were due to natural causes. Say something like, sometimes humans change the land and things on it, by building or taking away things. For now, we want to focus on examples that were from natural causes. Ask students to turn and tell a partner about the times that they have seen land change. Ask students to share their ideas with the whole class, and as students share, record their ideas on the Related phenomenon chart. (refer to slide U)" (Lesson 1, Teacher Guide)
- Lesson 6, Explore, Step 5. Students read the book, "Changes to the Land, Weathering and Erosion." Page 1 of the reading, the author asks: "Have you ever been to a beach and wondered why it seems to change over time?" The author of the book provides students with the opportunity to reflect on their personal experiences. Page 16 "Where will you find evidence of weathering and erosion near you?" The author invites the reader to consider evidence of erosion in their local area. (Lesson 6, Teacher Guide)
- Lesson 8, Synthesize, Step 4: Community Connections "Encouraging all students to share their ideas and experiences can help bring in valuable knowledge from their families and communities — especially about how land changes in places they know well. Students might share observations of things like construction, erosion, flooding, wildfires, or new plant growth in their neighborhoods, parks, or places they visit often. These personal connections can diversify classroom discussions about Earth's processes and make science more relevant and meaningful to all learners." (Lesson 8, Teacher Guide)
- Lesson 11, Navigate, Step 1: "Community Connections Prompt students to share and reflect on personal or community experiences related to predicting natural hazards. This helps them connect scientific reasoning with real-world relevance. Try saying: "Before we look at specific tools for predicting and locating volcanic eruptions,

let's pause and think: Have you ever experienced—or heard stories about—how people in your family, culture, or community have located or predicted where natural hazards, like volcanic eruptions, earthquakes, or floods happen? What signs or clues did they notice in nature? What tools did they use?" (Lesson 11, Teacher Guide)

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.

- Lesson 1, Connect, Step 6: "Look back on our consensus model that explains the changes to Seawall Road. If it is not already, place the related phenomena chart next to the initial consensus model that explains the causes of the changes to Seawall Road, and our How Land and Things On It Change chart. Facilitate a discussion about the similarities and differences between the possible causes to Seawall Road and the related phenomena that we identified." (Lesson 1, Teacher Guide)
- Lesson 6, Synthesize, Step 3 Sidebar: "Additionally, encourage students to connect their prior experiences and stories about weathering and erosion to their reasoning from this investigation." (Lesson 6, Teacher Guide)
- Lesson 7, Navigate, Step 7: "Consider changes to land in our own community. Say something like, Wow! We have figured out about several different ways that land can change at National Parks and the different causes for those changes. Do you think the land in our own community changes in the same ways? Display slide N and ask students to consider what examples of changes to land and things on it there are in our community and what causes those changes. Encourage students to use the "How land and things on it change" chart to remind them of the mechanisms and examples of change that we have explored so far."
- Lesson 8, Synthesize, Step 4: "Add our community land changes to the How land and things on it change chart. Display the How land and things on it change chart (see slide G). Suggest that adding the examples of how land and things on it change from our own community can help us find patterns in how these mechanisms change land. Reference the Mechanism column of the How land and things on it change chart, starting with the first one, and ask students if they noticed any changes in the community that were caused by this mechanism. If they did, record that change in the example column, using a photo or drawing of the example, if possible. Continue with this process until you have recorded examples of the mechanisms you have evidence for from the community." (Lesson 8, Teacher Guide)
- Lesson 12, Connect, Step 4: "Examine natural hazards in our places. Display slide I. Assign students to groups of four and ensure each group has access to 3-4 of the hazards maps from Lessons 11 and 12, including at least one map that should have some locally relevant hazards. Give students 10 minutes to work with their groups to look through the maps and develop responses to the prompts on the slide." (Lesson 12, Teacher Guide)

Criterion-Based Suggestions for Improvement: N/A

II.B. Student Ideas

EXTENSIVE

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.

These pieces of evidence support the **extensive** rating because there are opportunities for students to express, clarify, justify, interpret, and represent their ideas across the unit. They provide feedback to peers and receive feedback from peers and their teacher when appropriate. Throughout the unit, students demonstrate that their thinking has evolved, as shown by their use of the My Growing Ideas Chart and through two self-reflections in Lessons 5 and 15. Students have the opportunity to revise models to show changes in their thinking several times throughout the unit; however, the revision does not always result in individual artifacts and is often done using group consensus models. There are teacher-to-student and peer-to-peer feedback loops that provide students with opportunities to clarify their thinking over time.

Student ideas are clarified, justified, and built upon

- Lesson 1, Explore, Step 3: "Start the How Land and Things On It Change chart. Use the Notice and Wonder chart to point out the different natural hazards that students wondered about, and again celebrate that an important thing scientists do is try to figure out why and how things happen; suggest that we spend more time considering these possible causes. Select one natural hazard from the Notice and Wonder chart and ask students to share why they wonder if this type of event was responsible for the changes to Seawall Road. Use a piece of chart paper or a digital space to start the How Land and Things On It Can Change chart (refer to slide O). Be ready to draw simple icons for wind, shaking ground, waves, and rain, or have icons from the Large Printable Icons reference ready to add to the first column of the chart." (Lesson 1, Teacher Guide)
- Lesson 1, Synthesize, Step 4: "Think-Pair-Square After about 5 minutes, display slide Q and have students share their ideas with the rest of the group by engaging in a think-pair-square. Explain to students that in the first round they will think-pair-share with the person across from them. Then in the next round they will think-pair-share with the person next to them. Finally in the third round they will think-pair-share with the person diagonal from them. Remind students that we all have different ideas of what caused the land and road to change. Explain that we may agree on some ideas and others we may not, and that is OK. Encourage students to circle or put a check mark near areas of agreement, and place question marks in areas of uncertainty." (Lesson 1, Teacher Guide)
- Lesson 2, Synthesize, Step 3: "Engage in a Building Understandings Discussion to interpret the data. If not already in a Scientists Circle, gather students for a Building Understandings Discussion about how the evidence can be used to identify what type of event happened that week in Acadia. Be sure the students have both their Acadia and natural hazard cards. Display slide J. Explain to students that our goal in this Building Understandings Discussion is to consider what the data we gathered in our investigation mean for us in terms of whether we can figure out which type of event happened in Acadia that could have caused the damages." (Lesson 2, Teacher Guide)
- Lesson 3, Synthesize, Step 6: "Tell students that it will be important for them to not only share what they observed in the investigation, but listen to and connect with what other groups/students share so we can understand what we think we figured out about what causes waves to move things and where we still have questions. Point out the sentence starters on slide O for them to use during this discussion." (Lesson 3, Teacher Guide)
- Lesson 4, Navigate, Step 1: "Leverage uncertainty to point out that there is a lot we do not know about waves, including where they come from or how and why they are sometimes different from other times. Suggest that it might be helpful to use a model to clarify how we are talking about how waves can be different." (Lesson 4, Teacher Guide)

- Lesson 10, Explore, Step 3: "Observe photos of plant roots breaking things. Display slide O and explain that we have some photos of the roots of plants that we can observe. Pair students up and distribute the Plant Roots Breaking Things images. Ask students to observe the photos and look for evidence that plant roots can break rocks. Encourage students to circle and annotate areas of the photos that could be evidence of plant roots breaking rocks." (Lesson 10, Teacher Guide)
- Lesson 12, Explore, Step 2: "Let's share the patterns each group found. Each pair share: What patterns did you see in where your natural hazard occurs? Where are people likely to be impacted by your hazard? Show the other students what on the map(s) made you think that. Then identify similarities and differences between your findings and record on your handout." (Lesson 12 Slides, Slide P)
- Lesson 13, Synthesize, Step 4: "Develop criteria and constraints as a class. Display slide H. Gather students together with their sticky notes. Tell students that you are excited to hear more about their ideas from the prior step, as it sounded like many of them might be good criteria and constraints. Review the definitions of criteria and constraints again if needed, then use the prompts on the slide to elicit students' ideas from the sticky notes. Display the Erosion Solution Considerations chart. For each prompt, have students take a moment to confer with their partner if any of their sticky notes apply, then have students share and add the sticky note in the relevant section (Criteria or Constraints), pair-by-pair. Group similar ideas together as they are added to the chart and summarize by writing directly on the chart. Once all relevant stickies have been posted for a prompt, give students an opportunity to add any other stickies that they think are important, then move on to the next prompt." (Lesson 13, Teacher Guide)

Artifacts show evidence of students' reasoning and changes in their thinking over time.

- Lesson 1, Explore, Step 3: "Start the How Land and Things On It Change chart. Use the Notice and Wonder chart to point out the different natural hazards that students wondered about, and again celebrate that an important thing scientists do is try to figure out why and how things happen; suggest that we spend more time considering these possible causes. Select one natural hazard from the Notice and Wonder chart and ask students to share why they wonder if this type of event was responsible for the changes to Seawall Road. Use a piece of chart paper or a digital space to start the How Land and Things On It Can Change chart (refer to slide O). Be ready to draw simple icons for wind, shaking ground, waves, and rain, or have icons from the Large Printable Icons reference ready to add to the first column of the chart. The following sample prompts provide an example of how this discussion may go for one of the natural hazards. Repeat this process until students feel satisfied that they have recorded all of the ways land can change on the chart." (Lesson 1, Teacher Guide) The class adds to this chart throughout the unit to show their increasing understanding of the science ideas.
- Lesson 1, Synthesize, Step 4: "Develop an initial model to explain the changes to land and road. Display slide P and arrange students into groups of 4. Pass out the Initial Model handout and a Factors that can change land handout to each group. Ask each student in the group to take one page from the Initial Model handout to work on individually." (Lesson 1, Teacher Guide) Throughout the unit, students update the class consensus model, but do not return to their small group models.
- Lesson 3, Synthesize, Step 6: "Create a My Growing Ideas chart. We have figured out something big here! Display slide P and tell students that we should create a My Growing Ideas chart and add this discovery to it." (Lesson 3, Teacher Guide) The purpose of this chart is described in the Elementary Teacher Handbook. "In grades 4 and 5, students use individual My Growing Ideas charts, which provide a personal space for students to process what they are making sense of and see how their ideas are growing and changing over time. Students can look back through their My Growing Ideas charts to reflect on what they have figured out in the unit, such as to support summative assessment opportunities. My Growing Ideas charts are provided as handouts in lessons where designers felt they would be most useful, and/or teachers can support students in creating a simple T-chart in their notebooks to record

the same ideas. Teachers can choose to use My Growing Ideas charts more or less often depending on the needs of their classroom. Since these charts provide personal thinking space, they are not intended to be scored or graded. However, teachers may choose to circulate in the classroom while students write and draw, and/or ask students to leave their notebooks open afterward to check in with their ideas and truly inform instruction for next time." (Elementary Teacher Handbook)

- Lesson 5, Synthesize, Step 5: "Reflect on how much progress we have made. Display slide I. Celebrate that we have figured out a lot about how land and things on it can change. Pass out one Self Reflection handout to each student. Point out that we made many changes to our model as we collected evidence. Suggest that we take some time to reflect on how we have let our ideas grow and change." (Lesson 5, Teacher Guide)
- Lesson 8, Explore, Step 3: "Display slide F and prompt students to find Part 2 on their Observing land change in our community handout. Remind students that they will be working in pairs to decide which mechanism caused one of the changes to land that they observed based on evidence. Give students time to work; if they have time to discuss more than one example of land changing, encourage them to add rows to their handout as needed for that." (Lesson 8, Teacher Guide)
- Lesson 9, Synthesize, Step 3: "Share with a partner. After about 10 minutes, bring students together and display slide N. Have students take turns explaining their model. Remind students of our agreement: We look, listen and respond to each other's ideas. Encourage students to use this time to practice this agreement. Tell students they will have 1 minute to present their model, and then their partner will take 1 minute to respond to the model. Explain that then students will switch roles, allowing the other person to share their model. Ask students to draw a checkmark on their models in the places where they had something similar to their partner." (Lesson 9, Teacher Guide)
- Lesson 13, Explore, Step 3: "Tell students that they will have 15 minutes to use the handout to clarify the exact problem at Seawall Road they want to address, brainstorm solution ideas, compare these ideas, and sketch a couple favorite ideas. Emphasize to students that in the brainstorming phase at the start of this activity, the goal is to think of as many ideas as possible and they should take some time to list multiple ideas. They should not worry whether these ideas are all good or even possible, because they will have a chance to think about which ones make the most sense after brainstorming is done." (Lesson 13, Teacher Guide)

Students receive feedback and revise their thinking accordingly.

- Lesson 3, Synthesize, Step 6: "Small and large group discussions and Wave Bin Observations provide an opportunity to gather evidence about Learning Goal 3, with the purpose of providing feedback and supporting students in using evidence to begin explaining how the depth of the water waves are made in affects the way that waves can move things. Use the following suggestions to provide feedback and determine next steps before moving on to the Navigate." (Lesson 3, Teacher Guide)
- Lesson 4, Lesson Assessment Guidance, "Use the information you gather in three ways: (1) to guide follow-up questions during the discussion in the Synthesize, (2) to identify a need to return to the activity for more careful observation of cause and effect relationships, or (3) to identify a need to return more explicitly to the anchoring phenomenon so that students are better prepared to use the investigation as evidence. If you notice that students need additional support identifying cause and effect relationships, redo the Wind Investigation, asking students, "What is the cause in this situation?" Then, after re-testing, "What was the effect?" If students do not make connections between the activity and storms, you may also need to discuss again what parts of a storm water and fan represent" (Lesson 4, Teacher Guide)
- Lesson 4, Navigate, Step 7: "Close the lesson by asking students to turn in Wind Investigation Reflections handout and tell students you are looking forward to sharing feedback with them. Provide written feedback on the student

handout and use the Lesson 4 Instructional Guidance to determine the next steps before the summative assessment in the next lesson." (Lesson 4, Teacher Guide)

- Lesson 5, Lesson Assessment Guidance: " Opportunities to revise their models will provide students with additional support in making progress on using models to explain the patterns and motions of ocean waves." (Lesson 5, Teacher Guide)
- Lesson 6, Explore, Step 5: "Distribute the Case Site Feedback handout to each pair and tell them which other pair they will share their chart with. Give the remainder of the activity time for pairs to share. Make sure each pair has an opportunity to both receive and give feedback." (Lesson 6, Teacher Guide)
- Lesson 9, Navigate, Step 9: "Collect students' models to explain how an island can form. Ask students to turn in their Updated Model handouts. Tell them you are excited to see all the ways they represent their thinking. Consider providing written feedback or set up mini conferences with students before moving on to Lesson 10. See the assessment guidance and assessment callouts in the lesson for suggestions on what to look for in student models." (Lesson 9, Teacher Guide)
- Lesson 11, Synthesize, Step 5: "Formative assessment: Predicting where a volcanic eruption could occur provides an opportunity to gather evidence about Learning Goal 11, with the purpose of providing feedback and supporting students in analyzing and interpreting data presented in maps in order to identify patterns in the locations of volcanoes. Students will have an additional opportunity to develop the elements in this learning goal in Lesson 12. Use the following suggestions to provide feedback and determine next steps before moving on to Lesson 12. As students are working in pairs to identify the patterns in the data on the maps, circulate the room and ask students questions like, What patterns do you notice in the locations of volcanoes in Area 1? What about Area 2? Do you notice differences in these patterns? What could that mean about the likelihood of a volcanic eruption? Can you point to the data on the map that supports your choice? Why are patterns in the locations of the volcanoes helpful in predicting where volcanic eruptions might take place?" (Lesson 11, Teacher Guide)
- Lesson 12, Navigate, Step 5: "Collect student handouts and tell students you look forward to sharing feedback with them. Provide written feedback on the handout and/or conference with students to support them as they move on to future lessons." (Lesson 12, Teacher Guide)

Criterion-Based Suggestions for Improvement

- Ensure that "[s]tudent artifacts include elaborations, reasoning, and reflection and show how students' reflective thinking has changed over time. Descriptions of student thinking may be written, oral, pictorial, kinesthetic, or models." [Detailed Guidance, p. 23]
    - Consider how students' individual models can be revised to ensure that all students have the opportunity to show how their thinking has changed over time.

II.C Building Progressions

EXTENSIVE

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.

The reviewers found **extensive** evidence that the materials identify and build upon students' prior learning in all three dimensions. This is because the learning students are expected to have prior to entering this unit, for all three dimensions, is identified in both the teacher overview and within specific lessons, where applicable. The materials do explicitly identify prior learning expected for all three dimensions, but not at the element level. The support for teachers clearly explains how prior learning will be built upon by highlighting specific past units that students have experienced. The materials provide explicit support to teachers in clarifying their understanding of potential alternate conceptions that they or their students may hold during the unit.

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

The Unit Front Matter describes prior student learning for all three dimensions.

Disciplinary Core Ideas:

- **Earth's changing surface:** "Students will bring various understandings to class about how the Earth's surfaces change. Some may believe that the world has always looked the way it does now, that rocks don't change, and that if the Earth's surface does change, it happens quickly. Students who have experienced Unit 2.1: How do wind and water change the shape of land and what can we do about it? will have built some ideas already about changes to Earth's surface, and they will deepen those understandings in this unit. Students will make observations and gather evidence in this unit that the Earth's surface is constantly changing, very slowly and occasionally somewhat more quickly, and the changes that happen have patterns we can use to identify their causes."
- **Volcanoes and mountains:** "Students may think that all mountains are caused by volcanic activity. In this unit, students will explore the patterns of Earth's features, including the locations of volcanoes and mountain ranges. They will figure out that while some mountains and mountain chains are indeed formed by volcanoes, not all mountains are. (This unit will not support students in figuring out ideas about plate tectonics or the collisions of plates that have formed most mountain ranges; they will build those ideas in middle school. See the About the Science section for more information.) Regarding volcanoes, students may have ideas such as that volcanoes build mountains rapidly, that volcanoes are located randomly around Earth's surface, that they are only found on land, that they always erupt violently, or that they erupt because they get too hot. In this unit, students will explore the patterns of where volcanoes are located on Earth, and observe the visible effects of lava as it can change land, but they will not investigate why they are where they are or how they happen. If students raise questions about the causes of volcanic activity, or why some volcanoes occur outside the "Ring of Fire" pattern, consider inviting them to do additional research as an extension of what they figure out in this unit."
- **Earthquakes:** "Students' understandings of what earthquakes are and how they happen will vary widely, especially if students have or have not lived in earthquake-prone locations. Students may think that earthquakes cause volcanoes or vice versa, or that earthquakes and volcanoes only happen near each other. Students will likely not yet have understandings around how or why earthquakes occur, and that is not something they will investigate in this unit.

You can help students make sense of ideas about earthquakes in this unit by focusing them on the physical changes earthquakes can cause, and using maps to figure out where earthquakes are likely to occur."

- **Using fossils as evidence of land changing over time:** "Students will bring various understandings to class about fossils. Students who have experienced Unit 3.3: Why do animals look and act the way that they do? will have built some ideas already about using fossils as evidence of the types of organisms that lived long ago and the nature of their environments. Students will build on those ideas in this unit when they read about how fossils also provide evidence of changes to a landscape over time. Be aware that communities around the world have important norms, cultural traditions, and beliefs about digging and removing cultural artifacts such as fossils. Additional guidance is provided in the Lessons 6 and 7 teacher guides."
- **Solutions for problems involving land changing:** "Students will bring many varied experiences to solving engineering problems; in OpenSciEd, two units per grade level involve students in engineering design. If students experienced Unit 2.1: How do wind and water change the shape of land and what can we do about it?, they will have some specific connections to make. In that unit, students engineer solutions to prevent land from moving in their communities. Students will explore and test some similar solutions in this unit but for the problem of waves moving rocks near/onto a road."
- The information in the front matter is general and does not reference specific elements of the DCIs.

Science and Engineering Practices:

- **Developing and Using Models:** In previous grades, students have worked to identify the difference between a model and the real thing as well as developed simple models to represent tools, amounts, and/or relationships. In this unit, students begin to develop more complex models that can be used to explain or predict phenomena. In several lessons, students develop initial models to explain the observed changes to land, then they collect evidence and return to refine their models based on evidence. As students work to develop an understanding of waves they begin to develop models that can be abstract or constructed around an analogy, like using a parachute or bedsheet to represent ocean water.
- **Analyzing and Interpreting Data:** As students collect data in grades K-2, they focus on recording observations, using pictures or drawings of observations, and using those observations to answer questions or solve problems. In this 4th-grade unit, students analyze and interpret data using reasoning that is logic-based. For example, in several lessons, students use logical reasoning as they look for patterns on maps to make predictions as to where natural hazards could occur.
- **Constructing Explanations and Designing Solutions:** Before grade 4, students have been working to develop explanations of phenomena based on observation, used materials to build a device that solves a problem, and generated and/or compared multiple solutions to a problem. In several lessons in this unit students work to identify the evidence that supports an explanation, like using rock layers or fossils to explain how a landscape may have changed over time. Students also compare solutions to problems in a more complex way as they consider how a solution meets a set of criteria and constraints.
- The information in the front matter is general and does not reference specific elements of the SEPs.

Crosscutting Concepts:

- **Patterns:** From prior grades, students have developed ideas about observable patterns that can be used to describe phenomena, used to identify cause-and-effect relationships, and be used as evidence to support explanations of phenomena. In this unit, students build on their foundational understanding of patterns to sort and classify

phenomena (causes and mechanisms for how land changes), analyze simple rates regarding land changing, and continue to use more complex patterns as evidence to support explanations.

- **Cause and effect:** Throughout K-2 and grade 3, students have developed ideas about cause-and-effect relationships arising from observable patterns. In this unit, students leverage these experiences with using a cause-and-effect lens to consider causes (natural Earth processes), and what the effects are (changes to Earth's landscape and things on it). In most lessons of this unit, students identify cause and effect relationships, test them, and use them to explain changes to land. While this unit does not establish all the causes related to land changing (e.g., tectonic plate movement, climate change), students are building foundational ideas that will be elaborated on in middle school.
- The information in the front matter is general and does not reference specific elements of the CCCs.

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

- Alignment With The Three Dimensions Of NGSS: "The following three tables explain how students engage in Science and Engineering Practices, use Crosscutting Concepts, and figure out Disciplinary Core Ideas in this unit's lessons. The codes used to identify each dimension's elements are described in the Teacher Handbook." This document explains at the element level "How Students Engage in this Practice". (Alignment with the Three Dimensions of NGSS)
- Lesson 1, Lesson Assessment Guidance, "This is a pre-assessment. This is not an opportunity to take a grade or score. Instead, use this information to uncover students' initial ideas about sudden events and gradual processes that can cause land to change. Encourage students to share related experiences, examples from their lives, prior learning from Unit 3.2: Why do plants only grow well in certain places, and how can we protect them?" (Lesson 1, Teacher Guide)
- Lesson 3, Navigate, Step 1, Teacher Tip Sidebar, "Connect back to students' work with planning and carrying out fair tests in Unit 4.1: Why does an object's motion change? to help them understand why we should investigate only one change at a time." (Lesson 3, Teacher Guide)
- Lesson 4, Navigate, Step 7: "Discuss what we can and cannot explain as a class. Display slide N. Ask, Which of these pictures can we explain? What do we know about how and why they happened? Listen and look for these ideas: We can explain pictures C and D (Students may also say they can explain picture B because of prior work in Unit 3.2: Why do plants only grow well in certain places, and how can we protect them?)." (Lesson 4, Teacher Guide)
- Lesson 7, Navigate, Step 1, 'Teaching Tip Sidebar, "If students engaged in Unit 4.1: Why does an object's motion change? they should be familiar with the idea of variables. If students haven't yet done that unit, consider defining the concept of a variable in the moment as "one part of what we're investigating" (Lesson 7, Teacher Guide)
- Lesson 10, Explore, Step 3, Teacher Tip Sidebar, "Students who experienced Unit 2.4: How can plants grow in different places? will have many connections to make during this discussion. Encourage a brief review from that unit of how seeds could be spread to a place like a lava flow to start growing. Then steer the discussion to the question we are investigating in this lesson: What is happening with the land/lava/rocks that allows plants to be able to grow there at all?" (Lesson 10, Teacher Guide)
- Lesson 13, Explore, Step 3, Teaching Tip Sidebar, "If students have already engaged with Unit 4.2: How do we power clocks and other devices? these terms will be familiar to them (and may still be posted on your Word Wall) from that unit. If not, take more time here and in the next component to support students in developing their understandings of criteria and constraints; these terms were introduced in third grade units and even before that, students had worked with these ideas before naming them as such. Use everyday examples (for example, criteria and constraints around a pencil design) to support students' understanding." (Lesson 13, Teacher Guide)

- Lesson 14, Connect, Step 2, Teaching Tip Sidebar, "If students experienced Unit 3.2: Why do plants only grow well in certain places, and how can we protect them? in third grade, they might make connections between the solutions students in the Natural Processes in Our Communities book propose and the solutions they tested in that unit to prevent wind from damaging fruit trees. If so, encourage students to compare and contrast the criteria and constraints they recall for those solutions with the ones students in the book are using." (Lesson 14, Teacher Guide)

Explicit support is provided to teachers to clarify their understanding of potential alternate conceptions that they or their students may hold while building toward students' three-dimensional learning.

- Unit Overview, "Regarding volcanoes, students may have ideas such as that volcanoes build mountains rapidly, that volcanoes are located randomly around Earth's surface, that they are only found on land, that they always erupt violently, or that they erupt because they get too hot. In this unit, students will explore the patterns of where volcanoes are located on Earth, and observe the visible effects of lava as it can change land, but they will not investigate why they are where they are or how they happen. If students raise questions about the causes of volcanic activity, or why some volcanoes occur outside the "Ring of Fire" pattern, consider inviting them to do additional research as an extension of what they figure out in this unit." (4.3 Lesson Unit Overview)
- Unit Overview: "Students will bring various understandings to class about how the Earth's surfaces change. Some may believe that the world has always looked the way it does now, that rocks don't change, and that if the Earth's surface does change, it happens quickly." (4.3 Lesson Unit Overview)
- Unit Overview: "Students may think that earthquakes cause volcanoes or vice versa, or that earthquakes and volcanoes only happen near each other. Students will likely not yet have understandings around how or why earthquakes occur, and that is not something they will investigate in this unit. You can help students make sense of ideas about earthquakes in this unit by focusing them on the physical changes earthquakes can cause, and using maps to figure out where earthquakes are likely to occur." (4.3 Lesson Unit Overview)

Criterion-Based Suggestions for Improvement

- Ensure that "[t]he materials explicitly state the expected level of prior proficiency students should have with individual elements of all three dimensions for the core learning in the materials." [Detailed Guidance, p. 24]
    - Consider identifying prior learning at the element level across the unit whenever prior learning is addressed.

II.D. Scientific Accuracy

EXTENSIVE

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

The reviewers found **extensive** evidence that students use scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support their three-dimensional learning. Almost all student-facing materials feature precise, grade-appropriate wording to help students scaffold their understanding of concepts in all three dimensions, thereby minimizing the likelihood of misconceptions. Science ideas and representations are accurate. Students are encouraged to express their scientific ideas in light of new evidence.

The unit features an "About the Science" document designed to enhance teacher understanding. This document outlines the essential science ideas students will encounter in each lesson. It also includes a section titled "What are the boundaries of science ideas in this unit?", which clarifies science concepts that are above grade level or outside the unit's learning objectives. Additionally, the "What are recommended adult-level learning resources for the science concepts in this unit?" section provides background information and resources for teachers on the key scientific topics.

- Example of the science ideas that students will figure out: "This unit focuses on developing the foundational science idea that Earth's landscape changes over time. Students figure out that land changes over time (at different rates, usually very slowly) because of natural processes such as volcanoes, earthquakes, and weathering and erosion (from water, ice, wind, and living organisms). These processes and hazards do not cause changes consistently in all regions, so students also spend time in this unit using maps to identify patterns in where they are more likely to occur, related to Earth's land and water features. Along coasts, waves cause significant weathering and erosion, so students investigate wave patterns and the motion of waves. As land changes happen, rock formations and fossils provide evidence of those changes. Students also investigate how these Earth processes affect humans when land or things on it are changed. Students use their understandings to design, test, and evaluate solutions to prevent (but not stop) damage from weathering and erosion." (4.3, About the Science)
- Example of the boundaries of the science ideas: "Earth as a system. In this unit, students will begin to identify patterns of changes to land and name some of the mechanisms that cause those changes (eg, weathering and erosion), but not until later grades will students name the Earth as a system and explain how the interactions between the components of the Earth system are causing the changes to the landscape. Rock types. Students will identify hardened lava as rock, and they will explore how materials piling up over long periods of time can form rocks containing fossils, but they do not name igneous or sedimentary rocks. Tectonic plate movement. Students will begin to identify earthquakes and volcanoes as causes of changes to land and things on it, and they will notice patterns in the locations of some of Earth's features (e.g. volcanoes, mountain ranges, ocean trenches), but they will not explain why, how, or where these things happen related to tectonic plate movement. They will explore these ideas beginning in middle school." (4.3, About the Science)
- Example of adult-level learning resources: "National Research Council. (2012). A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. Download for free: https://nap.nationalacademies.org/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts
  - Read about PS4.A on pages ____
  - Read about ESS1, ESS2, and ESS3 on pages ____
  - Read about ETS1.B on pages ____

- Lesson 2, Explore, Step 2: "Prepare to look at data from natural hazards. Display slide E and tell students that you have a collection of natural hazards data cards that includes the possible causes students suggested and some additional ones that students might find interesting. Point out the example card on the slide (consider reading the information aloud and describing the photos). Ask how the data on that card could help us figure out what happened in Acadia. Establish that students will need to analyze the data from the new cards to see what kinds of data points are associated with the natural hazard on the card. Then we can match what we find out with the data points from Acadia when the land changed and the road broke to figure out what caused those things." (Lesson 2, Teacher Guide)
- Lesson 3, Explore, Step 2: "Watch videos of floating objects in deep water waves. Display slide E and play the videos, also linked here: Fishing Bobber Floating on Water and Seagull Floating on Water. Ask students to turn and tell a partner what they noticed about the floating objects and then share out as a class." (Lesson 3, Teacher Guide) Students engage in a discussion where they share observations that the floating object moves up and down, but the waves did not push them forward. (Lesson 3, Teacher Guide).
- Lesson 6, Explore, Step 2: "Explain that students can take turns cutting into bits of the softer rock (clay) tiny pieces at a time while their group-mates are looking away, to see if their group-mates notice the change when they look back. How much "rock" would they need to cut away in a "year" (one turn) for people to notice?" (Lesson 6, Teacher Guide) While the use of blocks and modeling clay is a developmentally appropriate way for students to explore weathering, referring to modeling clay as 'softer rock' may unintentionally lead to misconceptions because 'clay' is a term used to describe soil particle size and certain types of Earth material.
- Lesson 9, Synthesize, Step 8, "Consider what else scientists can learn from rock layers. Display slide X and have students Think, Pair, Share about the two prompts on the slide, which are similar to the ones they considered with their reading partner on the Volcanoes and the Island of Hawaii. Which layer of lava would have been the oldest in the image? Which layer of lava is probably the most recent? Bring students together after a few minutes of sharing with a partner, and use the prompts below to add additional ideas to the model." (Lesson 9, Teacher Guide) Students share that the bottom rock layers are older than the top ones.
- Lesson 11, Explore, Step 4: "Explain that there are so many seamounts in the ocean, and this map only shows the large ones. If we looked at a map with the seamounts, volcanic islands, and trenches, there would be so much to analyze at once. Display slide M and tell students that we have a map that shows the locations of volcanic islands and ocean trenches that we can analyze more easily for patterns." "Describe patterns in the locations of mountain ranges and volcanoes. Display slide S and tell students that we have a map that shows the locations of major mountain ranges and volcanoes around the world." (Lesson 11, Teacher Guide)
- Lesson 12, Explore, Step 2: Students examine maps to find the locations of earthquakes. Question: "Where do earthquakes occur compared to other land or ocean features?" Ideas to look for: "Sometimes they are in or near mountains. They are often at the edges of continents, especially along the Pacific Ocean." (Lesson 12, Teacher Guide)

Criterion-Based Suggestions for Improvement

- Ensure that "[s]tudent-facing materials have precise, grade-appropriate wording." [Detailed Guidance, p. 26]
  - In Lesson 6, instead of referring to the representation of "softer rock" as "clay," consider using more precise language such as "modeling clay" or "playdough" to avoid confusion with the actual Earth material.

II.E. Differentiated Instruction

EXTENSIVE

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.

These pieces of evidence support the **extensive** rating because the materials provide multiple and varied individualized learning strategies that support three-dimensional sensemaking throughout a majority of the materials. Differentiation strategies explicitly clarify how they address the needs of multilingual students, learners with special needs, learners who read well below grade level, and struggling students. Supportive ways to access instruction include engaging and valuing students' diverse identities, cultures, experiences, and communities; centering students' language resources and practices; dismantling barriers to participation; and building and sustaining inclusive, collaborative norms and routines. Extensions are provided for students with a high interest in the subject matter and who are ready to develop a deeper understanding in any of the three dimensions. However, it is not always apparent how these extension activities will support students in developing a deeper understanding of the three dimensions.

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

- K-5 Draft Elementary Teacher Handbook, Building an Equitable Classroom Community for Science, "The OpenSciEd Elementary program aims to create equitable science instruction for all students, centering students' resources, interests, and identities in the classroom community's sensemaking work. In particular, there are five principles that guide our equity design stance. Though described separately, it is important to note that these principles are not mutually exclusive and often intersect in critical ways." The five principles are:
  - Principle 1 - Engage and value students' diverse identities, cultures, experiences, and communities.
  - Principle 2 - Center students' language resources and practices.
  - Principle 3 - Dismantle barriers to participation.
  - Principle 4 - Build and sustain inclusive, collaborative norms and routines.
  - Principle 5 - Use science to figure out and better understand meaningful phenomena, and to solve meaningful problems. (K-5 Draft Elementary Teacher Handbook)
- K-5 Draft Elementary Teacher Handbook, "Broadening Access callouts focus on moments during instruction in which a certain population may benefit from a particular strategy--for example, supporting language development for emergent multilingual learners, providing extended learning opportunities or readings for students with high interest, providing specific strategies for students with special learning needs." (K-5 Draft Elementary Teacher Handbook)

- K-5 Draft Elementary Teacher Handbook, "OpenSciEd units provide multiple means for students to access information; lessons incorporate models, data tables, texts, graphs, videos, and discussions. The units and lessons are carefully designed so that all materials incorporate accessibility features (e.g., alternative text, alternative representations, video captions, described videos, descriptive transcripts, color contrast) that foster the use of multiple access and entry points and appropriate representations that will accentuate the assets and mitigate the barriers of diverse learners as they work toward a rich understanding of science." K-5 Draft Elementary Teacher Handbook)
- 4.3 Earth Processes Unit Front Matter "Importantly, we encourage you to follow the guidance of students' IEPs/504s and to seek out assistance from members of your school team who specialize in different aspects of equitable and accessible learning, such as your special education team members, multilingual education staff, assistive and/or district technology specialists, reading and math specialists, and any other education team member who can get to know your students, your classrooms, and your unique needs from unit to unit. It is critical that any differentiation and/or accommodations made do not lessen or take away from the sensemaking work that students engage in throughout this unit." (4.3, Unit Front Matter)

Differentiation strategies address the needs of students when an obvious need arises:

Emerging multilingual students learning English:

- Lesson 1, Explore, Step 2 Sidebar: "The Notice and Wonder chart should capture not only students' ideas, but also the rich ways that students express their ideas. This is especially important for multilingual students because their language resources and practices are not always noticed or valued in school spaces. If a student shares an idea using words or phrases in a named language other than English (e.g., in Spanish, Arabic, Mandarin), record their idea exactly as they shared it and then add a translation in English next to it. If a student drew ideas on their handout, sketch those onto the chart, as well. If possible, have students record ideas onto the chart themselves." (Lesson 1, Teacher Guide)
- Lesson 4, Synthesize, Step 3: "If applicable, you might encourage multilingual students to add vocabulary words and kid-friendly definitions to the word wall across named languages (e.g., Spanish, Mandarin, Arabic) that they know and use if it would support their sensemaking throughout the unit." (Lesson 4, Teacher Guide)
- Lesson 5, Synthesize, Step 5 Sidebar: "When recording students' ideas on the consensus model, it is important that students have their ideas recorded in alignment with the ways they shared them (e.g., using their own words, home languages, capturing gestures they might have used, etc.). If possible invite students to write or draw on the consensus model. Doing so not only helps students understand what is recorded on the model, but also sends the message that their language resources and practices are valuable for the classroom community's sensemaking work. This is an important message for all students to receive, and especially for those whose language resources are not always valued in school spaces, such as multilingual students." (Lesson 5, Teacher Guide)
- Lesson 6, Explore, Step 5 Sidebar: "Intentionally group students to support English language use and development (sometimes with peers who know the same languages as them, and other times with peers whose English language development is slightly more advanced). Thoughtful grouping that varies throughout a unit allows multilingual students to benefit from working with different peers and learn from the uses of other students' linguistic resources." (Lesson 6, Teacher Guide)
- Lesson 7, Synthesize, Step 5 Sidebar: "Encourage students to share their thinking in a variety of ways, and validate all the ways we communicate our ideas, through linguistic (oral and written language) and nonlinguistic modes, such as gestures or body movements, pointing at the posters, drawings (if helpful), and words from any languages your students use. Making connections between written or spoken words and nonlinguistic representations helps

all learners, especially multilingual students generate richer understandings of scientific phenomena." (Lesson 7, Teacher Guide)

- Lesson 14, Navigate, Step 1 Sidebar: "During the engineering process in lessons 14 and 15, as students continue to plan, test, and compare their solutions, the work they are doing collaboratively relies on students to communicate thoughts about their 3D design often in a 2D format by writing and drawing. As you see students using gestures or objects to express their thinking, recognize and encourage that multimodal communication." (Lesson 14, Teacher Guide)
- Lesson 15, Explore, Step 3 Sidebar: "As groups test their designs, many of the results will be descriptive and qualitative. These types of results lend themselves well to multimodal communication as students make observations. Note and validate the range of ways students express their observations, including spoken and written words, gestures, pointing, facial expressions, drawings or symbols, or using objects to reenact what happened. Mirroring these as students use them can validate a range of forms of communication." (Lesson 15, Teacher Guide)

Learners with special needs (visual impairments, tactile engagement, etc.)

- Lesson 4, Explore, Step 5: "As students share observations, encourage them to use gestures or even quick drawings on the board to share what they observed. Encourage students to indicate the amplitude and wavelength of waves for additional practice with those terms." (Lesson 4, Teacher Guide)
- Lesson 7, Explore, Step 3: "Broadening Access If any students in your class have mobility or vision impairments consider structuring the gallery tour differently. For example, consider taking photos of the posters so students may make sense of them on an electronic device or a print out copy. Digital photo copies can allow students to zoom into pictures or text, and if possible, include screen reader-friendly text. Additionally, students can record audio descriptions of their posters for the student(s) to listen using headphones during the gallery tour. Furthermore, you can pair students with a peer who can describe each poster verbally in a clear and detailed way, with attention to any visuals, or consider having all students take turns explaining their poster out loud, which benefits all learners and also ensures auditory access. (Lesson 7, Teacher Guide)
- Lesson 11, Explore, Step 4, Broadening Access Sidebar, "Before beginning the movement-based discussion, offer all students multiple means to participate. For students with mobility limitations or for whom moving across the room may be challenging, provide alternative options such as pointing to a choice card, using a hand signal, or stating their opinion aloud. You can also use desk markers or visual indicators (e.g., colored cards or labeled objects) so students can show their thinking from where they are seated. Emphasize that everyone's ideas are important, and there are many valid ways to share them." (Lesson 11, Teacher Guide)

Learners reading below grade level

- Lesson 1, Explore, Step 2: "Maps are a visual type of text that students can engage with in science time to support their sensemaking. Remind students that engaging with texts, like maps, can help readers understand more about where places and things (features) are on Earth. Encourage students to notice and explain the labels, colors and icons on the map of the US and Maine to make sense of where this place is in the world (RI.4.7)." (Lesson 1, Teacher Guide)
- Lesson 2, Explore, Step 3, Literacy Supports Sidebar, "As students investigate the data cards, prompt students to notice and explain visual components (e.g., photographs, maps) alongside the words in the text. Interpreting information presented visually supports RI.4.7. Considering strategies for interpreting written and visual components of text further supports this standard." (Lesson 2, Teacher Guide)

- Lesson 5, Synthesize, Step 7, Literacy Supports Sidebar, "As students complete this assessment, they will be using precise language and domain-specific vocabulary to explain what happened to the Tay (W.4.2D). You can direct them to the word wall to encourage them to use some of these words (e.g., wave, amplitude) to explain the events leading to the shipwreck." (Lesson 5, Teacher Guide)
- Lesson 7, Connect, Step 6: "Read an Article" Literacy Supports Encourage students to paraphrase what they read after reading each paragraph of the article with a partner. This supports SL.4.2, ensures that students comprehend the text, and helps students integrate information from the article into their developing understanding of the different ways that land can change.
- Lesson 10, Explore, Step 3, Literacy Supports Sidebar, "Support students as they use the cards to annotate the photos and find key details (i.e., evidence that plant roots can break rocks). Learners might already be familiar with strategies for annotating text. Encourage students to use their existing annotation strategies (e.g., circling, underlining, highlighting, jotting notes in the margins) to point out important information on the photographs. This work supports RI.4.7 as students interpret visual information via annotation." (Lesson 10, Teacher Guide)
- Lesson 11, Explore, Step 4 Sidebar: "Before beginning the movement-based discussion, offer all students multiple means to participate. For students with mobility limitations or for whom moving across the room may be challenging, provide alternative options such as pointing to a choice card, using a hand signal, or stating their opinion aloud. You can also use desk markers or visual indicators (e.g., colored cards or labeled objects) so students can show their thinking from where they are seated. Emphasize that everyone's ideas are important, and there are many valid ways to share them." (Lesson 11, Teacher Guide)

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

- Lesson 2, Lesson Assessment Guidance, "If students need more support in recognizing the similarities and differences in the patterns that occur due to various natural hazards, consider working with small groups or individual students after the group Synthesize. Gather a set of natural hazard data cards and the conditions in Acadia data and go through each condition asking students to point to the data on their card that describes that condition. Ask students if the condition that happens during the natural hazard is similar or different than those of Acadia the day the storm broke. Continue this process until students determine the natural hazard that has the most similarities with the conditions in Acadia." (Lesson 2, Teacher Guide)
- Lesson 5, Lesson Assessment Guidance, "If you notice students need more support in using observations to describe how waves can break and change, you might: Use repeated words, sketches, and/or gestures to help students focus on how waves: Move rocks near the beach., Do not move the rocks far away from the beach, or need to be large in order to remove the rocks from under the road." (Lesson 5, Teacher Guide)
- Lesson 6, Lesson Assessment Guidance, "If students do not yet seem to understand the mechanisms, you may discuss them further with the class or have each pair pick out the one that makes the least sense to them and discuss it with another pair. If they struggle to make observations or identify patterns in them, use sentence starters such as "I notice..." and "___ could be connected to ___ because...". Finally, if students are confident in their explanations, be prepared to seed some uncertainty around whether we have experimental evidence that the patterns students identified connect to the physical features. If they are less confident, you may leverage this uncertainty to motivate the investigations in Lesson 7." (Lesson 6, Teacher Guide)
- Lesson 7, Lesson Assessment Guidance, "If you notice students need more support in describing the rates of the changes they observed in the form of words, drawings, written or spoken descriptions, movement, and/or gestures, you might: Use repeated words, sketches, and/or gestures to help students focus on how long each mechanism might have

taken to make the changes, Invite students to return to their models. Use repeated words, sketches, and/or gestures to help them develop their ideas around how long the changes to the land took., In Lesson 10, when students are considering how long it may take for plant growth in Hawaii to return after a volcanic eruption, consider going back to the Timescale of Land Changes We Observe chart and discussing where plants regrowing may fall on that timeline."

- Lesson 11, Lesson Assessment Guidance, "If students need more support in identifying patterns in ocean and land features you may consider analyzing and interpreting the data on maps of areas students are more familiar with in small groups or individually. Making sense of areas that have personal context to students may help them make the connections between what the maps are representing. Students will also have additional opportunities to analyze and interpret data on maps in order to identify patterns in land features in Lesson 12." (Lesson 11, Teacher Guide)
- Lesson 14, Lesson Assessment Guidance, "If students are unable to give examples of how communication with peers or criteria and constraints led to an improved design, this may be because they didn't: recognize the impact classmates had on the revisions they made to their design, use ideas from peers to make revisions to their design, or have a solid understanding about how to apply weathering and erosion mitigation strategies. A conversation with those students will give them an opportunity to develop a deeper understanding prior to their final opportunity to demonstrate their understanding. Students can look at revisions their group made on Develop a Design Solution for evidence of communication with peers improving their design. They can look at Comparing Design Solutions or Develop a Design Solution for evidence on how the criteria and constraints informed their design solution." (Lesson 14, Teacher Guide)

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.

- Lesson 2, Explore, Step 2, Community Connections Sidebar, "Extension Opportunity: To build stronger connections to your community, and after ensuring any trauma-related concerns or stories students share have been addressed and resolved, consider taking time for students to use the hazard cards to first identify which hazards their community might experience or that they have had prior experience with, and second, encourage students to focus on learning about organizations or current efforts that support these communities negatively impacted by natural hazards. Students will have an opportunity to build more on these ideas in Lessons 12-15." (Lesson 2, Teacher Guide)
- Lesson 6, Explore, Step 2, Teaching Tip Sidebar, "Students may raise questions about what happens to the material that is broken off and carried away. Record these questions and ideas and consider using the extension around this process, called deposition, in Lesson 7." While teachers are encouraged to use students' questions and ideas as an extension in the next lesson, no extension is included in Lesson 7.
- Lesson 9, Explore, Step 2, Teaching Tip Sidebar "As students share initial ideas about volcanoes, be aware of some common ideas they may have: students might think that volcanoes build mountains rapidly, that they always erupt violently, or that they erupt because they get too hot. In this unit, students will observe the visible effects of lava as it can change land, but they will not investigate how volcanoes happen. If students raise questions about the causes of volcanic activity, consider inviting them to do additional research as an extension of what they figure out in this unit." (Lesson 9, Teacher Guide) It is not explicit how this research will support students in developing a deeper understanding in any of the three dimensions.
- Lesson 11, Explore, Step 4, Teaching Tip Sidebar, "Note that students might think that volcanoes are located randomly around Earth's surface or that they are only found on land. In this lesson, students will explore the patterns of where volcanoes are located on Earth, but they will not investigate why they are where they are. If students raise questions about why some volcanoes occur outside the "Ring of Fire" pattern, consider inviting them to do additional research as an extension of what they figure out in this unit." (Lesson 11, Teacher Guide) It is not explicit how this research will support students in developing a deeper understanding in any of the three dimensions.

Criterion-Based Suggestions for Improvement

- Ensure that the materials include supports for "[s]tudents who have already met the performance expectation(s) or who have high interest in the subject matter and are ready to develop deeper understanding in any of the three dimensions." (Detailed Guidance, p. 28)
  - For example, in Lessons 9 and 11, students are invited to do additional research. Consider whether this extension can be more structured to include support for the teacher, ensuring that students develop a deeper understanding in at least one of the dimensions.

II.F. Teacher Support for Unit Coherence

EXTENSIVE

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.

The reviewers found **extensive** evidence of teacher support for unit coherence. The materials support teachers in facilitating coherent learning experiences over time by including specific lesson structures that the teacher becomes familiar with. Strategies for linking student engagement across lessons include a navigation component at the beginning and end of every lesson. Strategies for ensuring student sensemaking is linked to the three dimensions include sidebar callouts of specific dimensions to support instructors.

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.).

- Open SciEd Elementary Teacher Handbook (p. 17): Elementary Teacher Handbook, Navigate Component.
  - What is the instructional purpose of this component? The Navigate component directly supports coherence for students from lesson to lesson. This component generally happens at the beginning and end of each lesson and provides opportunities for the class to take stock of where they are in finding answers to their questions, remind themselves what they figured out last time, and decide where they want to go next. Often this navigation will come naturally from questions generated by students, but occasionally the teacher will "problematize" an idea or investigation result by asking a salient question or pushing the class to consider other situations or new directions.
  - What are the potential outcomes of this component? During the Navigate component, students ask questions, define problems, and make predictions. The class builds their sense of shared purpose, sees progress toward answering their questions, and takes ownership of their science work.

- Lesson 1, Navigate, Step 7: "Look back at: Your notice and wonder handout, Your initial model, Our consensus model" (Lesson 1 Slides, Slide V). Students use their handout, initial model, and consensus model to write questions that the teacher can refer back to throughout the unit.
- Lesson 2, Navigate, Step 1: "Consider where to go next. Display slide A. Display the Ideas for Investigation chart, Notice and Wondering chart, and the How Land and Things on it Change chart from Lesson 1 so that students can refer to these charts. Use these charts, the slide, and the prompts below to remind students about their ideas of what caused the damage in Acadia and to facilitate a discussion about what evidence we need to figure this out. Work together to reach consensus that we need evidence of what was happening in Acadia when the damage occurred. You may also establish a need for evidence of what happens during the types of events (on the Notice and Wonder chart) they think may have caused the damage, but students may first need to realize that the Acadia data alone doesn't provide all the information they need to explore." (Lesson 2, Teacher Guide)
- Lesson 2, Synthesize, Step 3: "Using the questions on slide J, work as a class to notice that there was no ground shaking nor any lava in Acadia that week and that this means the cause could not have been an earthquake or volcano. If students are struggling to make this connection, first refer them to their Acadia data cards and notice that there is some type of connection to all the data/mechanisms except for ground shaking and lava, for example. Then refer to the hazard cards to notice that earthquakes are associated with ground shaking and volcanoes are associated with lava...Summarize that since we can tell clearly that those two hazards were not the cause, we can set them aside for now. However, we did have several other possibilities based on the data from Acadia that week." (Lesson 2, Teacher Guide) Teachers ask the class questions about ground shaking and volcanoes. In Lesson 2, teachers are not cued or supported to see the future connection and the need for this line of questioning that will be used again in Lesson 8.
- Lesson 4, Navigate, Step 1: "Leverage uncertainty to point out that there is a lot we do not know about waves, including where they come from or how and why they are sometimes different from other times. Suggest that it might be helpful to use a model to clarify how we are talking about how waves can be different." (Lesson 4, Teacher Guide)
- Lesson 4, Navigate, Step 7: "Discuss what we can and cannot explain as a class. Display slide N. Ask, Which of these pictures can we explain? What do we know about how and why they happened? Listen and look for these ideas: We can explain pictures C and D (Students may also say they can explain picture B because of prior work in Unit 3.2: Why do plants only grow well in certain places, and how can we protect them?) C and D happened because: High winds caused waves in the ocean As these waves moved toward shore, they applied a force to push rocks upward and onto the road Then follow up by asking, Which pictures can't we explain? Listen for recognition that we do not know how waves or something else made the road get so cracked and break down. Rocks probably were not enough to do that. Suggest that this would be a good area for investigation in our next lesson." (Lesson 4, Teacher Guide)
- Lesson 5, Navigate, Step 8, "Re-visit the DQB. Display the Driving Question Board and give students a few minutes to remove questions that the class has made progress on. Invite students to read the question and then share what the class figured out about that question." (Lesson 5, Teacher Guide) Guidance is not provided to teachers on how to address questions that were not answered on the DQB.
- Lesson 5, Navigate, Step 8, "Transition to exploring other interesting places in Acadia. Explain that people come to Acadia National Park to see a variety of natural places, and there are several more areas of the park that we can explore to help us continue to answer our question about; "What Causes Land and Things on it to Change? Introduce Thunder Hole. Display slide M and share with students that you found an interesting phenomenon that people love to visit while in Acadia National Park." (Lesson 5, Teacher Guide) There is no guidance provided to teachers to bridge the changes in the land to the interesting places in Arcadia.

- Lesson 6, Navigate, Step 6, the teacher poses a question to the class about what they still need to figure out. "What are we still unsure about or need more evidence for?" (Lesson 6, Teacher Guide)
- Lesson 7, Navigate, Step 7: "Consider changes to land in our own community. Say something like, Wow! We have figured out about several different ways that land can change at National Parks and the different causes for those changes. Do you think the land in our own community changes in the same ways? Display slide N and ask students to consider what examples of changes to land and things on it there are in our community and what causes those changes. Encourage students to use the "How land and things on it change" chart to remind them of the mechanisms and examples of change that we have explored so far." (Lesson 7, Teacher Guide)

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

- K-5 Teacher Handbook, "The Importance of the Three Dimensions in a Storyline: Each OpenSciEd unit is anchored in a phenomenon or set of phenomena and strategically integrates the DCIs, SEPs, and CCCs to create a storyline path in which the students and teachers, as a learning community, work together to manage the trajectory of their knowledge-building. The class, as a whole, incrementally develops ideas over time that are motivated by questions about phenomena in the world, where each step is an attempt to address a question or a gap in the class's current explanatory model, while developing, using, and extending parts of the DCIs, SEPs, and CCCs as needed. The storyline approach supports students' agency in sensemaking: WE figure out the science ideas and WE put those ideas together over time." (K-5 Teacher Handbook, p11)
- Lesson 3, Explore, Step 2, Developing and Using Models Sidebar, "One important element of this practice is considering the limitations of a model. As students think through how to set up their wave bin models, emphasize that while our model was very different from the area of land near Seawall Road in the beginning of the lesson, we have ideas about things we can add to our model that will make it have fewer limitations." (Lesson 3, Teacher Guide)
- Lesson 3, Explore, Step 4, Teaching Tip Sidebar, "Students may want to add another material on top of the bricks to represent Seawall Road, but due to the limitations of a small model of a large system, adding another material also adds unnecessary complexities. Students will be able to make sense of the cause of the rocks moving forward onto the road; emphasize that we are able to see the rocks moving forward from the ocean and shore onto the bricks in our model and that gives us the evidence that we need to see the cause and effect relationship between waves near a shore and rocks moving forward." (Lesson 3, Teacher Guide)
- Lesson 3, Synthesize, Step 6: "[BH:1]Cause and Effect Support students in identifying that waves near a shore can cause rocks to move forward. Encourage them to explain that this cause and effect relationship is why the rocks on the shore in Acadia move onto the Seawall Road during the coastal storm. Students will get multiple opportunities to further develop this cross cutting concept in future lessons in this unit."
- Lesson 6, Connect, Step 4, Planning and Carrying Out Investigations Sidebar, "Students will have a more extended opportunity to engage with these infographics later, but throughout the lesson encourage observations from both the images and text. They will later use these observations as initial evidence for possible explanations of how land changed in these National Parks." (Lesson 6, Teacher Guide)
- Lesson 8, Navigate, Step 8: "Look for and discuss similarities. Ask students to reflect on all of the examples of land change that we have explored together. Display slide O and ask students to turn and talk with a partner about the similarities between all of the land changes that they notice. To ensure that students can meaningfully make sense of the similarities and differences between the examples of changes to land that we have explored together, take a photo of the "How Land and Things on it Change" chart and provide each pair of students with digital or print access to

the photo of the chart. Bring students together and invite them to share what their partner said." (Lesson 8, Teacher Guide)

- Lesson 9, Synthesize Step 7: Constructing Explanations and Designing Solutions During this part of the lesson, students will shift to identifying the evidence that they used to update their explanation of how an island like Hawai'i could form (change over time). Highlight that scientists continually look for evidence to support or revise their explanations for phenomena.
- Lesson 10, Synthesize, Step 4, Planning and Carrying Out Investigations Sidebar, "Students continue to engage in the work of this practice by making observations and using them to explain how Hawaii has so many plants even though it has many volcanic eruptions. In this lesson, they are working toward identifying the observations that serve as the evidence for their explanation." (Lesson 10, Teacher Guide)

Criterion-Based Suggestions for Improvement

- Ensure that "[g]uidance and support are provided for how to recognize what students figure out in a lesson, what questions are left unanswered, and what new questions could be answered in the next investigation." [Detailed Guidance, p. 30]
  - Consider adding a teacher tip in Lesson 2 to ensure that they do not skip the lava discussion, as it is referenced in Lesson 8.
  - In Lesson 5, consider providing teachers guidance on what to do with questions that were not answered on the DQB.
  - In Lesson 6, consider guiding teachers to bridge the changes in the land to the interesting places in Arcadia, like the thunder hole.

II.G. Scaffolded differentiation over time

EXTENSIVE

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.

The reviewers found **extensive** evidence that supports are provided to help students engage in the practices as needed and supports are gradually adjusted over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems for nearly all of the intentionally developed SEP elements.

MOD: Developing and Using Models

Claimed Element: MOD-E3: Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.Claimed in Lessons 4 and 5.

- Lesson 4, Explore, Step 2: "Remind students that we use models to explain something and review what we are trying to explain with this model: How can we describe different kinds or sizes of waves? Elicit ideas about what different parts of the model might show. Remind students of play parachutes that they may have seen before and point out that a bedsheet can be used similarly. Ask, If we are waving the bedsheet, what does the bedsheet represent from what we have been thinking about at Seawall Road? What does it mean if there is a wave in the bedsheet? Lead students toward general agreement that the bedsheet represents the surface of the water and a wave in the bedsheet represents a water wave." (Lesson 4, Teacher Guide)
- Lesson 5, Synthesize, Step 7, Student Assessment 1, "Use words, symbols, and/or drawings to explain how the pattern of motion of a boat on top of the water is different far from the shore and close to the shore" (Lesson 5, Student Assessment 1)
- Only one opportunity is provided for students to engage with this element before using it independently.

Claimed Element: **MOD-E4: Develop and/or use models to describe and/or predict phenomena.** Claimed in Lessons 1, 7, and 9.

- Lesson 1, Synthesize, Step 4: "Develop an initial model to explain the changes to land and road. Display slide P and arrange students into groups of 4. Pass out the Initial Model handout and a Factors that can change land handout to each group. Ask each student in the group to take one page from the Initial Model handout to work on individually. Explain that for each image, students should focus on explaining the changes to the land and/or road." (Lesson 1, Teacher Guide)
- Lesson 7, Explore, Step 2: "Provide time for small groups to investigate their mechanisms. Give students time to use their model to investigate their site." (Lesson 7, Teacher Guide) Students engage in a different part of the element in Lesson 7 as they are using a pre-developed model.
- Lesson 9, Synthesize, Step 3: "Develop a model to explain how an island can form. Pass out one Initial Model to each student. Display slide M. Encourage students to use words, symbols, and/or drawings to explain how an island can form in the ocean." (Lesson 9, Teacher Guide)

INV: Planning and Carrying Out Investigations

Claimed Element: **INV-E3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.** Claimed in Lessons 3, 4, 5, 6, 7, 8, 10.

- Lesson 3, Synthesize, Step 6: "In small groups, discuss what caused some gravel to move onto the road. Direct students to the bottom of Wave Bin Observations. Display slide N and ask them to recall what they observed the gravel doing in their wave bin when they made waves. Encourage them to use the observations they recorded during their investigation to support their thinking. Ask students to discuss why they think the gravel moved." (Lesson 3, Teacher Guide)
- Lesson 4, Explore, Step 5: "Carry out the investigation. Present slide H. Have students gather around the wave bin. Test the "wind" by turning on the fan, directing it across and in parallel to the surface of the water. Make sure to show a couple different "wind speeds" by adjusting the fan speed. Elicit students' observations. Repeat as needed so that all students are able to see what their peers noticed." (Lesson 4, Teacher Guide)
- Lesson 5, Explore, Step 4: "Carry out the investigation. Display slide F. Have students gather around the wave bin and carry out the investigation using the following procedure: Place the mix of pea gravel and aquarium on the bricks in a long pile like the road. Draw a reference line on the bricks to indicate where the gravel started. Invite a student

to come up and make waves. Allow students to make observations about what happens to the rocks. Invite other students to continue making waves until a large portion of the rocks have been removed from where they started." (Lesson 5, Teacher Guide)

- Lesson 6, Explore, Step 5: "Give time for exploration. Display slide Q and the Thunder Hole, Acadia National Park" chart from earlier in the lesson. Tell students they will have 12 minutes to examine the data for their site and complete their poster. Encourage students to leave room in each box to add more later on." (Lesson 6, Teacher Guide)
- Lesson 7, Explore, Step 3: "Add evidence to our National Park site posters. Display slide E Explain that now that we have gathered data from our investigations, we can use it as evidence to support our predictions about how mechanisms caused the changes to the land at our National Park site. Adding that evidence to our National Park site posters will support our explanations when we share them with the class." (Lesson 7, Teacher Guide)
- Lesson 8, Explore, Step 8, "Observe photographs and video of the Carbella Bridge and Yellowstone River. Display slide H and introduce students to the Carbella Bridge and the Yellowstone River in Gardiner Montana. Ask students what they notice about the Carbella Bridge and the Yellowstone River." (Lesson 8, Teacher Guide)
- Lesson 10, Explore, Step 3: "Observe photos of plant roots breaking things. Display slide O and explain that we have some photos of the roots of plants that we can observe. Pair students up and distribute the Plant Roots Breaking Things images. Ask students to observe the photos and look for evidence that plant roots can break rocks. Encourage students to circle and annotate areas of the photos that could be evidence of plant roots breaking rocks." (Lesson 10, Teacher Guide)

DATA: Analyzing and Interpreting Data

Claimed Element: **DATA-E2: Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.** Claimed in Lessons 2, 11, and 12.

- Lesson 2, Explore, Step 2: "Analyze data from Acadia. Use the prompts on the slide to guide students in working with a partner to read and annotate the data card. Give pairs about 6 minutes to complete this task. As they work, circulate around the room and help students navigate how to annotate the cards." (Lesson 2, Teacher Guide) Students work with a partner to read and annotate the data cards.
- Lesson 11, Synthesize, Step 5: "Explain to students that they will be working in pairs to analyze a map that includes volcanoes, volcanic islands, and mountain ranges. There are two locations on the map. Point out where the two locations are on the map on slide U. Ask students to work with their partner to determine which area would be more likely to experience a volcanic eruption and support their thinking with evidence from the maps." (Lesson 11, Teacher Guide) Students work in pairs to analyze the locations on the map.
- Lesson 12, Explore, Step 2: "Dig into the earthquakes map. Use these prompts to guide students through making sense of the earthquakes map alone and in conjunction with other layers." Students engage with the following question prompts: What patterns do you notice about where earthquakes occur? (If needed: Do earthquakes tend to cluster or be separate from one another?)" and "Where do earthquakes occur compared to other land or ocean features?" (Lesson 12, Teacher Guide) Students work in pairs and as a whole group.
- Lesson 12, Navigate, Step 5: "Administer an exit ticket. Display slide L. Distribute the Lesson 12 Exit Ticket and give students the remainder of class to complete it. Point out that questions 1-3 are opportunities for them to show what they've figured out, but prompt 4 is not about something we figured out yet. However, ideas students share about that will help us make progress next time on one of our unresolved questions from the lesson." (Lesson 12, Teacher Guide) Students individually analyze maps to predict whether a natural hazard will occur in a given area.

CEDS: Constructing Explanations and Designing Solutions

Claimed Element: **CEDS-E3: Identify the evidence that supports particular points in an explanation.**Claimed in Lessons 9 and 10. Evidence was found in 9 and 10, examples include

- Lesson 9, Synthesize, Step 7: "As students are sharing their models, circulate and use the following questions to probe students' thinking. What new ideas are you adding to your model? What evidence caused you to add that idea? What did you see with the wax or in the reading that made you think that? How does this compare to what you originally thought? What made you change your mind?" (Lesson 9, Teacher Guide)
- Lesson 10, Explore, Step 5: "Construct an explanation. Tell students that it sounds like we have figured out another form of evidence that can tell us about how the landscape of Hawaii has changed over time. Display slide X and ask students to explain how lava trees and tree molds tell us about what the landscape of different areas of Hawaii were like in the past on their Lava Trees handout." (Lesson 10, Teacher Guide)

Claimed Element: **CEDS-E5: Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.** Claimed in Lessons 13, 14, 15, and 16.

- Lesson 13, Explore, Step 3: "Display slide E and distribute Solution Brainstorming to each student. Have students pair up. Tell students that they will have 15 minutes to use the handout to clarify the exact problem at Seawall Road they want to address, brainstorm solution ideas, compare these ideas, and sketch a couple favorite ideas." (Lesson 13, Teacher Guide)
- Lesson 14, Explore, Step 3: "Compare solutions. Each person will have 1-2 minutes to share their design idea. After each person shares, the group should take about three minutes to discuss and capture how well that design attends to each criteria/constraint. They do not need to write complete sentences in each box, but the group can develop a system (i.e., symbols, ratings, bullet points, etc.) to capture their thoughts." (Lesson 14, Teacher Guide)
- Lesson 15, Explore, Step 3: "First groups test and compare designs. When the class feels comfortable with how they will test, display slide E. Point out that one group will test at a time while the other group observes and takes notes. Distribute a copy of Collaborator Group Notes to each student, and point out that the Collaborator Group will be looking at the design for both the small waves and big waves." (Lesson 15, Teacher Guide)
- Lesson 16, Synthesize, Step 4: "Compare solutions for the problem at Indiana Dunes. Display slide F. Help students to recall that wind was causing erosion in Indiana Dunes National Park in Michigan. Support students in remembering that the dunes were moving and eroding away. Suggest we use what we figured out from the book and the investigation results to consider solutions that could reduce the erosion of the dune." (Lesson 16, Teacher Guide)

Criterion-Based Suggestions for Improvement

- Ensure that "[s]caffolding is explicitly reduced over time for use of nearly all SEP elements stated as targeted learning objectives, supporting students to become more independent in their use of the SEP elements over the course of the learning experience." [Detailed Guidance, p. 33]
  - Consider how additional opportunities to engage with MOD-E3 can be provided to students, allowing scaffolds to be gradually removed and ensuring successful independent work.
  - Consider how students can develop the models used in Lesson 7 to ensure that they are using the same parts of the element across all three lessons.

CATEGORY III

Monitoring NGSS Student Progress

III.A. Monitoring 3D Student Performance

EXTENSIVE

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.

The reviewers found **extensive** evidence that materials elicit direct, observable evidence of three-dimensional learning and that students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions. Teachers are prompted to assess student performance using individual formative assessments in Lessons 4, 10, and 12, while they provide students with summative assessments in Lessons 5, 8, and 16. In assessments in lessons 7, 9, and 15, students create group artifacts that could serve as evidence of learning; however, the materials do not provide support for teachers to capture or document individual student understanding from these group products.

Formal tasks in the materials are driven by well-crafted phenomena- and problem-based scenarios that can elicit rich student performances.

The unit materials identify the formative assessments in Lessons 4, 10, and 12 as key assessments and identify three summative assessments in Lessons 5, 8, and 16. In Lesson 5, students are asked to explain the events of the Tay Shipwreck. In Lesson 8, students are asked to explain land changes near the Yellowstone River. In Lesson 16, students are asked to apply their understanding of the anchor phenomenon to explain the erosion of the Indiana Dunes.

- Lesson 4, Explore, Step 5: "Expand on observations. Have students return to their seats. Display slide I and distribute Wind Investigation Reflections. Give students 5-7 minutes to complete the handout." (Lesson 4, Teacher Guide)
- Lesson 5, Synthesize, Step 7: "Individually explain the events of the Tay Shipwreck. Display slide L. Pass out one copy of Explaining the Tay Shipwreck to each student. Point out that we have figured out a lot about waves and how they can change land and things on it. Suggest we use our science ideas to explain the events that led to the photo that we saw of the beach." (Lesson 5, Teacher Guide)
- Lesson 8, Synthesize, Step 7: "Individually determine the mechanism that caused changes to the Carbella Bridge. Display slide M and tell students that the Carbella Bridge experienced some changes the same day that the video of the river did. Explain that they are going to observe additional photographs of the Carbella Bridge before, during and after June 13th in order to determine what could have caused the changes." (Lesson 8, Teacher Guide)
- Lesson 10, Synthesize, Step 4: "Construct an explanation of how Hawaii has so many plants. Suggest that now that we have made many observations and gathered evidence about how so many plants can be living in Hawaii, we can construct an explanation that answers this question." (Lesson 10, Teacher Guide)
- Lesson 12, Navigate, Step 5: "Administer an exit ticket. Display slide L. Distribute Lesson 12 Exit Ticket and give students the remainder of class to complete it. Point out that questions 1-3 are opportunities for them to show what they've figured out, but prompt 4 is not about something we figured out yet. However, ideas students share about that will help us make progress next time on one of our unresolved questions from the lesson." (Lesson 12, Teacher Guide)
- Lesson 16, Synthesize, Step 4: "Distribute Indiana Dunes Erosion Solutions. Pass out one copy of Indiana Dunes Erosion Solutions to each student. Review the different parts of their assessment, and answer any clarifying questions. Point out the Our Engineering Process chart they can use as a resource. Give students about 25 minutes to complete the assessment." (Lesson 16, Teacher Guide)

Student performances produce artifacts of integrating the three dimensions in service of sense-making or problem-solving.

Several individual student artifacts are produced during the unit.

- Lesson 3, Explore, Step 6: "Use the observations that you recorded while observing the waves to help you answer the question: What caused the gravel in your wave bin to move forward?" (Lesson 3 slides, Slide N) **INV-E3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. PS4.A-E1: Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. CE-E1: Cause and effect relationships are routinely identified, tested, and used to explain change.**
- Lesson 4, Explore, Step 5, students complete a reflection of their investigation and answer the following questions: "What did you observe the water doing in the Wind Investigation? Describe the patterns of waves in terms of amplitude and wavelength. What do you think your observations tell us about how waves form?" (Lesson 4 Handout, Wind Investigation Reflections) **INV-E3: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. PS4.A-E2: Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). PAT-E1: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.**
- Lesson 10, Synthesize, Step 4: "Construct an explanation of how Hawaii has so many plants. Suggest that now that we have made many observations and gathered evidence about how so many plants can be living in Hawaii, we can construct an explanation that answers this question. Display slide R and distribute How has Hawaii changed over time? and organize students into pairs." (Lesson 10, Teacher Guide) **CEDS-E3: Identify the evidence that supports particular points in an explanation. ESS1.C-E1: Local, regional, and global patterns of rock formations reveal changes over time due to Earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. PAT-E3: Patterns can be used as evidence to support an explanation.**
- Lesson 11, Explore, Step 4: Display slide M and tell students that we have a map that shows the locations of volcanic islands and ocean trenches that we can analyze more easily for patterns. Organize students into pairs and distribute the map of ocean floor features, and ask students to analyze the map and notice where the ocean floor features are located on the map. Have them annotate the map to show the patterns in the ocean floor features they notice." (Lesson 11, Teacher Guide) **DATA-E2: Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. ESS2.B-E1: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features of Earth.PAT-E2: Patterns of change can be used to make predictions.**
- Lesson 12, Explore, Step 2: "Explore where other hazards occur. Distribute Natural Hazards Mapping and tell students it will help them orient to another natural hazard. Give each pair of students one of the additional hazards maps: hurricanes, tsunamis, thunderstorms, tornadoes, landslides, or floods. Display slide D and give students 10 minutes to use this map and the land and ocean features map, boundaries map, and population map to complete the row on Natural Hazards Mapping." (Lesson 12, Teacher Guide) **DATA-E2: Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. ESS3.B-E1: A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. PAT-E2: Patterns of change can be used to make predictions.**

Students routinely produce artifacts with evidence of using the grade-appropriate elements of SEPs, CCCs, and DCIs that are targeted as learning objectives.

Lesson 2 Learning Target: **Analyze and interpret data to make sense of** the **similarities and differences in the patterns** of data during **a variety of hazardous natural processes**.

- Lesson 2, Explore, Step 2: "Break students into groups of 3-4 students. Distribute multiple copies of data cards for one hazard in the Natural Hazard Cards to each group, giving each group a different hazard. If you have more groups than types of hazards, some groups can review the same type of hazard. Use the text on the slide to guide students to annotate the cards with a focus on which data points are associated with their natural hazard. Distribute sticky notes and markers for students to write new questions on to save for later in the lesson. Give groups about 8 minutes to gather and analyze data from their data cards." (Lesson 2, Teacher Guide)

Lesson 3 Learning Target: Make observations **that can be used as evidence to explain** that **the depth of the water (cause)** affects **the way waves move things (effect).**

- Lesson 3, Synthesize, Step 6: "In small groups, discuss what caused some gravel to move onto the road. Direct students to the bottom of Wave Bin Observations. Display slide N and ask them to recall what they observed the gravel doing in their wave bin when they made waves. Encourage them to use the observations they recorded during their investigation to support their thinking. Ask students to discuss why they think the gravel moved." (Lesson 3, Teacher Guide)

Lesson 6 Learning Target: **Make observations** of **patterns to use as evidence** for **how water, ice, wind, and living things break land into smaller pieces and move it around at different rates** to **change physical characteristics of the region**.

- Lesson 6, Explore, Step 5: "Give time for exploration. Display slide Q and the Thunder Hole, Acadia National Park" chart from earlier in the lesson. Tell students they will have 12 minutes to examine the data for their site and complete their poster. Encourage students to leave room in each box to add more later on." (Lesson 6, Teacher Guide)

Lesson 7 Learning Target: **Use a model to explain** the **mechanisms of erosion** that **caused change to land over time at different rates.**

- Lesson 7, Synthesize, Step 5, Students discuss the evidence from their models to explain the mechanisms of erosion by answering the following question, "What evidence do we have to support that these are the mechanisms that caused the changes at these sites?" (Lesson 7, Teacher Guide) Students do not produce an individual artifact.

Lesson 9 Learning Target: Identify evidence in the **patterns** of **rock layers to explain how Hawai'i has changed over time due to volcanic eruptions.**

- Lesson 9, Synthesize, Step 8, Students add to their consensus model and identify evidence when they answer the following questions, "We had initial ideas that lava had something to do with the way that Hawai'i formed, what new ideas should we add?" and "How did the wax investigation help you to update your model?" Students do not produce an individual artifact.

Lesson 10 Learning Target: Make observations **to serve as evidence** that **more rainfall in an area** can **cause more plants to be able to live in the area** and that **plants can cause land to be broken into smaller pieces**.

- Lesson 10, Synthesize, Step 4: "Construct an explanation of how Hawaii has so many plants. Suggest that now that we have made many observations and gathered evidence about how so many plants can be living in Hawaii, we can construct an explanation that answers this question." (Lesson 10, Teacher Guide)

Lesson 11 Learning Target: **Analyze and interpret data presented in maps** in order to **identify patterns in the locations of Earth's features in order to predict** the locations of potential future volcanic eruptions.

- Lesson 11, Synthesize, Step 5: "Predict which location is more likely to experience a volcanic eruption. Display slide U and point out students that now that we can identify the patterns in the locations of volcanoes, we can use them to predict which areas of the world would be more likely to experience a volcanic eruption. Explain to students that they will be working in pairs to analyze a map that includes volcanoes, volcanic islands, and mountain ranges. There are two locations on the map. Point out where the two locations are on the map on slide U. Ask students to work with their partner to determine which area would be more likely to experience a volcanic eruption and support their thinking with evidence from the maps. Distribute one copy of Predicting where a volcanic eruption could occur to each pair of students and ask them to record their thinking on the handout." (Lesson 11, Teacher Guide)

Lesson 14 Learning Target: **Improve engineering designs based on peer comparisons** about **how well designs attend to criteria and constraints generated** to minimize the **effects of weathering and erosion**.

- Lesson 14, Synthesize, Step 4: "Revise your solution. Display Slide I. After groups have seen other designs, read through their sticky notes, and gotten some additional ideas from the discussion, give groups about 10 minutes to revisit their design and make any revisions the group thinks will help the design better attend to the criteria and constraints." (Lesson 14, Teacher Guide)

Lesson 15, Observe **how multiple solutions affect erosion caused by coastal storms under a range of likely conditions to compare how well they meet the criteria and constraints.**

- Lesson 15 Synthesize, Students engage in a consensus discussion with the following questions, "What did you notice about the designs?, Which designs seemed to attend to the criteria and constraints best?, What were features of the designs that worked best that they had in common?, What can our investigation tell us about protecting Seawall Road? And What about other places near us that are at risk of weathering and erosion?" (Lesson 15, Teacher Guide) Students do not produce an individual artifact.

Criterion-Based Suggestions for Improvement

- Ensure that "[s]tudent artifacts that require grade-appropriate elements of all three dimensions to be used together are used frequently, including to evaluate targeted learning objectives. Many of these artifacts may be from group activities if there is evidence that the teacher has recorded evidence from individual students (e.g., through video or notes)." (Detailed Guidance, p. 35)
  - Consider providing specific guidance for the teacher on how to record evidence from group artifacts to document individual student understanding, on assessments in Lessons 7, 9, and 15.

III.B. Formative

EXTENSIVE

Embeds formative assessment processes throughout that evaluate student learning to inform instruction.

The reviewers found **extensive** evidence that formative assessment processes evaluate student learning to inform instruction. There are opportunities in every lesson for gathering, recording, and using formative assessment information to inform future instruction. The majority of formative assessments include suggestions on how to modify instruction within the same lessons and occasionally mention when the teacher will have an additional opportunity to check for understanding, as in Lesson 6 Assessment Guidance. The key formative assessments in Lessons 4, 10, and 12 include an Assessment Tool for Teachers to attend to students' individual levels and needs and modify instruction accordingly.

Materials include explicit, frequent, and varied supports for formative assessment processes.

- Elementary Teacher Handbook, "Formative assessment opportunities include prompts (verbal, gestures, written) embedded into activities that allow teachers to "quickly" determine whether students are building understanding. These prompts are included in tables that have ideas that teachers should look for and listen for in student responses. There are also suggestions for follow-up questions or prompts for teachers to use to support students' ongoing learning. In addition, at the beginning of each lesson, there is a table that provides information for teachers on how to use the information that they elicit to best support learning." (Elementary Teacher Handbook)
- Lesson 4, Lesson Assessment Guidance, "Use the information you gather in three ways: (1) to guide follow-up questions during the discussion in the Synthesize, (2) to identify a need to return to the activity for more careful observation of cause and effect relationships, or (3) to identify a need to return more explicitly to the anchoring phenomenon so that students are better prepared to use the investigation as evidence. If you notice that students need additional support identifying cause and effect relationships, redo the Wind Investigation, asking students, "What is the cause in this situation?" Then, after re-testing, "What was the effect?" If students do not make connections between the activity and storms, you may also need to discuss again what parts of a storm water and fan represent." (Lesson 4, Teacher Guide)
- Lesson 6, Lesson Assessment Guidance, "Use the information you gather to (1) determine students' understanding of the erosion mechanism cards, (2) identify students' ability to use observations of patterns as evidence in explanations, and (3) make decisions about how to motivate Lesson 7. If students do not yet seem to understand the mechanisms, you may discuss them further with the class or have each pair pick out the one that makes the least sense to them and discuss it with another pair. If they struggle to make observations or identify patterns in them, use sentence starters such as "I notice..." and "___ could be connected to ___ because...". Finally, if students are confident in their explanations, be prepared to seed some uncertainty around whether we have experimental evidence that the patterns students identified connect to the physical features. If they are less confident, you may leverage this uncertainty to motivate the investigations in Lesson 7." (Lesson 6, Teacher Guide)
- Lesson 7, Lesson Assessment Guidance, "As you look and listen for students' ideas during the discussion, notice how they explain how fossils found in rock layers reveal patterns of changes to landscape over time. Students should be at a secure understanding that fossils found in rock layers provide evidence that the landscape was not the same as it is now in the past. When needed, encourage students to reference their article for evidence that would support their ideas about how fossils can provide evidence of land changes. In Lesson 10, students will have an opportunity to revisit trace fossils found in rock layers and explain how they provide evidence of what a landscape was like in the past independently." (Lesson 7, Teacher Guide)

- Lesson 13, Lesson Assessment Guidance, "Use the information you gather to (1) determine whether students' brainstormed solutions are geared toward preventing impacts from weathering and erosion from water, (2) identify students' use of research and patterns between conditions at different sites, and (3) make decisions about how to use student-identified problems and possible solutions to motivate thinking about criteria and constraints. If students' brainstormed solutions are not generally targeted at Seawall Road, encourage them to brainstorm more with a more specific prompt. If students do not narrow down to sketched solutions based on their research, do not have students redo sketches but use this misalignment to help motivate the need for clear criteria and constraints." (Lesson 13, Teacher Guide)

Teachers are given some guidance on how to modify instruction based on student responses: Key Formative Assessment Tasks in Lessons 4, 10, and 12.

- Lesson 4, Key Formative Instructional Guidance: This document provides teachers with support based on a range of possible student responses or levels of student proficiency. "If you notice students…are not yet describing patterns of waves in terms of amplitude and wavelength." "Possible Next Steps: If this applies to a few students in your class: Before Lesson 5, have students draw what they observed in the Wind Investigation, then use the amplitude and wavelength cards on the Word Wall to attach names to these patterns. If this applies to most or all of your class: Before Lesson 5, use materials from the Wind Investigation and the Play Parachute Investigation to review key ideas. Ask students to move the parachute to resemble what they observed during the Wind Investigation, then invite students to turn and talk with a partner to use amplitude and wavelength to describe the patterns. Ask students, "When else have we noticed the amplitude and wavelength of a wave? Do all waves have similar patterns?" "If this applies to most or all of your class: Before Lesson 5, use materials from the Wind Investigation and the Play Parachute Investigation to review key ideas. Ask students to move the parachute to resemble what they observed during the Wind Investigation, then invite students to turn and talk with a partner to use amplitude and wavelength to describe the patterns. Ask students, "When else have we noticed the amplitude and wavelength of a wave? Do all waves have similar patterns?" (Lesson 4, Key Formative Instructional Guidance)
- Lesson 10, Key Formative Instructional Guidance: This document provides teachers with support based on a range of possible student responses or levels of student proficiency. "If you notice students…Students needing support with describing what the landscape could have looked like in the past. "Possible Next Steps: Ask students to share what they see in the current picture and look for them to indicate that there is cooled lava rock and tree molds. Ask students to describe how a tree mold can form. Focus students on the part when they explain that trees and plants are covered in lava. Return to Lava Trees and Tree Molds Infographic with students and focus their attention on how a tree mold forms. Encourage students to describe the process in their own words. Ask students to consider what the land looked like before the lava flow as they describe the process. Encourage them to draw that as the "before." Return to slide Z from the Lesson 9 slides and have students share what they notice in the image. Ask them to focus on the trees and plants in the middle of the lava flow. Return to the images on the assessment and point to the lava flow with the tree mold and ask students to share what that is most like on the image on slide Z (Lesson 9)." (Lesson 10, Key Formative Instructional Guidance)

Formative assessment processes routinely provide varied support for student thinking across all three dimensions.

Each formative assessment includes a three-dimensional learning goal, specific criteria for evaluating student responses, and suggestions on how to utilize the assessment information.

Lesson 3, Lesson Assessment Guidance

- Three-Dimensional Learning Goal: Make observations **that can be used as evidence to explain** that **the depth of the water** (**cause**) affects **the way waves move things** (**effect**).
- Where to Check for Understanding: In the Synthesize and on the Wave Bin Observations handout
- What to look and listen for: Evidence of students' ideas may be expressed in words, drawings, written or spoken descriptions, movement, and/or gestures, including:
  - **The gravel moved forward because the water was shallow**.
  - **Waves in shallow water** could have **been the cause of rocks getting pushed onto Seawall Road**.
    - Also look and listen for how students are making connections between their observations and the evidence they are drawing on to support their new ideas, such as:
  - **I saw the waves push the gravel forward. This is evidence that waves in shallow water can cause things to move forward.**
    - Evidence of students' ideas may be expressed in words, drawings, written or spoken descriptions, movement, and/or gestures.
- How can I use this assessment information? If you notice students need more support in using observations to explain the cause and effect relationship between the depth of the water and the way waves move things, you might:
  - Use repeated words, sketches, and/or gestures to help students focus on how waves:
  - Move rocks in shallow water.
  - Do not move the rocks when they are in deeper water.
  - Gather students around a wave bin set up and facilitate small group discussions about what we observe the gravel doing as we make waves in the bin, encouraging students to share their thinking in real time. Talking through observations as they happen helps students make sense of the phenomena more easily, since they can focus on immediate sensory details rather than relying on memory or static representations like drawings, which may miss key aspects of the motion or pattern.

Students will have additional opportunities to use their observations of waves to explain how waves work and how that impacted Seawall Road.

Formative assessment processes routinely attend to multiple aspects of student equity.

- Lesson 4, Explore, Step 5: Teaching Tip," [BH:1]Teaching Tip As students share observations, encourage them to use gestures or even quick drawings on the board to share what they observed. Encourage students to indicate the amplitude and wavelength of waves for additional practice with those terms." (Lesson 4, Teacher Guide)

- Lesson 7, Synthesize, Step 5: "[BH:1]Broadening Access Encourage students to share their thinking in a variety of ways, and validate all the ways we communicate our ideas, through linguistic (oral and written language) and nonlinguistic modes, such as gestures or body movements, pointing at the posters, drawings (if helpful), and words from any languages your students use. Making connections between written or spoken words and nonlinguistic representations helps all learners, especially multilingual students generate richer understandings of scientific phenomena." (Lesson 7, Teacher Guide)
- Lesson 9, Synthesize, Step 3: "Community Connections. To foster collaboration and community, review the classroom agreements before partner sharing and whole class discussion. Particularly, "We share ideas even when we are not sure" and "We look, listen, and respond to each other's ideas" might dissuade hesitations and encourage students to share their model and thinking. Furthermore, "We let our ideas change and grow" can support students to recognize the collaborative efforts it takes in figuring out the lesson's phenomena, and foster an equitable classroom community where everyone's ideas play an important role. Ask students why they think it is important for them to engage with these agreements, and what it might look like for them to do so. This conversation might encourage students to engage more with peers' ideas, and in doing so could prompt additional students to go beyond just listening to their peers' ideas." (Lesson 9, Teacher Guide)
- Lesson 10 Instructional Guidance: "If you notice students are not yet noticing the cause and effect relationship between plant roots breaking rocks and more plants being able to grow. If this applies to most or all of your class, consider asking students to revisit and revise their explanations after the class collectively updates their "How volcanoes form and change land" model. Having this whole group experience in modeling the changes to the island as a class, may help students solidify their understand of the role of rainfall and plant roots in the regrowth of the vegetation on the island. If this applies to some of your class, consider the following options:
  - Individually or with a small group, revisit the photos of the plant roots and have a similar discussion as students had in the Explore (slide P). Make sure to have all of the photo cards and slide deck for L10 available so that as students discuss with you, they can reference all of the evidence that we have been using in this lesson.
  - In Lesson 15, as students are building and/or testing designs, consider working with a small group of students to demonstrate how the pipe cleaners can create more spaces in the land for seeds to possibly fall into. Allow students to manipulate the pipe cleaners/land.
  - In Lesson 16, as students read the Meet the Experts: Coastal Erosion book during the Connect (slide B), support students in making connections to how the plants can cause cracks in the sand and how that can lead to more plants being able to grow.

Criterion-Based Suggestions for Improvement: N/A

III.C. Scoring Guidance

EXTENSIVE

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.

The reviewers found **extensive** evidence that the materials include 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. Each lesson contains an identified formative assessment that is aligned to an assessment target. Teachers are provided with look-fors related to the elements of the three dimensions within the assessment target. There are three identified summative assessments within the unit, each accompanied by a rubric with detailed scoring guidance for teachers; however, none include sample student responses across a range of levels.

Every lesson has a "Lesson Assessment Guidance" and "Assessment Opportunity" section that provides teachers with the three-dimensional learning goal and what to look for and listen to from students for the lesson. For example,

- Lesson 6, Lesson Assessment Guidance: **Make observations** of **patterns to use as evidence** for **how water, ice, wind, and living things break land into smaller pieces and move it around at different rates** to **change physical characteristics of the region**. (Lesson 6, Teacher Guide)
  - **Where to check for understanding:**
  - In the Explore, when students observe patterns of evidence in images and data from National Park sites (slides Q-R).
  - **What to look and listen for:** Evidence of students' ideas may be expressed in words, drawings, written or spoken descriptions, movement, and/or gestures, including:
  - **Observations** of **patterns** across the near-school observations, images of National Park sites, and data.
  - Use of **observations** and **patterns** as **evidence for particular explanations** of physical feature formation.
  - **Water, ice, wind, and living things, breaking land into smaller pieces and moving it around** as **explanations** of physical feature formation.
  - **Explain** some **changes in physical characteristics of the region through the actions of living things**.
  - Relative **rates of change** of these phenomena, determined from **patterns** of **evidence**.

Support for planning instruction

- Lesson 2, Lesson Assessment Guidance: "If students need more support in recognizing the similarities and differences in the patterns that occur due to various natural hazards, consider working with small groups or individual students after the group Synthesize. Gather a set of natural hazard data cards and the conditions in Acadia data and go through each condition asking students to point to the data on their card that describes that condition. Ask students if the condition that happens during the natural hazard is similar or different than those of Acadia the day the storm broke. Continue this process until students determine the natural hazard that has the most similarities with the conditions in Acadia." (Lesson 6, Teacher Guide)
- Lesson 6, Lesson Assessment Guidance: "If students do not yet seem to understand the mechanisms, you may discuss them further with the class or have each pair pick out the one that makes the least sense to them and discuss

it with another pair. If they struggle to make observations or identify patterns in them, use sentence starters such as "I notice…" and "___ could be connected to ___ because…". Finally, if students are confident in their explanations, be prepared to seed some uncertainty around whether we have experimental evidence that the patterns students identified connect to the physical features. If they are less confident, you may leverage this uncertainty to motivate the investigations in Lesson 7." (Lesson 6, Teacher Guide)

- Lesson 7, Lesson Assessment Guidance: "If you notice students need more support in describing the rates of the changes they observed in the form of words, drawings, written or spoken descriptions, movement, and/or gestures, you might:
  - Use repeated words, sketches, and/or gestures to help students focus on how long each mechanism might have taken to make the changes.
  - Invite students to return to their models. Use repeated words, sketches, and/or gestures to help them develop their ideas around how long the changes to the land took.
  - In Lesson 10, when students are considering how long it may take for plant growth in Hawaii to return after a volcanic eruption, consider going back to the Timescale of Land Changes We Observe chart and discussing where plants regrowing may fall on that timeline." (Lesson 7, Teacher Guide)
- Lesson 10 Assessment Tool: "Consider shortening the revision of the 'How can a volcano form and change an island?' model in the Synthesize of this lesson (Slide R). Provide opportunities for them to explore other areas that experience plant regrowth to determine if the process works in the same way. One example could be the regrowth of plant life on newly created sand dunes. Provide opportunities for students to observe and consider areas and instances in their communities where people need to consider where and why to grow certain plants." (Lesson 10 Assessment Tool)
- Lesson 14 Lesson Assessment Guidance: "A conversation with those students will give them an opportunity to develop a deeper understanding prior to their final opportunity to demonstrate their understanding. Students can look at revisions their group made on Develop a Design Solution for evidence of communication with peers improving their design. They can look at Comparing Design Solutions or Develop a Design Solution for evidence on how the criteria and constraints informed their design solution." (Lesson 14, Teacher Guide)

Support for ongoing feedback

- Lesson 4, Key Formative Instructional Guidance: This document provides teachers with support based on a range of possible student responses or levels of student proficiency. "If you notice students…are not yet describing patterns of waves in terms of amplitude and wavelength." "Possible Next Steps: If this applies to a few students in your class: Before Lesson 5, have students draw what they observed in the Wind Investigation, then use the amplitude and wavelength cards on the Word Wall to attach names to these patterns. If this applies to most or all of your class: Before Lesson 5, use materials from the Wind Investigation and the Play Parachute Investigation to review key ideas. Ask students to move the parachute to resemble what they observed during the Wind Investigation, then invite students to turn and talk with a partner to use amplitude and wavelength to describe the patterns. Ask students, "When else have we noticed the amplitude and wavelength of a wave? Do all waves have similar patterns?" "If this applies to most or all of your class: Before Lesson 5, use materials from the Wind Investigation and the Play Parachute Investigation to review key ideas. Ask students to move the parachute to resemble what they observed during the Wind Investigation, then invite students to turn and talk with a partner to use amplitude and wavelength to describe the patterns. Ask students, "When else have we noticed the amplitude and wavelength of a wave? Do all waves have similar patterns?" (Lesson 4, Key Formative Instructional Guidance)

- Lesson 6, Lesson Assessment Guidance, "Use the information you gather to (1) determine students' understanding of the erosion mechanism cards, (2) identify students' ability to use observations of patterns as evidence in explanations, and (3) make decisions about how to motivate Lesson 7. If students do not seem to understand the mechanisms, you may discuss them further with the class or have each pair pick out the one that makes the least sense to them and discuss it with another pair…" (Lesson 6, Teacher Guide)
- Lesson 13, Lesson Assessment Guidance, "Use the information you gather to (1) determine whether students' brainstormed solutions are geared toward preventing impacts from weathering and erosion from water, (2) identify students' use of research and patterns between conditions at different sites, and (3) make decisions about how to use student-identified problems and possible solutions to motivate thinking about criteria and constraints. If students' brainstormed solutions are not generally targeted at Seawall Road, encourage them to brainstorm more with a more specific prompt. If students do not narrow down to sketched solutions based on their research, do not have students redo sketches but use this misalignment to help motivate the need for clear criteria and constraints." (Lesson 13, Teacher Guide)

Rubrics are included for Summative Tasks in Lessons 5, 8, and 16.

- Lesson 5: Scoring Guidance for Student Assessment. This document provides scoring guidance for the Lesson 5 summative assessment, including a range of responses: Beginning, Developing, and Secure. Within each level, the assessment targets are incorporated into the guidance. A sample response for the beginning and secure levels is provided to the teacher. The scoring guidance does not provide examples of how drawings (if that was the student's choice of modality) would meet the criteria.
- Lesson 8: Scoring Guidance for Student Assessment. This document provides scoring guidance for the Lesson 8 summative assessment, covering a range of responses: Beginning, Developing, and Secure. Within each level, the assessment targets are incorporated into the guidance. A sample response for the beginning and secure levels is provided to the teacher.
- Lesson 16, Scoring Guidance for Student Assessment. This document provides scoring guidance for the Lesson 16 summative assessment, covering a range of responses: Beginning, Developing, and Secure. Within each level, the assessment targets are incorporated into the guidance. A sample response for the beginning and secure levels is provided to the teacher.

Criterion-Based Suggestions for Improvement

- Ensure that "[a] range of student responses, not just exemplar responses, and interpretation guidance are described to support teachers. This could include sample student work (e.g., models, drawings, etc.) or expected student responses." (Detailed Guidance, p. 41)

III.D. Unbiased Tasks/Items

EXTENSIVE

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

The reviewers found **extensive** evidence that tasks/items assess student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students. Supports are available for students in various forms, including information shared through books, infographics, and diagrams. When new vocabulary is introduced, it is first explored with students in their everyday language, and then it is recommended that a class definition be co-constructed. For longer assessments, teachers read through directions to ensure that students are prepared to engage in the task. The unit tasks include a range of modalities that students can respond to throughout the unit, including writing, gestures, and drawing. The unit includes a key formative assessment that provides students with a choice across multiple modalities, but does not include a summative assessment that provides students with a choice across multiple modalities.

Multiple modes of communication

Students are encouraged to show their understanding in a variety of ways. New vocabulary is introduced after students have experiences with the science ideas. These words are then used to support the formative assessment within the lesson.

- Elementary Teacher Handbook: "Students develop their scientific language through reading science texts and communicating their science ideas in classroom discussions or written communication. Students learn to explain and use scientific words or vocabulary throughout completing an OpenSciEd unit. These units have been designed to intentionally build student understanding of vocabulary. In the work of the lessons, students make sense of a science idea before discussing the word used to name that idea. For this reason, it is important not to teach this vocabulary all at once before starting the unit (sometimes called "pre-teaching vocabulary"). Rather, teach vocabulary in particular lessons as described in the Teacher Guide." (Elementary Teacher Handbook)
- In every lesson where academic language is encountered, there is guidance for the teacher on when the words are introduced and how they should be defined. These words are then used to support the formative assessment within the lesson.
  - Lesson 3, Lesson 1 Vocabulary: "These are words that students will use for sensemaking in this unit. We will continue using them throughout the unit, so post them on the Word Wall." There is a table that includes the steps in the lesson that word(s) are engaged with. (Lesson 3, Teacher Guide)
- Lesson 3, Synthesize, Step 1: Update our initial consensus model. Display slide B and ask students to use what we now know about the conditions in Acadia to update our "What caused the changes to the land and road in Acadia National Park?" initial consensus model. Prompts to use: What changes did we notice happen on Seawall Road? Ideas to look and listen for: There were tree branches in the road. There were rocks all over the road. The road was broken and cracked! Possible follow-up responses: Show a signal if you agree or disagree." The facilitation of the whole-class discussions opens opportunities for assessing all student ideas. (Lesson 3, Teacher Guide)
- Lesson 4, Synthesize, Step 6: "What did you observe the water doing in the Wind Investigation? Describe the patterns of waves in terms of amplitude and wavelength. If you wish, you may use the blank space to expand on your ideas with pictures." (Lesson 4 Handout, Wind Investigation Reflections)
- Lesson 5, Synthesize, Step 7: "Normally, ships do not get too close to shore, but on that night in 1911, the Tay got too close to the shore and crashed. Use words, symbols, and/or drawings to explain how the pattern of motion of a boat

on top of the water is different far from the shore and close to the shore." (Lesson 5 Assessment, Explaining the Tay Shipwreck)

- Lesson 7, Connect, Step 6: Directions: Read the article with your partner, then write and/or draw your ideas to answer these questions and make sense of what you read." (Lesson 7 Handout, Making Sense of the Fossil Day Article)
- Lesson 9, Explore, Step 2: "Add 'volcano' and 'lava' to the word wall. Point out that we have been using the words 'volcano' and 'lava' a lot. Suggest we agree on definitions of these words before we investigate further. Work with students to develop a definition for a volcano like an opening in the earth where melted rock comes out and becomes part of the surface. Then work with students to develop a definition for lava like, hot melted rock. Add both words to the word wall with the agreed-upon definitions...Construct an initial consensus model to explain how a volcano can create an island. Display a chart with the title "How a Volcano can Form an Island." (refer to slide O). Use the prompts and sample chart below to support students in developing an initial model that explains how a volcano can form an island. Encourage students to use both linguistic and non-linguistic resources (e.g., gestures, pointing at their models)" (Lesson 9, Teacher Guide)
- Lesson 10, Explore, Step 3: "Observe each lava flow and write or draw what you notice about the plants and the rock layer in each." (Lesson 10 Handout, Lava Flow Pictures)

Supports success for all students

The unit includes various ideas for supporting all students.

- Elementary Teacher Handbook, Scaffolds for Read Alouds, During Reading, "When you observe students who... need additional help noticing relevant information in the text. You might respond by...pointing and gesturing to images and/or parts of the text. Rationale: Gestures help students understand what part of the text is relevant to the question being posed or idea being discussed. Gestures may be particularly helpful to support students' listening comprehension." (Elementary Teacher Handbook, p. 50)
- Earth Processes Unit Front Matter, "Furthermore, OpenSciEd units are designed based on Universal Design for Learning guidelines to provide equitable and accessible learning from the outset of the units. Universal Design for Learning focuses on maximizing student engagement and participation during core instruction, which aligns with and integrates to Tier 1-core instruction in the Multi-Tiered System of Supports (MTSS) framework. Please see the Teacher Handbook to learn more about the principles that guided our design work and how UDL aligns with MTSS." (Earth Processes Unit Front Matter, p. 38)
- Lesson 1, Synthesize, Step 5 Sidebar: "Encourage students to share their thinking in a variety of ways and validate all the ways we communicate our ideas, such as with gestures or body movements, drawings, and words from any languages your students use. This allows for multiple means of expression and communication and can provide richer discussions of ideas in the classroom." (Lesson 1, Teacher Guide)
- Lesson 2, Explore, Step 2 Sidebar: "To support students in making sense of and describing the various data points in Acadia, provide optional sentence frames such as "For _____, the data were _____." or "The data for _____ in Acadia were _____." (Lesson 2, Teacher Guide)
- Lesson 2, Explore, Step 2 Sidebar: "In order to accommodate different processing speeds and language proficiency, provide time for each student to preview the data cards on their own before sharing/listening to other ideas. By encouraging individual processing time, students are more likely to generate some ideas that can be added to the pair's conversation." (Lesson 2, Teacher Guide)

- Lesson 7, Synthesize Step 5: "[BH:1]Broadening Access Encourage students to share their thinking in a variety of ways, and validate all the ways we communicate our ideas, through linguistic (oral and written language) and nonlinguistic modes, such as gestures or body movements, pointing at the posters, drawings (if helpful), and words from any languages your students use. Making connections between written or spoken words and nonlinguistic representations helps all learners, especially multilingual students generate richer understandings of scientific phenomena." (Lesson 7, Teacher Guide)
- Lesson 13, Connect, Step 2: "Directions: Discuss these questions with your group. You do not need to write or draw your ideas unless that's helpful. Be ready to share your ideas with the class." (Lesson 13 Handout, How do communities prepare for natural processes?)

Multiple modalities and student choice

Students have some choice in how they express their ideas. Summative assessments in Lessons 8 and 16 do not allow students to respond in a chosen modality.

- Lesson 4, Wind Investigation Reflections, "What did you observe the water doing in the Wind Investigation? Describe the patterns of waves in terms of amplitude and wavelength. If you wish, you may use the blank space to expand on your ideas with pictures." (Lesson 4, Student Handout)
- Lesson 4, Explore, Step 5, Teaching Tip Sidebar, "As students share observations, encourage them to use gestures or even quick drawings on the board to share what they observed. Encourage students to indicate the amplitude and wavelength of waves for additional practice with those terms." (Lesson 4, Teacher Guide)
- Lesson 5, Student Assessment 1, "Use words, symbols, and/or drawings to explain how the pattern of motion of a boat on top of the water is different far from the shore and close to the shore." (Lesson 5, Teacher Guide) Students are given a choice of responding with words or drawings.
- Lesson 10, Handout 5, "Use the spaces below to explain how there can be so many living things in Hawaii even though there are frequent volcanic eruptions there. Be sure to include the evidence that we have to support our claims." The task includes both drawings and words, giving students the opportunity to explain using different modalities.
- Lesson 12 Exit Ticket: Students have the opportunity to choose a natural hazard and a place to make predictions about how the natural hazard may impact that location. However, students do not have the opportunity to respond in multiple modalities.

Criterion-Based Suggestions for Improvement

- Ensure that "[t]he materials include at least one significant task that provides students with a choice across multiple modalities." (Detailed Guidance, p. 43)
  - Consider if summative tasks in Lessons 8 and/or 16 could allow students to respond in a chosen modality.

III.E. Coherent Assessment System

EXTENSIVE

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

The reviewers found **extensive** evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning. There is an assessment system that supports teachers in understanding how students' three-dimensional performances in each assessment fit together to reflect student learning related to the assessment statements across the unit.

Matches three-dimensional learning objectives

Lesson 2, Learning Objective: **Analyze and interpret data to make sense of** the **similarities and differences in the patterns** of data during **a variety of hazardous natural processes**. (Lesson 2, Teacher Guide)

- **Using the lens of: Patterns (CCSC)**
- **Students will: Analyze and interpret data (SEP)**
- **To make sense of: A variety of hazardous natural processes. (DCI)**

Lesson 9, Lesson learning goal: Identify evidence in the **patterns** of **rock layers to explain how Hawai'i has changed over time due to volcanic eruptions.** (Lesson 9, Teacher Guide)

- **Using the lens of: Patterns CCC)**
- **Students will: Constructing Explanations and Designing Solutions (SEP)**
- **To make sense of: how Hawai'i has changed over time due to volcanic eruptions. (DCI)**

Pre-, formative, summative, and self-assessment

Pre-Assessment

- Lesson 1, Assessment Opportunity, "Pre-assessment: Developing the Driving Question board will provide information about learning Goal 1.B. The purpose is to generate initial questions about the phenomenon. Encourage students to ask open-ended questions, such as: How and why questions (cause-and-effect). When and where questions (patterns). Fast or slow questions (stability and change). If students are not yet asking open-ended questions, do not ask students to change their questions; accept those questions and encourage them to refer back to the Notice and Wonder, consensus model, and related phenomena charts and ask additional questions. Refer to the Lesson Assessment Guidance at the beginning of the lesson." (Lesson 1, Teacher Guide)
- Lesson 1, Lesson Assessment Guidance, "This is a pre-assessment. This is not an opportunity to take a grade or score. Instead, use this information to uncover students' initial ideas about sudden events and gradual processes that can cause land to change. Encourage students to share related experiences, examples from their lives, prior learning from Unit 3.2: Why do plants only grow well in certain places, and how can we protect them?, and their initial ideas and reasoning, such as: When students share ideas for how wind, water, and/or ground shaking could change land, ask them why they think that and to share other times or locations they have seen land change. When students share ideas for events that can suddenly change land, ask them to share reasoning and support students in describing how the event could change land. There is no need to have the exact mechanisms of the events; instead look for students

to suggest ideas such as wind, water, and/or the ground shaking that are somehow involved. When students are considering if the changes to land were fast or slow, probe them for reasoning by asking why they think it happens fast or slow, or to describe something else they have seen that makes them think it is that type of change." (Lesson 1, Teacher Guide)

Formative Assessment

At least one formative assessment is included in each lesson. (See III B for a specific analysis of formative assessment).

- Each lesson includes a three-dimensional statement of the learning goals, the assessment type, where to check for understanding, what to look and listen for, and a narrative about how the assessment information can be used. Additionally, each formative assessment includes supplementary information in a yellow box, providing support for teachers to offer targeted feedback to students. Some formative assessments are labeled as key assessments, and additional information is provided to teachers in the instructional guidance document.

Summative Assessment

Summative assessments are used in Lessons 5, 8, and 16. However, Lesson 5 is not consistently identified as a summative task in all unit materials.

- Lesson 5, Synthesize, Step 7: "Individually explain the events of the Tay Shipwreck. Display slide L. Pass out one copy of Explaining the Tay Shipwreck to each student. Point out that we have figured out a lot about waves and how they can change land and things on it. Suggest we use our science ideas to explain the events that led to the photo that we saw of the beach." (Lesson 5, Teacher Guide) However, the 4.3 Earth Processes Assessment System Overview does not list Lesson 5 as a summative.
- Lesson 8, Synthesize, Step 7: "Individually determine the mechanism that caused changes to the Carbella Bridge. Display slide M and tell students that the Carbella Bridge experienced some changes the same day that the video of the river did. Explain that they are going to observe additional photographs of the Carbella Bridge before, during and after June 13th in order to determine what could have caused the changes." (Lesson 8, Teacher Guide)
- Lesson 16, Synthesize, Step 4: "Distribute Indiana Dunes Erosion Solutions. Pass out one copy of Indiana Dunes Erosion Solutions to each student. Review the different parts of their assessment, and answer any clarifying questions. Point out the Our Engineering Process chart they can use as a resource. Give students about 25 minutes to complete the assessment." (Lesson 16, Teacher Guide)

Self Assessment

- Lesson 5, Synthesize, Step 5: "Reflect on how much progress we have made. Display slide I. Celebrate that we have figured out a lot about how land and things on it can change. Pass out one Self Reflection handout to each student. Point out that we made many changes to our model as we collected evidence. Suggest that we take some time to reflect on how we have let our ideas grow and change. Give students 3-4 minutes to quietly fill out their reflections. Collect the Self Reflection and use it to provide feedback and check-in with students before they take the assessment in the next part of the lesson" (Lesson 5, Teacher Guide)
- Lesson 15, Navigate, Step 5: "Take stock of what we've figured out. Display slide G and distribute a copy of Self Reflection to each student. Point out that the class has completed the steps in Our Engineering Process, so it's important to take a moment to reflect on our work as engineers. Give students a few minutes to complete the

handout then, if there's time, invite a few students to share with a partner or with the class something they learned." (Lesson 15, Teacher Guide)

The rationale for the coherent three-dimensional assessment system is clearly described.

- The Elementary Teacher Handbook describes the desired assessment system in the unit. "The goal for assessment in OpenSciEd Elementary is to provide students with opportunities to share their ideas, experiences, and ways of making sense of the world and for these ideas, experiences, and sensemaking strategies to be welcomed, valued, and used to support ongoing learning. When this philosophy toward assessment is enacted in classroom communities that have built norms and routines to invite students to make their thinking visible and use this thinking to help make sense of science phenomena, students can see how their ideas drive science learning. All OpenSciEd Elementary curriculum units have assessment opportunities woven throughout the lessons to support teachers in being responsive to students' ideas and to support students in building their science understandings. These assessment opportunities encourage multimodal communication such that students have many different ways of demonstrating their ongoing sensemaking. Teaching tips and other educative features include prompts and questions to increase participation for traditionally minoritized learners within the whole class and cooperative learning groupings." (Elementary Teacher Handbook)
- The Assessment System Overview document gives a lesson-by-lesson description of the types of assessment and the three-dimensional learning goals for each assessment.

Criterion-Based Suggestions for Improvement

- Ensure that all assessments are consistently identified across all materials (e.g., Teacher Guide and 4.3 Earth Processes Assessment System Overview).

III.F. Opportunity to Learn

EXTENSIVE

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

The reviewers found **extensive** evidence that the materials provide multiple opportunities for students to demonstrate the performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback from teachers and peers. There is evidence that students have multiple opportunities to demonstrate performance of the targeted learning objectives for each of the three dimensions. For one Performance Expectation (4-ESS3-2), there is only one opportunity to demonstrate progress toward proficiency.

Multiple, interconnected opportunities over time

Students have multiple opportunities to use the SEPs, DCIs, and CCCs when coming to an understanding of a targeted learning objective.

4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

Lesson 3 Learning Target: Make observations **that can be used as evidence to explain** that **the depth of the water** (**cause**) affects **the way waves move things** (**effect**).

- Lesson 3, Synthesize, Step 6: "In small groups, discuss what caused some gravel to move onto the road. Direct students to the bottom of Wave Bin Observations. Display slide N and ask them to recall what they observed the gravel doing in their wave bin when they made waves. Encourage them to use the observations they recorded during their investigation to support their thinking. Ask students to discuss why they think the gravel moved." (Lesson 3, Teacher Guide)

Lesson 4 Learning Target: **Use a model that can be analogized** to water waves to identify **patterns** including **wave amplitude and wavelength.**

- Lesson 4, Explore, Step 5: "Expand on observations. Have students return to their seats. Display slide I and distribute Wind Investigation Reflections. Give students 5-7 minutes to complete the handout."

Lesson 5 Learning Target: **Develop a model to describe the patterns of waves and how those waves can cause objects to move in different ways.**

- Lesson 5, Synthesize, Step 7: "Individually explain the events of the Tay Shipwreck. Display slide L. Pass out one copy of Explaining the Tay Shipwreck to each student. Point out that we have figured out a lot about waves and how they can change land and things on it. Suggest we use our science ideas to explain the events that led to the photo that we saw of the beach." (Lesson 5, Teacher Guide)

4-ESS1-1: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

Lesson 7 Learning Target: **Obtain and communicate information about** how **fossils found in rock layers reveal patterns of changes to landscape over time.**

- Lesson 7, Connect, Step 6, Students read an article and engage in the following discussion questions, "How are the fossils fourth graders have seen at Guadalupe Mountains National Park similar? What pattern are they noticing about the fossils there?" and "What evidence does that pattern give us about what this land used to be like very long ago?" (Lesson 7, Teacher Guide)

Lesson 9 Learning Target: Identify evidence in the **patterns** of **rock layers to explain how Hawai'i has changed over time due to volcanic eruptions.**

- Lesson 9, Synthesize, Step 8, Students add to their consensus model and identify evidence when they answer the following questions, "We had initial ideas that lava had something to do with the way that Hawai'i formed, what new ideas should we add?" and "How did the wax investigation help you to update your model?"
- Lesson 9, Synthesize, Step 8, "Consider what else scientists can learn from rock layers. Display slide X and have students Think, Pair, Share about the two prompts on the slide, which are similar to the ones they considered with their reading partner on the Volcanoes and the Island of Hawaii. Which layer of lava would have been the oldest in

the image? Which layer of lava is probably the most recent? Bring students together after a few minutes of sharing with a partner, and use the prompts below to add additional ideas to the model." (Lesson 9, Teacher Guide)

Lesson 10 Learning Target: **Identify the patterns** in location of **tree molds and lava trees** that **support the explanation** that **the landscape of the area has changed over time**.

- Lesson 10, Explore, Step 6, Students explore the phenomena of lava trees and engage in the questions, "Observe the photo of an area on Kilauea on slide W. Do you notice any lava trees in the area? What does that tell you about what the landscape of this area was like in the past?" and "What pattern do you notice between where the tree molds and lava trees are and what the landscape of those areas were like in the past?" (Lesson 10, Teacher Guide)

4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features.

Lesson 11 Learning Target: **Analyze and interpret data presented in maps** in order to **identify patterns in the locations of Earth's features in order to predict** the locations of potential future volcanic eruptions.

- Lesson 11, Synthesize, Step 5: "Predict which location is more likely to experience a volcanic eruption. Display slide U and point out students that now that we can identify the patterns in the locations of volcanoes, we can use them to predict which areas of the world would be more likely to experience a volcanic eruption. Explain to students that they will be working in pairs to analyze a map that includes volcanoes, volcanic islands, and mountain ranges. There are two locations on the map. Point out where the two locations are on the map on slide U. Ask students to work with their partner to determine which area would be more likely to experience a volcanic eruption and support their thinking with evidence from the maps. Distribute one copy of Predicting where a volcanic eruption could occur to each pair of students and ask them to record their thinking on the handout." (Lesson 11, Teacher Guide)

Lesson 12 Learning Target: **Analyze and interpret data** from **maps** for **patterns of change** (emergence of natural hazards) **in order to predict** future hazards including **earthquakes in relation to land and water features.**

- Lesson 12, Navigate, Step 5: "Administer an exit ticket. Display slide L. Distribute Lesson 12 Exit Ticket and give students the remainder of class to complete it. Point out that questions 1-3 are opportunities for them to show what they've figured out, but prompt 4 is not about something we figured out yet. However, ideas students share about that will help us make progress next time on one of our unresolved questions from the lesson." (Lesson 12, Teacher Guide)

4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

Lesson 6 Learning Target: **Make observations** of **patterns to use as evidence** for **how water, ice, wind, and living things break land into smaller pieces and move it around at different rates** to **change physical characteristics of the region**.

- Lesson 6, Explore, Step 5: "Give time for exploration. Display slide Q and the Thunder Hole, Acadia National Park" chart from earlier in the lesson. Tell students they will have 12 minutes to examine the data for their site and complete their poster. Encourage students to leave room in each box to add more later on." (Lesson 6, Teacher Guide)

Lesson 7 Learning Target: **Use a model to explain** the **mechanisms of erosion** that **caused change to land over time at different rates.**

- Lesson 7, Synthesize, Step 5, Students discuss the evidence from their models to explain the mechanisms of erosion by answering the following question, "What evidence do we have to support that these are the mechanisms that caused the changes at these sites?" (Lesson 7, Teacher Guide)

Lesson 8 Learning Target: Make observations of **changes to a bridge and the land around it** in order to provide **evidence** that **heavy rainfall caused the changes**.

- Lesson 8, Synthesize, Step 7: "Individually determine the mechanism that caused changes to the Carbella Bridge. Display slide M and tell students that the Carbella Bridge experienced some changes the same day that the video of the river did. Explain that they are going to observe additional photographs of the Carbella Bridge before, during and after June 13th in order to determine what could have caused the changes." (Lesson 8, Teacher Guide)

4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Lesson 13 Learning Target: **Generate and compare (using patterns) solutions to reduce the impact of natural hazards, leveraging research on the problem.** There is only one opportunity to demonstrate progress toward proficiency.

- Lesson 13, Explore, Step 3: "Set up the task. Ask students how we could use what we have figured out, and listen for responses that suggest designing some of our own solutions. Display slide E and distribute Solution Brainstorming to each student. Have students pair up. Tell students that they will have 15 minutes to use the handout to clarify the exact problem at Seawall Road they want to address, brainstorm solution ideas, compare these ideas, and sketch a couple favorite ideas." (Lesson 13, Teacher Guide)

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.

Lesson 14 Learning Target: **Improve engineering designs based on peer comparisons** about **how well designs attend to criteria and constraints generated** to minimize the **effects of weathering and erosion**.

- Lesson 14, Synthesize, Step 4: "Revise your solution. Display Slide I. After groups have seen other designs, read through their sticky notes, and gotten some additional ideas from the discussion, give groups about 10 minutes to revisit their design and make any revisions the group thinks will help the design better attend to the criteria and constraints." (Lesson 14, Teacher Guide)

Lesson 15, Observe **how multiple solutions affect erosion caused by coastal storms under a range of likely conditions to compare how well they meet the criteria and constraints.**

- Lesson 15, Synthesize, Students engage in a consensus discussion with the following questions, "What did you notice about the designs?, Which designs seemed to attend to the criteria and constraints best?, What were features of the designs that worked best that they had in common?, What can our investigation tell us about protecting Seawall Road? And What about other places near us that are at risk of weathering and erosion?" (Lesson 15, Teacher Guide)

Multi-modal feedback loops

The unit supplies teachers with strategies for responding to student work.

- Lesson 4, Lesson Assessment Guidance, "Use the information you gather in three ways: (1) to guide follow-up questions during the discussion in the Synthesize, (2) to identify a need to return to the activity for more careful observation of cause and effect relationships, or (3) to identify a need to return more explicitly to the anchoring phenomenon so that students are better prepared to use the investigation as evidence. If you notice that students need additional support identifying cause and effect relationships, redo the Wind Investigation, asking students, "What is the cause in this situation?" Then, after re-testing, "What was the effect?" If students do not make connections between the activity and storms, you may also need to discuss again what parts of a storm water and fan represent." (Lesson 4, Teacher Guide)
- Lesson 5, Lesson Assessment Guidance, "This assessment is a formal opportunity to gather individual summative information about your students' progress. Students have had multiple opportunities in this unit to develop models to explain the patterns and motions of ocean waves. Explaining the Tay Shipwreck can be used as a summative assessment opportunity. Use the Scoring Guidance for Student Assessment to support your evaluation of students' materials. Consider allowing students to revise their assessments using feedback provided to them. Opportunities to revise their models will provide students with additional support in making progress on using models to explain the patterns and motions of ocean waves. If you find that some students are not yet demonstrating an understanding of waves, return to the waves bins and parachute examples from Lessons 3 and 4 with the purpose of having students observe the patterns and/or motions in these examples." (Lesson 5, Teacher Guide)
- Lesson 6, Explore, Step 5: "Distribute the Case Site Feedback handout to each pair and tell them which other pair they will share their chart with. Give the remainder of the activity time for pairs to share. Make sure each pair has an opportunity to both receive and give feedback." (Lesson 6, Teacher Guide)
- Lesson 7, Lesson Assessment Guidance, "As you look and listen for students' ideas during the discussion, notice how they explain how fossils found in rock layers reveal patterns of changes to landscape over time. Students should be at a secure understanding that fossils found in rock layers provide evidence that the landscape was not the same as it is now in the past. When needed, encourage students to reference their article for evidence that would support their ideas about how fossils can provide evidence of land changes. In Lesson 10, students will have an opportunity to revisit trace fossils found in rock layers and explain how they provide evidence of what a landscape was like in the past independently." (Lesson 7, Teacher Guide)
- Lesson 9, Navigate, Step 9: "Collect students' models to explain how an island can form. Ask students to turn in their Updated Model handouts. Tell them you are excited to see all the ways they represented their thinking. Consider providing written feedback or set up mini conferences with students before moving on to Lesson 10. See the assessment guidance and assessment callouts in the lesson for suggestions on what to look for in student models." (Lesson 9, Teacher Guide)
- Lesson 12, Navigate, Step 5: "Collect student handouts and tell students you look forward to sharing feedback with them. Provide written feedback on the handout and/or conference with students to support them as they move on to future lessons." (Lesson 12, Teacher Guide)
- Lesson 13, Lesson Assessment Guidance, "Use the information you gather to (1) determine whether students' brainstormed solutions are geared toward preventing impacts from weathering and erosion from water, (2) identify students' use of research and patterns between conditions at different sites, and (3) make decisions about how to use student-identified problems and possible solutions to motivate thinking about criteria and constraints. If students' brainstormed solutions are not generally targeted at Seawall Road, encourage them to brainstorm more with a more specific prompt. If students do not narrow down to sketched solutions based on their research, do not have students

redo sketches but use this misalignment to help motivate the need for clear criteria and constraints." (Lesson 13, Teacher Guide)

- Lesson 14, Synthesize, Step 4: "Give feedback on other solutions. Display slide G, and let the class know they have an opportunity to support other groups in the class with their design solution draft. Point out the criteria and constraints on the Erosion Solution Considerations chart, and remind students that it is important to focus feedback on how the design already does or how it could better attend to one of the criteria or constraints. Tell students they'll have 10 minutes to do a Gallery Tour during which they will: Look at two other groups' solutions to get a sense for their design and how they attend to the criteria and constraints (don't leave sticky notes here – these are to get information for the next two), and Visit two other designs and offer feedback." (Lesson 14, Teacher Guide)

Criterion-Based Suggestions for Improvement

- Ensure that "[f]or all targeted learning objectives for each of the three dimensions and their use together, there are multiple student performances that provide students with iterative opportunities, not including pre-assessment, to demonstrate their progress towards full proficiency over time." (Detailed Guidance, p. 47)
    - Consider providing additional opportunities for students to demonstrate their progress toward the performance expectation 4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Category Ratings

CATEGORY I	**NGSS 3D Design** *(Criteria A–F)*	0	1	(2)	3
CATEGORY II	**NGSS Instructional Supports** *(Criteria A–G)*	0	1	2	(3)
CATEGORY III	**Monitoring NGSS Student Progress** *(Criteria A–F)*	0	1	2	(3)
TOTAL SCORE				**8**	

Overall Ratings

Overall ratings:

The score total is an *approximate* guide for the rating. Reviewers should use the evidence of quality across categories to guide the final rating. In other words, the rating could differ from the total score recommendations if the reviewer has evidence to support this variation.

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)

Overall rating below:

E