

How and Why Does Earth's Surface Change?

DEVELOPER: OpenSciEd

GRADE: 6 | DATE OF REVIEW: September 2021



How and Why Does Earth's Surface Change?

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL RATING: E
TOTAL SCORE: 8

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

[Click here to see the scoring guidelines.](#)

This review was conducted by the [Science Peer Review Panel](#) using the [EQuIP Rubric for Science](#).

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

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Summary Comments

Thank you for your commitment to students and their science education. NextGenScience is glad to partner with you in this continuous improvement process. It is obvious that this unit was thoughtfully crafted to support student learning. The unit is strong in several areas, including providing many opportunities for students to develop and use grade-appropriate elements of the SEPs, consistently providing strategies for students who are struggling with the lesson-level performance expectations, providing regular opportunities for students to share and revise ideas in response to feedback, and organizing lessons and focus questions so that students figure out a central phenomenon and a series of related analogous phenomena. In particular, the concept of correlational versus causal relationships (**Cause and Effect**) is exceptionally well-developed through the construction and revision of the Potential Causes poster across the unit and many opportunities are provided for students to develop and use the CCC element in a way that builds both understanding and skill.

During revisions, the reviewers recommend paying close attention to the following areas:

- **Scaffolded Differentiation Over Time:** Consider intentionally introducing scaffolds that support students in developing both knowledge and skill with the focal SEP elements and then strategically reducing these scaffolds over time to increase student responsibility with the practice. Additionally, an element of **Using Mathematics and Computational Thinking** is claimed as a focal SEP in the unit. *However, the materials claim that students work on this element only in Lesson 2 and 13, and both lessons develop different aspects of the SEP.* The first lesson requires students to use digital tools and the other requires students to engage in proportional reasoning. Therefore, students may not have adequate opportunities to fully develop this SEP element in the unit.
- **Scoring Guidance, Coherent Assessment System, and Opportunity to Learn:** While the materials provide numerous assessment opportunities, various forms of assessments, and detailed assessment guidance, the materials do not provide explicit guidance to determine the degree to which students may be proficient with each of the focal SEPs, CCCs, DCIs, or PEs by the end of instruction.
- **Unit Coherence from the Students' Perspectives:** Although lessons build upon each other in a logical way, the teacher often motivates the next step in the learning. Consider including strategies that support students in more clearly seeing the need to investigate the driving question in each lesson, for example, by having more opportunities to raise questions that could be used to motivate the learning in the next instructional segment.
- **Making the Elements of the Three Dimensions Explicit:** Consider crossing out parts of the DCI that are not fully addressed in the unit. Additionally, consider incorporating language from the specific elements of the three dimensions in the assessment guidance and teacher supports so that how the lessons support students in making progress in three-dimensional learning is clearer.

Note that in the feedback below, black text is used for either neutral comments or evidence the criterion was met and *purple text is used as evidence that the criterion was not met.* All page citations refer to the Teacher Edition of the unit unless otherwise specified.

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CATEGORY I

NGSS 3D DESIGN

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

I.B. THREE DIMENSIONS

I.C. INTEGRATING THE THREE DIMENSIONS

I.D. UNIT COHERENCE

I.E. MULTIPLE SCIENCE DOMAINS

I.F. MATH AND ELA

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I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

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

- i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.
- ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.
- iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

Rating for Criterion I.A. Explaining Phenomena/Designing Solutions

Extensive
(None, Inadequate,
Adequate, Extensive)

The reviewers found extensive evidence that learning is driven by students making sense of phenomena or designing solutions to a problem because the materials are organized so that students are figuring out a central phenomenon about how mountains move and change heights with the use of related investigative phenomena in each lesson. However, although student questions or prior experiences related to the phenomena are elicited *at times, these questions and experiences are only sometimes used to create a need to engage in the learning from the students' perspectives.*

Most of the student learning in the materials is in service of students making sense of phenomena or designing solutions to a problem. Students return to the phenomenon multiple times to add layers of explanation based on new learning. Related evidence includes:

- Lesson 1: Students develop an initial model “for what you think are: possible causes for the increase in elevation of Mt. Everest” and “possible causes for Mt. Everest moving to the northeast” (Lesson 1, Slide G).
- Lesson 2: Students read “in 2015, there was an earthquake on Mt. Everest” and investigate “whether earthquakes caused these mountains to increase in height and change locations” (Lesson 2, Slide D).
- Lesson 3: Students develop a model of what they think they would find at the top of Mt. Everest on the surface and at various depths below the surface (Lesson 3, Slide C). Students collect and compare rock data at five different mountain sites to figure out the structure and composition of rock materials at and below Earth's surface (Teacher Edition, page 88).
- Lesson 4: Students develop models to explain what they think happened under the surface during an earthquake in Ridgecrest, California that could explain “why we saw a shift in the surface of the land” (Lesson 4, Slide I).
- Lesson 5: Students make a prediction about where “the North American plate will be located many years into the future” (Lesson 5, Slide F). Students then use a model to “explain what is causing the North American plate to move 2 cm per year” (Lesson 5, Slide G).

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- Lesson 6: Students revisit the anchoring phenomenon about the movements they observed at Mt. Everest. Students consider the models explaining plate movements that they developed in the previous lesson and are asked to “decide which model best shows what’s happening at Mt. Everest” (Lesson 6, Slide O) as well as which model “can be used to explain earthquakes” (Lesson 6, Slide R).
- Lesson 7: Students investigate whether volcanoes are another “potential cause for the kinds of changes that happen to mountains” (Lesson 7, Slide B). Students connect the patterns in data they find in different sites — Mt. Aoraki, Mt. Aconcagua, and Mt. Hotaka — to answer the question about the unit anchoring phenomenon: “What does this tell us about the changes that occur at Mt. Everest [...]?” (Lesson 7, Slide G).
- Lesson 8: Students review evidence and artifacts showing changes occurring at the Mid-Atlantic Ridge (Lesson 8, Slides H–J). As a class, students discuss and explain potential causes for the changes they observed along the ridge (Teacher Edition, page 196) as well as how it relates to the unit phenomenon regarding mountain movements (Teacher Edition, page 197).
- Lesson 9: Students make a claim using evidence to answer, “What causes a mountain to change in height or location?” “We have figured out quite a bit about what we initially thought could cause a mountain to change in elevation and location. All of the causes we have figured out are about things happening under the surface of Earth, and we have a lot of arrows and edits on our chart. Let’s use what we have here to reorganize what we have figured out about these processes below the surface” (Teacher Edition, page 209).
- Lesson 11: Students develop and compare their models of the “potential past locations” of the different land masses on Earth (Lesson 11, Slide E). Students also need to “Add all the data they think supports the position of the land masses” (Lesson 11, Slide M). “Turn and talk about other plates. Display Slide A. Have students turn and talk with a partner and consider the questions on the slide: We have evidence that the South American and African plates were together and are now moving apart. What has been happening to the other continental plates for millions of years? Where were the other plates located millions of years ago? How could we figure out where they were? What evidence would we need to look at to help us?” (Teacher Edition, page 239). **However, in this lesson, the location of the plates in the past is potentially a mechanism (i.e., proposed by scientists) rather than an observable phenomenon to be explained.**
- Lesson 12: Students review what they have figured out about the unit anchoring phenomena at the beginning of the lesson: “What have we figured out about what causes mountains, like Mt. Everest, to change in elevation and location?” (Lesson 12, Slide A). During the lesson, students work towards explaining “why the two mountain ranges [the Appalachians and the Urals] aren’t growing” (Lesson 12, Slide E). Students investigate and explain the formation of Urals and Appalachians compared to the formation of the Himalayas where Mt. Everest is located (Lesson 12, Slides L–O).
- Lesson 13: Students must explain “what causes mountains, like Mt. Mitchell to shrink” (Lesson 13, Slide A). Students make observations about what happens to these mountains over time (Lesson 13, Slide C) and discuss factors below and above the Earth’s surface (Lesson 13, Slides H and I) that result in mountains decreasing in height over time.

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- Lesson 14: Students apply what they have learned in the unit to explain how marine fossils are naturally exposed at the top of Mt. Everest (Lesson 14, Assessment).

In some cases, **but not consistently**, student questions or prior experiences related to the phenomenon or problem create a need to engage in the learning from the students' perspectives.

- Lesson 1: After students build a Driving Questions Board (DQB) of questions they want to investigate, the teacher revisits the board to identify questions to investigate next: "As you look back at the DQB and think about the ideas shared for investigations and types of data we would want, what makes sense to explore first?" (Teacher Edition, page 54). Students revisit the DQB in Lessons 6, 9, 10, and 14 to see which questions they can answer. Students also add to the DQB in Lesson 6. However, except for Lesson 1 (Teacher Edition, page 52) and Lesson 6 (Teacher Edition, pages 163–164), **the questions on the DQB are not explicitly used to drive the learning in the lessons.**
- Lesson 1: Students brainstorm a list of phenomena related to the anchoring phenomenon: "Think back on all your experiences where you've noticed a change in the surface of the land or landforms, such as hills, mountains, shorelines, or other features on Earth's surface [...] Ask students to share their related phenomena examples and potential causes for these changes" (Teacher Edition, page 48).
- Lesson 2: "Let's think about Earth moving or changing. Do we have any experiences with the ground moving, or know of any ways that the ground can move that we might want to add to our Potential Causes for Mountain Movement chart? [...] Ask students if they think that the earthquake happens and causes the changes, or if they think the earthquake happens at the same time that the land changes. Allow students to share out their ideas and ask students for their reasoning" (Teacher Edition, page 61). In the lesson, students investigate examples of earthquakes to determine if earthquakes are causing mountains to move.
- Lesson 3: The materials state that "Students should be encouraged to share their prior understandings, observations, and current thinking while working collaboratively with their peers to figure out the structure, composition, and temperature of materials found at and below the surface of Earth, as well as the changes that pressure and heat cause to bedrock deep below the surface" (Teacher Edition, page 99).
- Lesson 6: Students revisit the DQB to "review questions that have been answered and that remain to be answered" (Teacher Edition, page 163). The teacher anticipates that students might propose questions about "mountains getting shorter" and "volcanoes and other things we see happening on the surface," (Teacher Edition, page 164) which are investigated in future lessons. The materials provide guidance for checking which questions on the DQB will be relevant to future lessons and investigations. "The questions [on the DQB] they [i.e., students] have not yet answered should be relevant to the amount of time it takes for these changes to happen, and to the surface causes, like weather and water, that can impact landmasses" (Teacher Edition, page 164). Although the DQB is revisited in Lessons 9, 10, and 14 to identify questions that can be answered, **these and other lessons (both prior to and after Lesson 6) do not clearly use the student questions on the DQB to drive student learning as students move from lesson to lesson and do not provide opportunities for students to add new questions.**

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- Lesson 9: Students revisit the Related Phenomena chart to see if they can use what they learned to make sense of any of the phenomena on the list (Teacher Edition, page 215).
- Lesson 10: Students investigate the question “Do you think it is possible that the African and South American continents could have once been together?” (Lesson 10, Slide B) and what those two continents may have looked like long ago (Teacher Edition, page 221). The teacher leads a discussion about using rates of plate movement to construct a model for how the two plates must have been moving over time (Teacher Edition, page 223). However, the teacher rather than the students suggests next steps to answer the lesson driving question: “So if we want to see if the land was the same on both continents... where might we look for this data?” The teacher suggests “Would we want to look at evidence from on the continents, or look at evidence from the ocean?” as well as “So if the oceanic plates are being created or destroyed, should we also look at data from the oceanic plates from long ago?” (Teacher Edition, pages 230–231).
- Lesson 14: Students take an assessment to explain how a sea lily fossil is found naturally exposed at the top of Mt. Everest. The materials potentially miss an opportunity for students to discuss their prior experiences with fossils and generate questions that they will need to answer in the assessment.

Suggestions for Improvement

- Consider providing more opportunities for using students’ experiences and questions about those experiences to motivate the learning in more of the lessons. For example, the teacher could facilitate discussions about what the class has figured out so far; based on what the class still needs to answer, then the class could draw questions from the DQB and generate new questions to be used as the focus for upcoming lessons.
- In places where the teacher is leading the reasoning that moves students from lesson to lesson, consider providing opportunities for students to generate questions and ideas that will motivate sense-making from the students’ perspectives.
- Consider providing the ages of the mountains on the data sheets to help students use quantitative data to compare different mountains and identify potential patterns. This may help students ask questions about the relationship between the age and height of the mountain.
- In Lesson 11, consider having students revisit the fossil evidence from the Data cards from Lesson 1 to help students figure out how fossils can be used as evidence for plates’ locations in the past.

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I.B. THREE DIMENSIONS

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

- i. Provides opportunities to *develop and use* specific elements of the SEP(s).
- ii. Provides opportunities to *develop and use* specific elements of the DCI(s).
- iii. Provides opportunities to *develop and use* specific elements of the CCC(s).

Rating for Criterion I.B. Three Dimensions

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because students have numerous opportunities to develop and use specific elements of all three dimensions to make sense of phenomena. *However, some DCI and CCC elements claimed are not fully addressed in the materials.*

Science and Engineering Practices (SEPs) | Rating: Extensive

The reviewers found extensive evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the SEPs. There is a close match between the SEP elements that are claimed and evidence of SEP development and use in the materials. Many of the grade-appropriate elements that students are engaged in are in service of students making sense of phenomena.

Asking Questions

- *Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.*
 - Lesson 1: Students develop questions for the DQB after reading about Mt. Everest getting taller over time and gradually moving to the northeast, as well as analyzing data and reading about other mountain peaks around the world that are growing or shrinking (Lesson 1, Slide V).
- *Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.*
 - Lesson 1: After developing questions about Mt. Everest, students brainstorm ideas for investigations and information they might need to figure out how mountains grow and shrink (Lesson 1, Slide W). "Give students 3 minutes to talk with this small group to

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generate ideas about the types of data and information they would need to answer their questions on the DQB” (Teacher Edition, page 52). Students are therefore building toward this element.

Developing and Using Models

- *Develop and/or use a model to predict and/or describe phenomena.*
 - Lesson 1: Students develop initial models for what they think are “Possible causes for the increase in elevation of Mt. Everest” and “Possible causes for Mt. Everest moving to the Northeast” (Lesson 1, Slide G). Students add to their model to represent what they think is causing other mountains to shrink (Lesson 1, Slide N).
 - Lesson 3: Students develop models to represent what might be found at and below the surface at the top of Mt. Everest based on their observations of different rocks around where they live: “Develop a predictive model of what you think you would find at the top of Mt. Everest: On the surface, Below the surface [...]” (Lesson 3, Slide C).
 - Lesson 4: Students develop a class model to explain the 2019 earthquake at Ridgecrest. Students then use the model to develop a profile of the North American plate to represent the different elevation levels and the materials that would be found on and below the surface of the continent (Lesson 4, Slides M–U).
 - Lesson 11: Students develop a model that predicts where they think the continents would have been located millions of years ago (Lesson 11, Slide G).
 - Lesson 14: Students develop a model to describe the processes and interactions that resulted in sea lily fossils being naturally exposed at the top of Mt. Everest (Lesson 14, Fossil Assessment).
- *Develop a model to describe unobservable mechanisms.*
 - Lesson 1: When students develop initial models to explain different mountain movements, students represent causes or unobservable mechanisms in their models. Students develop ideas such as “There might be things under the mountain that are causing it to move. There might be things to the side of the mountain. Maybe it has to do with what the mountain is made up of [...]” (Teacher Edition, page 34).
 - Lesson 4: When developing models of the North American plate, students include unobservable components such as “differences in elevation across the North American plate, some type of sediment at the surface in the lower elevation areas, bedrock exposed on some of the higher elevations, and bedrock underneath everything going down deep. Additionally, they may represent rock beginning to shift or move far under the surface due to temperature” (Teacher Edition, page 115).
 - Lesson 6: To examine the effects of unobservable plate movements, students manipulate physical representations of the crust and mantle to observe the ways plates interact at their boundaries. Then students use diagrams and text to explain the ways that plates move when they interact. “Create 3 models — one for each type of plate movement you investigated. Include all the parts and interactions you saw. Include details that help explain what your model is showing [...]” (Lesson 6, Slide K).

Analyzing and Interpreting Data

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- *Distinguish between causal and correlational relationships in data.*
 - Lesson 8: Students analyze and discuss the data collected from artifacts at the Mid-Atlantic Ridge simulation. During the discussion the teacher says “Now we have analyzed volcanoes in areas where plates are moving apart and our mountains are not located. Do we still feel volcanoes are correlated to changes in our mountains? Or do we think they are a cause of these changes? [...] Students should confirm [their answers] with this evidence [...]” (Teacher Edition, page 198).
- *Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.*
 - Lesson 5: The teacher provides a map of plate movements from the Seismic Explorer and says that “the data that is included in Seismic Explorer is assembled using GPS tracking data” Teacher Edition, (page 133). Students are asked “What do you notice about the direction of movement at different locations on the plate?” (Teacher Edition, page 133) and eventually answer the question “How does plate movement affect the land around mountains?” (Lesson 5, Slide M).
 - Lesson 10: Students use map data — which include data from past glacier activity, dinosaur fossil evidence, rock strata, similar rock ages, and coral reef fossil data — to identify spatial relationships between the two continents and provide evidence for the continents touching in the past (Teacher Edition, pages 231–233).
 - Lesson 11: Students analyze maps of current plate movement as well as maps that show the geographical locations of past glaciers, past coral reefs, fossils, and rock strata, etc. on different continents to predict where continents were spatially located millions of years ago (Teacher Edition, page 242).

Using Mathematics and Computational Thinking

- *Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.*
 - Lesson 2: In groups, students use the Seismic Explorer tool to analyze a large data set of earthquake activity and investigate questions such as “How is Earthquake Depth Related to Where Mountains Are Moving?” and “How is Earthquake Strength (Magnitude) Related to Where Mountains Are Growing?” (Lesson 2, Slide T). **Although students may not be aware of the large data set behind the simulation,** they identify relationships between quantitative variables.
- *Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.*
 - Lesson 13: Students compare rates of change in uplift and erosion to figure out why Mt. Everest is still growing and why Mt. Mitchell is shrinking (Teacher Edition, pages 274–280).

Constructing Explanations

- *Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students’ own experiments) and the assumption that theories and laws that*

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describe the natural world operate today as they did in the past and will continue to do so in the future.

- Lesson 3: Students use evidence from video, images, readings, and investigations to explain the changes that occur as a result of increasing heat and pressure to these materials deep in Earth. “What happens to rock when it experiences high temperature and pressure deep below the surface of Earth? Why might these ideas be important in helping us figure out the changes happening at places like Mount Everest?” (Lesson 3, Slide U). “How does what we find on and below Earth’s surface compare in different places?” (Lesson 3, Slide W).
- Lesson 12: Students gather information from a virtual simulation that shows the past locations of the continents to explain the formation of the Appalachian and the Ural Mountains: “What claim can we make about the formation of the Appalachians and the Urals, and how their formation compares to the formation of the Himalayas? What evidence do we have to support our claim? How does the evidence support our claim?” (Lesson 12, Slide O).
- Lesson 14: Students develop an explanation for how fossils of a sea organism can be found naturally exposed at the top of Mt. Everest and are asked to “use evidence from your notebook” as they work towards their explanations (Lesson 14, Fossil Assessment).
- *Construct an explanation using models or representations.*
 - Lesson 4: Students discuss how to model and explain the earthquake at Ridgecrest using a pink foam board to represent what is happening to the land. “Think about how the piece of pink insulation could represent the bedrock across the region shown in the light blue box. What do you think happened to the solid bedrock just under the surface, across this entire area at the time of the earthquake, that could explain why we saw a shift in the surface of the land?” (Lesson 4, Slide I).
 - Lesson 6: Students use the physical and diagrammatic models they develop in the lesson to “Decide which model best shows what is happening at Mt. Everest. Make a list of why you think that the model is best” (Lesson 6, Slide O). Students also use their models to explain earthquakes (Lesson 6, Slide S).
 - Lesson 9: Students answer the question “What causes a mountain to change in height or location?” using the “Potential Causes for Mountain Movement chart” and the “Causal Chain of Events poster” that the class co-constructed (Teacher Edition, page 214).
- *Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.*
 - Lesson 7: Students use the data they collect in the lesson and from previous lessons to answer, “Are volcanoes a cause of changes in location and elevation that occur at any of our mountain sites? Explain” (Lesson 7, Slide R). Then students apply their learning to answer, “What happens at mountains where we see volcanic activity?” (Teacher Edition, page 181)
- *Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.*

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- Lesson 11: Students evaluate their models of the past location of continents millions of years ago by making a T-chart to organize “Strong support” and “Weak support” for their models. In groups, students talk with the other members “to decide which positions of the land masses you have the strongest data to support, and which positions you have less, or weaker data to support” (Lesson 11, Slide F). *However, students do not address why the evidence is adequate (e.g., strong enough) for their conclusion about the locations of the land masses.*

Engaging in Argument from Evidence

- *Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.*
 - Lesson 2: Students respond to the prompt “Do you think earthquakes are causing changes in mountain elevation, or just correlated with the changes? Do you think earthquakes are causing changes in mountain location, or just correlated with the changes? What evidence do we have that supports your claims?” (Lesson 2, Slide R). *However, students are not directly asked to provide scientific reasoning to support their claims.*
 - Lesson 6: Students make claims about which of their plate interactions models best explains the changes in Mt. Everest and changes observed with earthquakes. Students are asked to “Write down what evidence supports your explanation of which model is best” (Lesson 6, Slide Q) and “Write down what evidence supports your explanation of how earthquakes happen” (Lesson 6, Slide T). The materials state that “Through writing their written arguments, they [students] are identifying those pieces as evidence and articulating why the evidence supports the claim of causation.” *However, students themselves are not directly asked to include this kind of scientific reasoning — articulating why the evidence supports the claim of causation — in their written arguments.*
 - Lesson 8: Students cite evidence from the Mid-Atlantic Ridge storymap to support or refute their claims and create a written argument about what is happening between where two plates are moving apart. “Look back at your initial claim [about what happens when two oceanic plates move apart] and determine if the evidence supports or refutes your claim. What particular pieces of evidence best support or refute your claim and why?” (Lesson 8, Slide F). The materials suggest that if students struggle with this task “ask them to critically consider how the collected piece of evidence helps them to explain the validity of their claim” (Teacher Edition, page 194).

Disciplinary Core Ideas (DCIs) | Rating: Adequate

The reviewers found adequate evidence that students have the opportunity to use or develop the DCIs in this unit because there are numerous opportunities for students to use and develop grade-appropriate DCI elements and the elements are used in service of making sense of phenomena. *However, some claimed DCI elements are not fully addressed within the materials.*

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ESS1.C: The History of Planet Earth

- *The geologic time scale interpreted from rock strata provides a way to organize Earth’s history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.*
 - Lesson 10: Students use a trash can analogy to develop an understanding of the order of rock layers (Teacher Edition, pages 231–232) and use this knowledge to “analyze rock strata and fossil data to determine the location of past continents from the specified time period” (Teacher Edition, page 10). Students examine maps with data showing rocks of the same kind and age as well as rock layers and formations from Africa and South America. They also look at locations of fossils on these two continents from the same time periods (Student Edition, pages 34–35).
 - Lesson 11: Students continue to analyze rock strata data and answer the question “Would land masses that are connected be likely to have the exact same rock formations and the same layers? Why or why not? Why don’t all the layers match up?” (Teacher Edition, page 242).
 - Students do not use rock strata data or their understanding of this DCI element to construct a timeline of the Earth’s history or determine the relative time ordering of events in Earth’s history.

ESS2.A: Earth’s Materials and Systems

- *All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. This energy is derived from the sun and Earth’s hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth’s materials and living organisms.*
 - Lesson 3: Students answer a question about an Earth process: “What happens to rock when it experiences high temperature and pressure deep below the surface of Earth?” (Teacher Edition, page 95).
 - Lesson 5: Students use the class model “for the behavior of bedrock many miles below Earth’s surface” to describe the processes that explain “what is causing the North American plate to move 3 cm per year” (Teacher Edition, page 135).
 - Lesson 7: Students investigate Earth processes in addressing the question “Do volcanoes cause mountains to move?” (Teacher Edition, page 179).
 - Lesson 8: Students use information about an Earth process regarding the movement of matter beneath the Earth’s surface to figure out “What could be causing magma to push out of the surface of Earth?” (Student Edition, page 30). Students realize that “Magma from the mantle is pushing up from under the plate, which can be seen in places like volcanoes and fissures in Iceland and along ridges. New oceanic plate material is being formed at ridges. The pushing of magma on the plates causes the plates to move, which causes changes to mountain elevation and location over time” (Teacher Edition, page 9).
 - Lesson 9: Students figure out the answer to “What causes mountains to change?” (Student Edition, page 31) by using what they learned about plate movements and

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magma from previous lessons to make a claim supported by evidence (Student Edition, pages 31–32).

- Lesson 13: Students first “reason out that the energy source for erosion [as well as evaporation, wind, rain, weathering, etc.] is the sun.” The teacher then suggests that an energy source similarly must be “causing it to get hotter and hotter further and further under the Earth’s surface” (Teacher Edition, pages 280–283). Students are asked to “Share what you know about what causes uplift. Is energy involved?” (Student Edition, page 46). However, students do not directly address how energy flows connect to the cycling of matter in Earth’s systems.
- In the lessons above, students describe various mechanisms explaining the different Earth processes. However, students do not directly connect these changes in the matter under the surface of the Earth to the concept of matter cycling or how matter cycling is driven by energy flows.

ESS2.A: Earth’s Materials and Systems

- *The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future.*
 - Lesson 1: Students learn that Mt. Everest is increasing in elevation as well as moving northeast over time. They begin to consider the causes for these phenomena as well as similar and different phenomena in other locations (Student Edition, pages 3–5).
 - Lesson 2: Using video clips, maps and other data from Mt. Everest and Ridgecrest, California earthquakes, students look for evidence of correlations or causations of earthquakes and changes in mountains (Student Edition, pages 7–9).
 - Lesson 4: Students develop and use a profile model showing what occurred on and below the surface at Ridgecrest during an earthquake and extrapolate this information to figure out what might occur at Mt. Everest during an earthquake. Students also look at other mountains that show evidence for different types of changes (Student Edition, pages 15–17).
 - Lesson 5: Students try to figure out the answer to the question, “How does plate movement affect the land around mountains such as Mt. Everest?” (Student Edition, page 19) and Mt. Mitchell by examining evidence that the North American plate is moving at about 2 cm per year, modeling the movement, and considering plate movement that could be occurring in other parts of the world (Student Edition, pages 19–20).
 - Lesson 6: Students pursue the question, “How could plate movement explain how Mt. Everest and other locations are changing in elevation?” (Student Edition, page 21) by developing models showing interactions between different plate rock types and movements. They use what they see with their models to try to figure out what might be happening with mountains in different parts of the world (Student Edition, pages 21–24).

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- Lesson 7: Students try to figure out “What happens at mountains where we see volcanic activity?” (Student Edition, page 25) by looking for patterns in data from maps, viewing animations of plate interactions, using their models to simulate the interactions, and reading information (Student Edition, pages 25–28).
- Lesson 8: “We use evidence from an online simulation to construct an explanation for how and when the Appalachians and the Urals were formed.” Students figure out that “The Appalachian Mountains, first formed 470 million years ago, and the Ural Mountains, formed more than 300 million years ago, were both created in the same way that other mountains were formed” (Teacher Edition, page 11).
- Lesson 13: Students compare erosion and uplift rates to reason about “What causes mountains to shrink in elevation?” (Student Edition, page 45).
- Lesson 14: Students apply their understanding of tectonic plate movements and erosional processes to explain “the presence of marine fossils on mountains” (Teacher Edition, page 13).

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

- *Water’s movements — both on the land ~~and underground~~— cause weathering and erosion, which change the land’s surface features ~~and create underground formations~~.*
 - Lesson 13: Students watch a video and read an article and discuss how water’s movements and erosion change the surface of the land (Student Edition, page 45) and then develop a representation showing how erosion contributes to the changes in height of mountains (Teacher Edition, pages 274–283).

ESS1.C: The History of Planet Earth

- *Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches.*
 - Lesson 7: Students are reminded that when they modeled the interaction of two separating plates in Lesson 6, they noticed that mantle material rose to the surface as the plates moved apart. They then consider the question, “What do you think actually happens at the place where two oceanic plates move apart?” (Student Edition, page 28) as they complete their exit ticket. This claim forms the basis for developing an understanding of this process during Lesson 8.
 - Lesson 8: Students “make claims about what could be occurring at the Mid-Atlantic Ridge” and realize that “New oceanic plate material is being formed [and destroyed] at ridges” (Teacher Edition, page 9). Students use what they learn to analyze maps and determine the past plate locations (Teacher Edition, pages 230–233).
 - Lesson 10: Students discuss the question: “If the Mid-Atlantic Ridge is spreading apart one inch per year, does that mean that oceanic plate material has always existed in the Atlantic Ocean?” (Student Edition, page 33).
 - *The lessons do not include the part of this element about old sea floor being destroyed at trenches. The unit therefore only partially develops this DCI element.*

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ESS2.B: Plate Tectonics and Large-Scale System Interactions

- *Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.*
 - Lesson 10: Students speculate that Africa and South America were once touching and view maps that show evidence of locations of past mountains, glaciers, rock types, layers and formation, and fossils and look for patterns that indicate that these two continents might have once been touching and have moved apart over time (Student Edition, pages 33–35).
 - Lesson 11: Students wonder if all plates around Earth were once in different places. In groups, students analyze different sets of data and manipulate cutouts of continental plates to come to consensus about past locations of earth's plates (Student Edition, pages 37–39).
 - Lesson 12: To investigate why “the Appalachians are decreasing in elevation, while the Urals are neither increasing nor decreasing” (Teacher Edition, page 11), students gather data from satellite and relief maps as well as a simulation to determine how Earth's past plate movements can explain why some mountains grow in height and others are shrinking (Student Edition, pages 41–44).

Crosscutting Concepts (CCCs) | Rating: Adequate

The reviewers found adequate evidence that students have the opportunity to use or develop the CCCs in this unit because there are sufficient CCC elements and time that students are engaged in the CCCs for the length of the materials and there is a reasonable match between the CCCs that are claimed and evidence of the CCC use in the materials. *However, some of the claimed CCC elements are not fully addressed in the materials.*

Patterns

- *Graphs, charts, and images can be used to identify patterns in data.*
 - Lesson 10: Students use images of maps overlaid with data from over 146 million years ago to identify any patterns that can demonstrate that Africa and South America were once together (Lesson 10, Slides I and J). Students therefore build toward this element *but only clearly use it as an SEP rather than as a concept to understand, so students may be consciously using the 3–5 element, Patterns of change can be used to make predictions.*
 - Lesson 11: Students use the patterns they identified in Lesson 10 to determine where the continents were located in the past. “Work with your group to use the arrows from your Plate Movement Map and the data from your cards to reverse time and try to determine the potential past locations of your land masses. Place Africa and South America first. Use the data to organize the other landmasses where they make sense based upon your data” (Lesson 11, Slide E). Students therefore build toward this element *but only clearly use it as an SEP rather than as a concept to understand, so students may be consciously using the 3–5 element, Patterns of change can be used to make predictions*

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- *Patterns can be used to identify cause and effect relationships.*
 - Lesson 1: Students look for patterns of movement and change in elevation over time along five different mountain peaks and identify initial ideas for the causes of these changes (Lesson 1, Slide L). Students organize information they collect for “Data for Causing Growth,” “Data for Causing Decrease in Height”, and “Patterns Between Mountains” (Lesson 1, Patterns of Change for Mountains Handout).

Cause and Effect: Mechanism and Prediction

- *Cause and effect relationships may be used to predict phenomena in natural or designed systems.*
 - Lesson 1: Students develop models for the “Possible causes for the increase in elevation of Mt. Everest” and “Possible causes for Mt. Everest moving to the northeast” (Lesson 1, Slide G, Teacher Edition, page 151).
 - Lesson 6: Students make predictions about what will happen when the plate materials “move toward each other, slide past each other, move away from each other” (Lesson 6, Slide G). Later in the lesson, students make arguments about which model of plate interaction best explains how earthquakes happen (Teacher Edition, pages 160–163). *Although students make predictions, students are not explicitly asked to consider a cause-and-effect relationship or how a cause-and-effect relationship may be useful to make these predictions.*
- *Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.*
 - Lesson 1: In a discussion, students “share all the different potential causes they picture could make a mountain shrink” and the teacher accepts all responses about possible mechanisms (Teacher Edition, page 48). Although this CCC element is developed in later lessons in this unit, *evidence was not found for this CCC element in this lesson.*
 - Lesson 2: Students learn about causation versus correlation and craft an argument using evidence to support either a causal or correlational relationship between earthquakes and mountain growth and movement. “Do you think earthquakes are causing changes in mountain elevation, or just correlated with the changes?” (Lesson 2, Slide R).
 - Lesson 5: Students use patterns from a large set of GPS data to classify the relationship between mountain movement and plate movement as causal, and not merely correlational. They update the Potential Causes chart (Teacher Edition, pages 138–139).
 - Lesson 8: Students discuss the data collected from the Mid-Atlantic Ridge and determine if volcanoes are a cause of or correlated to mountain growth (Lesson 8, Slide K).
 - Lesson 9: As a class, students co-construct a causal chain model to explain how mountains change in height or location. In constructing the models, students distinguish between the “potential causes” that are causal and correlational (Teacher Edition, pages 209–215).

Scale, Proportion, and Quantity

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- *Phenomena that can be observed at one scale may not be observable at another scale.*
 - Lesson 2: Students use the Seismic Explorer simulation to zoom in and out on different regions to answer investigation questions such as “How is Earthquake Depth Related to Where Mountains Are Moving? How is Earthquake Strength (Magnitude) Related to Where Mountains Are Moving? How is Earthquake Depth Related to Where Mountains Are Growing? How is Earthquake Strength (Magnitude) Related to Where Mountains Are Growing?” (Lesson 2, Earthquake Investigations Handout). Students identify the different patterns in earthquake frequencies in different regions when observed from afar and are also asked “What do you think you would see if we zoom in on Ridgecrest?” (Teacher Edition, page 72).
 - Lesson 4: The class develops a cross-sectional model of the Ridgecrest earthquake process and students use the model to consider what’s happening at the scale of the North American plate. The teacher explains that “In Storms Unit, when we were trying to figure out what caused storms, we learned that when scientists are working with phenomena that is at a very large scale, they will look at different sections with similar characteristics or systems, to help them figure out what is happening on a larger scale” (Teacher Edition, page 120). *However, students are not directly asked to reason or think about what is observable or unobservable at the different scales, or to clarify what is meant by the two terms.*
 - Lesson 8: Students zoom in on various regions of the Mid-Atlantic Ridge using a simulation to observe geologic artifacts that will help them to determine what is happening where the plates are moving apart (Lesson 8, Slide E).
 - Lesson 12: Students use a virtual simulation to compare the formation of three different mountain ranges over the past hundreds of millions of years. “What changes did you observe in the Urals as the simulation went back in time? [...] How could we compare the formation of the Appalachians and the Urals with Mt. Everest and the Himalayas?” (Lesson 12, Slide N)
- *Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.*
 - Lesson 13: Students proportionally scale up uplift and erosion rates to predict the changes in the height of two different mountains 1 year, 100 years, 100,000 years and 1 million years into the future (Lesson 13, Erosion Rates vs. Uplift Rates Handout).
- *Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.*
 - Lesson 14: Students create a time-series model to show how “a fossil of a sea organism is at the top of the tallest mountain above sea level.” The materials claim that “Students condense the timescale of millions of years into a 3-part model to show this geologic change over time” (**Developing and Using Crosscutting Concepts**). *The teacher directly provides the model of these three timeframes to the students therefore students may not be using an understanding of this element, although they may be beginning to*

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develop it.

Systems and System Models

- *Models can be used to represent systems and their interactions — such as inputs, processes, and outputs— and energy, matter, and information flows within systems.*
 - Lesson 6: Students use models to explain how interactions between plates at plate boundaries can cause changes in Earth's surface. Together, students consider what needs to be included in their models (Lesson 6, Slides B–E) and are asked to “Include all the parts and interactions.” However, students are not asked to represent inputs, outputs, energy flows, or matter flows in their models and are not prompted to engage in conversation that draws out thinking in terms of systems.

Stability and Change

- *Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.*
 - Lesson 3: “Students revise their models in their Progress Trackers to represent their current understanding of the structure and composition of materials at and below the surface and the changes that occur due to pressure and heat deep in Earth's bedrock” (Teacher Edition, page 98). However, students do not directly examine changes over time or forces at different (atomic) scales.
 - Lesson 11: Students “compare two models for where the continents might have been in the distant past” and are asked “Which model is a better representation of where the continents were millions of years ago? Why?” (Lesson 11, Evaluating Two Models). However, students do not explicitly construct, revise, or build towards an explanation of stability or change when comparing the models.
- *Stability might be disturbed either by sudden events or gradual changes that accumulate over time.*
 - Lesson 14: Students explain how marine fossils such as the sea lily can become exposed at the top of a mountain and are asked “Do you think that these newly exposed fossils will be visible on the mountain range thousands or millions of years from now?” (Lesson 14, Fossil Assessment). Students may be using only part of this element as they are not asked to think about stability of the system in light of sudden events versus gradual changes over time.

Suggestions for Improvement

Science and Engineering Practices

- Where there are only partial matches to the grade-level elements claimed, consider including additional prompts, questions, or strategies to engage students in fully using or developing the element. For example, consider increasing the extent to which students are prompted to use scientific reasoning to connect their claims and evidence when writing or orally stating arguments.

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- When students are developing or using models to predict phenomena, consider providing prompts that help students identify and use the attributes of the model that lead toward its use in predicting or describing the phenomena under study.

Disciplinary Core Ideas

- Consider revising questions, prompts, or tasks strategically throughout the materials to prompt students to develop and use the aspects of the DCI that are missing or not addressed in the unit. For example:
 - In cases where students are developing a sense of the timescale of geoscience processes, consider incorporating questions that ask students to reason about the relative time frame in which the process occurs to support development of the first element of **ESS2.A: Earth's Materials and Systems**.
 - Consider incorporating phenomena and activities that support students in developing and using the DCI elements involving the cycles of matter within Earth's system, (i.e., through the Earth processes of melting, crystallization, and deformation) supporting development of the second element of **ESS2.A: Earth's Materials and Systems**.
 - Consider incorporating phenomena and activities that support students in using rock strata data to construct a timeline of the Earth's history or determine the relative time ordering of events in Earth's history, supporting development of **ESS1.C: The History of Planet Earth**.
- Consider striking out sections of the DCI elements that are not fully or directly addressed in the unit. A note could be added to explain why DCIs are partially addressed and in which other units the rest of the DCI is addressed.

Crosscutting Concepts

- Consider revising questions, prompts, or tasks strategically throughout the materials to prompt students to develop and use the aspects of the CCC that are claimed but are currently missing or only partially addressed in the unit.
- Consider making the CCCs more explicit in questions, prompts, and tasks. For example, if students are developing an understanding of the element in **Stability and Change** — *Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale* — students could be asked to explain to what extent a system will remain stable or change over time and explain why based on processes that occur over different timescales as well as forces at different spatial scales.

I.C. INTEGRATING THE THREE DIMENSIONS

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

Rating for Criterion I.C. Integrating the Three Dimensions

Extensive
(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena or designing solutions to problems because there are numerous events where students are expected to figure something out in a way that requires the use of grade-appropriate elements of each of the three dimensions working together.

The materials state that students engage in integrated, three-dimensional performance expectations in all lessons. For example:

- Lesson 1: “Ask questions that arise from our analysis of information showing that Mt. Everest and four other mountain peaks are changing to seek additional information about what caused the changes (effects) we read about.”
- Lesson 3: “Construct a scientific explanation based on evidence from text, media, and investigations to explain changes that occur to materials below the surface of Earth that are not directly observable.”
- Lesson 7: “Apply scientific ideas and evidence to construct an explanation for the processes that cause some of the large-scale interactions of Earth’s plates that result in the effects (volcanoes) of those interactions.”
- Lesson 8: “Support or refute a claim orally and in writing, based on evidence from multiple locations over a large distance along the ridge to explain what is happening where two plates are moving apart.”
- Lesson 11: “Construct an explanation of changes in the global position of land masses over time including reasoning that shows how rock strata and fossil evidence adequately supports a map of where Earth’s land masses (parts of plates that were not created or destroyed as plates were moving) were located millions of years ago.”

Throughout the unit, there are multiple events where students utilize the grade-appropriate elements of all three dimensions in a coordinated way in order to make sense of phenomena. As one example, In Lesson 13, the materials claim that students “Apply mathematical concepts (proportional relationships and unit rates) from the unobservable processes of erosion and plate movement over time to figure out how much Mt. Everest and Mt. Mitchell are changing now and use these to predict how much they would change in the future” (Teacher Edition, page 267). For this performance, students use elements from all three dimensions:

- Students use the SEP **Using Mathematics and Computational Thinking** — *Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems* — when they use uplift and erosion rates to

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predict what will happen to Mt. Mitchell and Mt. Everest in the future (Teacher Edition, page 285).

- Students use the CCC **Scale, Quantity, and Proportions** — *Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes* — when they respond to the prompt “If erosion rates stay at 9.3 mm/year and uplift rates stay at 20 mm/year, how much will the elevation of Mt. Everest potentially change in 1,000 years? 1 million years?” (Teacher Edition, pages 328–329).
- In making their predictions — “Using your predictions above, which mountain do you predict will change more over the next 10,000 years? Why?” (Teacher Edition, page 329) — students use an understanding of uplift and erosion in the DCI elements **ESS2.C Water’s movements— both on land and underground— cause weather and erosion which change the land’s surface features [...]** and **ESS2.A The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future.**

The following are additional examples where students make sense of phenomena using grade-appropriate elements of the three dimensions:

- Lesson 5: Students analyze a graphical display of a large data set of plate movement (SEP) in order to determine whether a causal or correlational relationship exists (CCC) between plate movement and mountain movement (DCI) (Teacher Edition, pages 125 and 133–137).
- Lesson 9: Students construct an explanation using representations (SEP) on the Causal Chain of Events poster to explain how (SEP) causal rather than not correlational events (CCC) lead to a mountain changing in elevation or location (DCI) (Teacher Edition, pages 205 and 209–214).
- Lesson 10: Students analyze maps displaying patterns of large sets of data sets (SEP and CCC) to determine that Africa and South America could have been touching at the Mid-Atlantic Ridge between roughly 125 and 146 million years ago (DCI) (Teacher Edition, pages 217–233).

Suggestions for Improvement

None

I.D. UNIT COHERENCE

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Lessons fit together to target a set of performance expectations.

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

Rating for Criterion I.D. Unit Coherence

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that lessons fit together coherently to target a set of performance expectations because key thematic or content linkages are created across the unit such that students see explicit connections between most lessons. *However, some of the unit coherence is motivated by the teacher and may not be as obvious from the student's perspective, and the lessons do not provide sufficient repeated experience for students to develop proficiency in the full targeted set of performance expectations.*

Most lessons build directly on prior lessons in a way that makes sense from students' perspective using a variety of strategies. Related evidence includes:

- At the end of Lesson 1, the teacher says, "As you look back at the DQB and think about the ideas shared for investigations and types of data we would want, what makes sense to explore first?" (Teacher Edition, page 54). At the beginning of Lesson 2, the teacher builds upon the ideas students developed in the previous lesson about the causes of the mountain movements: "Ask students to look back at their individual mountain models and the class consensus models. Say, Now let's list all the potential causes we have for these changes" (Teacher Edition, page 60).
- At the end of Lesson 2: "Say, OK, so we still have questions about what is occurring under the surface, and if that is correlated with or causing our mountains to change in elevation and location. We still think there is something happening underground that might be contributing to the changes we see happening to mountains above ground. What would we even find down there if we were to look underground?"
- At the end of Lesson 3, the teacher closes the lesson by saying "We have figured out that there is bedrock everywhere below the surface of Earth. [...] We next need to think about what might be happening to the bedrock when an earthquake occurs" (Teacher Edition, page 98).
- At the end of Lesson 4, the materials state that when asked "can we add anything to or revise anything on our Potential Cause for Mountain Movement chart?" students should say "we are more sure now that earthquakes are related to mountains moving and growing, but we need to figure out more about plates, like do they move? And if they do move, how does this happen?" (Teacher Edition, page 122). *However, students may not readily see the need to investigate plate movement after learning about earthquakes' relationship to mountains moving without prior prompts that help students begin to figure out that there may be connections.*

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- At the end of Lesson 5, the teacher says “It seems like we’ve figured out some things about how plates are related to the movement of Mt. Everest and mountain movement in general. But we also see that based on today’s investigation, there are still some things we cannot quite explain” (Teacher Edition, page 140). At the beginning of Lesson 6, the teacher facilitates a discussion where the class takes stock of what they can now explain and what they still cannot explain. The teacher highlights the next logical step in the investigation: “So, we have been figuring out a lot about what plates are and how they move, and we’ve seen that mountains are near the edges of plates. We need some evidence to figure out whether plate movement causes mountains to get taller or shorter” (Teacher Edition, page 147). Although this next step is logical, it is the teacher who is connecting the dots in the figuring out process rather than prompts being provided that help students propose the need for evidence to establish a causal relationship.
- At the end of Lesson 6, students have learned about the different models of plate movements and are asked “Are there other surface phenomena that these models might help explain?” (Teacher Edition, page 164). In the next lesson, “But sometimes there can be more than one cause for something to change. There is another potential cause that we still have on our chart and need to investigate — volcanoes” (Teacher Edition, page 169).
- At the beginning of Lesson 10, the teacher builds upon what students did in the previous lesson: “We ended last class by thinking about the Mid-Atlantic Ridge. As I was reading through your handouts, I saw similar ideas across the class converging towards a common argument.” After a discussion: “It sounds like we are thinking that if we were to go backwards in time, or reverse time, that the continents might have been together, and we are thinking that it even looks like they could fit together. What data do we already have about how the continents are moving that we can use to do this ‘reverse’ time and see where these continents would have been in the past so we can figure out if they might have been together?” (Teacher Edition, page 223).
- At the beginning of Lesson 12, students make observations about three mountain ranges and notice some differences in the earthquake frequencies in two of the mountain ranges. The teacher encourages students to brainstorm ideas for why this phenomenon occurs: “So if we are noticing that there are very few earthquakes happening in these two mountain ranges that are not growing, what are some of your ideas for why this could be the case?” (Teacher Edition, page 252). Students’ questions about this phenomenon become the focus of the lesson.

The unit provides opportunities across the lessons for students to build proficiency in the targeted learning for all three dimensions. **However, the lessons do not always work together to provide sufficient opportunities for students to build proficiency for all of the claimed targeted learning.** The unit claims to build towards four PEs: **MS-ESS1-4:** *Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history;* **MS-ESS2-1:** *Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process;* **MS-ESS2-2:** *Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales;* and **MS-ESS2-3:** *Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of the past plate motions.* Each of the 14 lessons in the unit claim to build toward all four PEs. The materials explain how lessons build toward the focal DCIs of these PEs. For example, the materials

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describe that for **ESS2.A: Earth’s Materials and Systems**: *The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future,* “Students analyze plate interactions from large spatial and temporal scales and compare them to annual rates of plate movement and erosional forces to determine that the processes of mountain creation and destruction occur over millions of years. Students use the understanding that these interactions have happened in the past and will continue to do so in the future to explain why a marine fossil was found on Mt. Everest will not always be there. Students also learn about the causes and why earthquakes are such sudden events, and about how small erosional rates can add up over thousands to millions of years” (Teacher Edition, page 16). However, not all of the elements of the three dimensions of the targeted PEs are fully developed. For example, students use rock strata data as evidence that continents were once connected in the past in Lesson 10. However, students do not explicitly use the rock strata data to “establish relative ages of major events in Earth’s history” as described in the clarification statement for **MS-ESS1-4**. Additionally, in Lessons 7 and 8 students develop the idea that magma may be a cause of plate movement. However, students do not develop models of phenomena that explicitly address “the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth’s materials,” which is specified in the clarification statement for **MS-ESS2-1**. See Criterion I.B for additional details where elements of the target PEs are not fully developed.

Suggestions for Improvement

- Consider including strategies that support students in more clearly seeing the need to investigate the driving question in each lesson. Strategies could include using different prompts, highlighting an intriguing aspect of the anchoring phenomenon, or even introducing a new investigative phenomenon around which students could generate observations and questions. The navigation strategy in Lesson 12 described above is an excellent example of how highlighting an intriguing aspect of a phenomenon can motivate learning in a way that makes logical sense from students’ perspectives.
- Consider increasing opportunities for students to raise questions related to what they have learned and to use those questions to connect learning from one lesson to another to increase the coherence of sense-making from the students’ perspectives.

I.E. MULTIPLE SCIENCE DOMAINS

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

- i. Disciplinary core ideas from different disciplines are used together to explain phenomena.
- ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.

Rating for Criterion I.E. Multiple Science Domains

Extensive
(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that links are made across the science domains when appropriate because the unit focuses on developing DCIs in the Earth Science domain and, when appropriate for explaining the phenomena in the unit, connections are made to ideas in the other science domains that were learned in previous units. **However, the usefulness of the Crosscutting Concepts to make sense of phenomena across science domains is only pointed out to students in one lesson.**

The unit focuses on six DCI elements in the Earth Sciences domain and the materials explain how students develop these elements in the unit. For example:

- Teacher Background: **“ESS2.A: Earth’s Materials and Systems.** *The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future.* Students analyze plate interactions from large spatial and temporal scales and compare them to annual rates of plate movement and erosional forces to determine that the processes of mountain creation and destruction occur over millions of years. Students use the understanding that these interactions have happened in the past and will continue to do so in the future to explain why a marine fossil was found on Mt. Everest will not always be there. Students also learn about the causes and why earthquakes are such sudden events, and about how small erosional rates can add up over thousands to millions of years” (Teacher Edition, page 16).
- Teacher Background: **“ESS1.C: The History of Planet Earth.** *Tectonic processes continually generate new ocean sea floor at ridges and destroy old seafloor at trenches (HS.ESS1.C GBE), (secondary).* Students analyze data from the Mid-Atlantic Ridge and plate movement data to determine that the seafloor and Atlantic Ocean is getting wider in that location. Students generalize this understanding in order to determine that over time, as plates move away from each other, new seafloor is created at ridges. Students analyze interactions at the Andes and determine that seafloor is also destroyed over time as plates move together. This occurs at all of our trenches” (Teacher Edition, page 16).
- Teacher Background: **“ESS2.B: Plate Tectonics and Large-Scale System Interactions.** Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth’s plates have moved great distances, collided, and spread apart. Students speculate that

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Africa and South America were once touching. They use data from their mathematically derived time period of when they might have been touching to explain that there are patterns across continents based upon rocks, fossil, land, and water patterns from before 146 million years ago. Students then wonder if all plates were once in different places, and use the data listed to determine that Earth’s land masses have moved great distances, collided, and spread apart” (Teacher Edition, page 16).

To explain the Earth phenomena in this unit, the materials draw upon ideas from the Physical Science domain that were learned in previous units. For example:

- Lesson 8: The teacher asks, “What did we figure out in *Cup Design Unit* was happening to cause a liquid to warm up inside of a cup?” Students use the idea that “when particles are heated up, they transfer energy to each other and some move faster and some move slower” (Teacher Edition, page 201) in order to explain what is “happening underground with different materials being heated at different locations around the world” (Teacher Edition, page 202).
- Lesson 8: “So we know the energy from sunlight causes air and water to move above Earth’s surface. What does this source of thermal energy from deep below Earth’s surface end up moving?” (Teacher Edition, page 201).
- Lesson 13: “In the same unit, *Storms Unit* students figured out that materials that are less dense than the surrounding area will rise and materials that are more dense than the surrounding area will sink. They figured this out in terms of air masses. In the brief discussion we have about why rock gets hotter deeper underground, we want students to begin thinking about the possibility this could have to do with density of the material under the surface as it heats up differently underground” (Teacher Edition, page 280).

The usefulness of the crosscutting concepts in making sense of phenomena or ideas across science domains is pointed out to students in one lesson. **However, there may be missed opportunities to highlight this property of the CCCs in other lessons as well.**

- Lesson 2: The teacher leads a discussion about exploring potential causes in a previous unit — the *Cup Design Unit* — in order to help students develop the understanding that causes can be classified as causal or correlated: “How did we investigate those variables to determine whether or not each variable could cause the observed changes, or whether they are just correlated (related to) with the changes?” (Teacher Edition, pages 62–63).
- Lesson 13: The teacher facilitates a discussion to connect what students learned about energy in the *Storms Unit* to changes occurring below the Earth’s surface. For example, the teacher says, “We said above the surface, the sun is what heats things up. Could the sun be causing it to get hotter and hotter further and further under the Earth’s surface?” (Teacher Edition, page 281). **However, the lesson potentially misses an opportunity to help students explicitly use a crosscutting concept, such as an element from **Matter and Energy** or **Systems and System Models**, to make connections across science domains.**

Suggestions for Improvement

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Consider providing additional prompts for students to reflect on the usefulness of the CCC across science domains. For example, in Lesson 13, specific prompts could be added to help students articulate how the lens of **Matter and Energy** or **Systems and System Models** was helpful in developing ideas in Physical Science and how it might be helpful to explain the phenomena in Earth Science.

I.F. MATH AND ELA

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

Rating for Criterion I.F. Math and ELA

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics, English language arts (ELA), history, social studies, or technical standards because appropriate connections are made to mathematics standards. However, many ELA standards, particularly ELA writing standards, are not stated despite opportunities for the materials to make these connections, and students are not supported to make connections between their science learning and their ELA and mathematics activities.

The materials explicitly state ELA and mathematics standards that are used in the unit to explain or help understand the scientific concepts, phenomena, or results. For example:

- Lesson 1: The materials claim "**CCSS.ELA-LITERACY.SL.6.1.A** *Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.*" In the lesson, students "use the information they have found in the articles in the class discussion to develop initial models representing the changes occurring to different mountains" and "draw on evidence they find in these texts and be ready to support the pieces they cite from the reading" (Teacher Edition, page 54).
- Lesson 7: The materials claim "**CCSS.ELA-LITERACY.SL.6.1.A** *Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.*" In the lesson, "students obtain information from a reading and use that information to describe the mechanisms that cause the formation of volcanoes and the changes that volcanoes make to Earth's surface" (Teacher Edition, page 183).
- Lesson 9: The materials claim "**CCSS.ELA-LITERACY.SL.6.1** *Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.*" In the

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lesson, “Students will engage with peers in a Scientist’s Circle to come to consensus on a causal chain of events representation for mountains changing” (Teacher Edition, page 216).

- Lesson 13: The materials claim “**CCSS.MATH.CONTENT.6.RP.A.3** Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.” In the lesson, “Students work with constant unit rates of change for erosion and uplift to determine how both Mt. Mitchell and Mt. Everest will change over different time periods (1,000 years and 1,000,000 years). Using the unit rates for both erosion and uplift students will determine how the elevation of each of the two mountains will be affected over time” (Teacher Edition, page 286).

The materials also describe prerequisite mathematics concepts necessary for the unit. For example, “Prerequisite math concepts that may be helpful include: [...] **CCSS.Math.Content.5.NBT.A.3** Read, write, and compare decimals to thousandths. **CCSS.Math.Content.5.NBT.A.4** Use place value understanding to round decimals to any place. [...]” (Teacher Edition, page 21).

Students have many opportunities to read, speak, and write throughout the materials. However, there are multiple missed opportunities to make connections to ELA standards in the materials. The materials also do not list any writing standards even though students write frequently throughout the unit. For example:

- Lesson 5: “Facilitate a whole-group discussion for the next 6 minutes. Ask for a volunteer from several groups to share one thing they noticed and wondered about from their Seismic Explorer investigation” (Teacher Edition, page 137). Although students engage in discussions, an ELA connection is not made.
- Lesson 6: Students are asked to write an argument and “add a few sentences supporting the claim using evidence” that “Earthquakes are caused by plates moving past each other [...]” (Teacher Edition, page 163). An ELA connection is not made although students engage in writing.
- Lesson 8: Students “Engage in a discussion regarding magma movement and density from previous units” (Teacher Edition, page 200). There is a missed opportunity to incorporate an ELA connection for the class discussion.
- Lesson 10: Students are asked to “make a claim about South America and Africa touching or not touching in the distant past,” “list any data sources that you can use as evidence to support your claim” and “Explain why that data source helps to support your claim” (Lesson 10, Slide J). However, an ELA writing standard is not mentioned.

Suggestions for Improvement

- Whenever students engage in talk or discussion in a unit, an appropriate ELA connection could be made even if the standard is below grade level. Consider stating the appropriate ELA standards in all lessons where students speak, write, or engage in discussion.
- Consider identifying connections to ELA standards when students are engaged in writing tasks.
- For an extensive rating, also consider:

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- providing clear opportunities for students to use their writing skills to explain and communicate scientific information or understanding in writing assignments that are varied in both structure and purpose, and
- providing opportunities for students to realize how their mathematics and ELA work supports their science learning.

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



CATEGORY II

NGSS INSTRUCTIONAL SUPPORTS

II.A. RELEVANCE AND AUTHENTICITY

II.B. STUDENT IDEAS

II.C. BUILDING PROGRESSIONS

II.D. SCIENTIFIC ACCURACY

II.E. DIFFERENTIATED INSTRUCTION

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

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II.A. RELEVANCE AND AUTHENTICITY

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

- i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).
- ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.
- iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.

Rating for Criterion II.A. Relevance and Authenticity

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because the students interact with the various Earth Science phenomena throughout the unit in ways that are potentially engaging and interesting to them.

However, few connections are made to students' prior experiences, homes, neighborhoods, communities, and/or cultures.

Students experience phenomena as directly as possible through various media, including computers, as well as physical representations. For example:

- Lesson 1: Students explore the location of Mt. Everest on a map compared to the location of their school. Then students discuss what they know about Mt. Everest before they read an article about some puzzling movements and changes occurring with Mt. Everest (Teacher Edition, pages 32–33).
- Lesson 2: Students watch a brief narrative about climbers who experienced the earthquake on Mt. Everest (Teacher Edition, page 64) as well as footage of an earthquake taken from a parking lot in Ridgecrest, California (Teacher Edition, page 66).
- Lessons 2, 4, and 5: Students work directly with GIS data (adapted for the classroom) in the Seismic Explorer to visualize earthquake frequencies and appearance over different time and spatial ranges, earthquake depths, and patterns.
- Lesson 6: Students observe physical models of plates as they interact with each other in different ways (Teacher Edition, page 313) in order to explain “which model best shows what’s happening at Mt. Everest” (Lesson 6, Slide O).
- Lesson 7: Students compare maps of volcano frequency and earthquake frequency around the world to determine the extent to which volcanoes are the cause of mountains changing and moving (Teacher Edition, page 170).

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- Lesson 8: Students investigate a virtual storymap to analyze different geologic artifacts along the Mid-Atlantic Ocean floor to make sense of what is happening where plates spread (Teacher Edition, page 192).
- Lesson 12: Students manipulate the time variable in a scientific simulation to figure out what changes occurred in three different mountains millions of years ago compared to their current location and arrangement (Teacher Edition, page 254).

Students have **some** opportunities to connect their learning to phenomena around their home and community, mostly in Lessons 1 and 2. For example:

- Lesson 1: “Think back on all your experiences where you’ve noticed a change in the surface of the land or landforms, such as hills, mountains, shorelines, or other features on Earth’s surface... If you can’t think of any that happened where you live but you can think of a change that you saw happen somewhere that you visited or that you read about, that is okay too. Take a couple of minutes and record all of the related phenomena you can think of in your notebook and what you think the causes of these changes might be” (Teacher Edition, page 48).
- Lesson 2: Students share experiences they have with earthquakes on what changes or effects earthquakes have on the land. “Since we are going to learn more about earthquakes, I’d love to hear more about what experiences you have had with earthquakes or what you know about what happens to the Earth or land before, during, or after an earthquake. Have a couple of students share out what they have experienced or have knowledge about and what changes or effects they have seen happen to the land” (Teacher Edition, page 63).
- Lesson 2: “Use the space below to describe some of these natural materials you see on the surface in the area that you live. Next time you meet with your class, be ready to share the natural materials you found in the area that you live. Describe some of the things that you notice on Earth’s surface near your home or school” (Lesson 2 Handout: What Do We See on Earth’s Surface Where We Live?). In the next lesson, the teacher prompts students to connect what students found at home to what they might observe at the surface of Mt. Everest: “Do you think you would find the same types of materials, or sediments, on the surface at the top of Everest? What about if you could dig down below the surface at the top of Everest?” (Teacher Edition, page 86).

Students have **at least one** possible opportunity to ask questions about phenomena related to their prior experiences.

- Lesson 1: “To prompt an array of questions, remind students to think carefully about the changes happening to Mt. Everest, any changes to the mountains described in the cards, and other related phenomena” (Teacher Edition, page 50). Students add their questions about Mt. Everest or the Related Phenomena to the DQB (Teacher Edition, page 51).

Students have **at least one** opportunity to connect their explanation of phenomena to questions from their own experiences. **However, the students only make superficial rather than compelling or substantive connections between the phenomena they investigated in the unit and the phenomena from their own experience.**

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- Lesson 9: The teacher asks, “Now that we have figured out so much about what is going on below the surface to cause changes to the mountains we have been investigating from Lesson 1, do you think these same processes could be affecting the events we have on our Related Phenomena poster?” Students share their responses during a discussion and begin “to think about how [other things around them and] not only mountains are affected by earthquakes, volcanoes and plates moving” (Teacher Edition, page 215).
- Lesson 9: “Guide students to add in a portion about the land around them. [...] Let’s think not only about these changes to mountains, but also consider what changes might be happening to land as these mountains change, and if changes have been occurring to our land as well” (Teacher Edition, page 216).

Suggestions for Improvement

- For an extensive rating, consider using different phenomena or strategies for introducing students to phenomena in a way that is compelling and that students authentically want to figure out or solve. For example, helping students form a sense of connection with this phenomenon by having students think about and discuss “why should I care about mountains or landscapes changing shapes and sizes?” Alternatively, consider providing opportunities for students to brainstorm why learning about mountains or different landscapes may be important for the communities or certain groups of people.
- Consider grounding the learning directly in students’ prior experiences in a way that allows students to make deeper connections between the unit phenomena and the phenomena from students’ own experiences. For example, consider suggesting that teachers include a local mountain (if possible) in Lesson 1 to help students connect to a landscape they are familiar with.
- Consider including more opportunities for students to connect their explanation of phenomena to questions from their own experiences in ways that are substantive and meaningful to students.
- Before showing the headline on the slide in Lesson 1, consider connecting to students’ prior knowledge and experiences about news headlines in media. For example, consider having students share the types of news they have seen headlines about in the media, then share the headline on the slide. It may be effective to display the headline using headline type font and size so it can “feel” like a headline they are reading.

II.B. STUDENT IDEAS

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

**Rating for Criterion II.B.
Student Ideas**

Extensive
(None, Inadequate, Adequate, Extensive)

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The reviewers found extensive evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas. Students have opportunities to share their ideas with others throughout the unit and to receive and respond to feedback from the teacher and other students.

Students have numerous opportunities to share and respond to each other's thinking through "Turn and Talks." For example:

- Lesson 1: "I noticed we have many different ideas for what could be causing the changes we saw in the different mountains. What cause makes sense to figure out more about first? Give students a minute or two to turn and talk with a partner" (Teacher Edition, page 53).
- Lesson 2: "Ask students to turn and talk to a partner about the question on Slide D. What do you think you would see happening if you were on Mt. Everest during the 2015 earthquake? Do you think it would provide enough evidence to support whether the earthquakes caused these mountains to increase in height and change locations?" (Teacher Edition, page 64).
- Lesson 6: "Facilitate a class discussion to identify the components of models that we could use to try to answer our question. Display Slide B. Have students turn and talk for a couple of minutes to articulate some ideas. [...] Students will use these lists as a guide as they develop their models" (Teacher Edition, page 147).
- Lesson 8: "Thinking back to the claims we have about what we think is happening at the place plates are moving apart, talk with a partner about the questions on the slide. Give students a moment to turn and talk to a partner about the prompts on the slide. [...] What type of evidence might we look for to support or refute our claims? Why would we look for evidence that could possibly refute a claim?" (Teacher Edition, page 192).

During class discussions, the materials frequently provide sample questions for the teacher to elicit, probe, and clarify students' ideas. For example:

- Lesson 3: "Show Slide U and use the questions on the slide to guide this Building Understandings Discussion. What are some things you figured out about the different types of rock found at the mountain sites? [...] Why might these ideas be important in helping us figure out the changes happening at places like Mount Everest?" (Teacher Edition, page 95).
- Lesson 8: "Lead a brief discussion to determine that volcanoes signify the presence of magma from the mantle pushing on and up through the plates causing the plates to move, which in turn causes mountains to change in elevation and location. Example prompts and responses are below" (Teacher Edition, page 199).
- Lesson 9: "Through the next part of this discussion that is supported through the prompts and responses below, students should come to agree that volcanoes are correlated with these events, but not the causes of these events. [...] If we add earthquakes and volcanoes to our poster, where should they go?" (Teacher Edition, page 212).
- Lesson 12: "Bring the class back together after viewing the maps. Ask students to share their observations regarding the potential relationship between plate boundaries and our mountain cases that are growing versus mountain cases that are not growing or shrinking in elevation. [...]"

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What do you notice about where the mountain sites are located in relation to plate boundaries?” (Teacher Edition, page 253).

Scientists Circles are used in Lessons 1, 8, and 14 for students to share and compare their ideas. During the Scientists Circles, students are expected to “listen to one another, press on one another’s ideas, and ask questions of one another [...]” (Teacher Edition, page 35). The materials provide guiding questions for the teacher to elicit student ideas. For example:

- Lesson 1: “Let’s begin our class model by representing what we know from the data in the reading. What are some of the data that we want to be able to explain using our class model? Okay so how should we represent that Mt. Everest has grown over time?” (Teacher Edition, page 37).
- Lesson 1: The materials also provide a strategy to encourage students building on others’ questions: “Having the student who volunteered and posted a question choose the next student to share (from those whose hands are raised) is a great way to turn over the pacing and cadence of this group work to the students. Reuse this technique in future Scientists Circles to encourage increased student agency in the classroom learning community. [...]” (Teacher Edition, page 51).
- Lesson 8: “What evidence did you see happening in between the plates in artifact X? [...] What type of landforms do we see in this artifact? What are they made of? Are they old or new? Is there any evidence of change or movement that might be important to what is occurring at the ridge?” (Teacher Edition, page 196).
- Lesson 14: “Discuss as a class the questions the class can now answer. [...] Which questions have we made the most progress on? What have we figured out?” (Teacher Edition, page 291).

Students receive feedback and revise their thinking accordingly. Artifacts show changes in reasoning and thinking over time. For example:

- Lesson 2: The class develops a “Possible Causes for Mountain Movement” chart in which students share their ideas about the possible causes for different changes and movements observed on Earth’s surface (Teacher Edition, page 60). The materials explain that students’ “ideas will be used and leveraged to help us determine what we want to investigate over the course of the unit” and that the class will revise this chart in Lessons 9, 12, and at the end of the unit (Teacher Edition, page 60).
- Lesson 2: Students “Make a claim regarding earthquakes and mountain changes.” Students are asked to “share their ideas with a partner and receive feedback on the evidence they have used to support their argument” as well as “revise their evidence as they share with their partner” (Teacher Edition, page 73).
- Lesson 3: Students “use their predictions to develop an initial model that represents their thinking about what they would find if they were at the top of Mt. Everest [...] on the surface and below the surface [...]” at the beginning of the lesson (Teacher Edition, page 87). Later in the lesson, students “think about the evidence we have collected about the materials we find at and below the surface of Earth [...] and] make any changes to their models to better reflect what we have learned about the materials found at and below the surface of Earth” (Teacher Edition, page 90).

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- Lesson 8: Students “Review claims made by partners and create a class record of claims” about what is happening at the Mid-Atlantic Sea Ridge. Students “turn and talk with a partner about their claims, and whether they think we are able to support or refute the different claims made by their partners” and then “share any claims they just discussed with their partner that they think can be supported by our evidence with the class” (Teacher Edition, page 196).
- Lesson 10: Students use mathematical reasoning to estimate plate movements. After the class discussion, students are allowed to “pick one more estimate (for example 1,000,000 years), or revise their estimate from above as a class” (Teacher Edition, page 227).
- Lesson 11: The teacher provides “feedback to students on their written work and models that calls out any missing elements in order to bring these to students’ attention” (Teacher Edition, page 245).
- Lesson 13: The class revises their model to include new ideas that emerge from a question during a class discussion. “If we think about the wind and rain that cause erosion, how could we revise our mountain model to represent the primary source of where the energy comes from?” (Teacher Edition, page 280).

In the assessment opportunities in each lesson, the Assessment Guidance provides additional prompts and strategies that the teacher can use to provide feedback to students and criteria are provided for the teacher to check if the revisions are appropriate. For example, in Lesson 2, “If students try to create a causal relationship between the events, ask students if any ground cracked or changed in elevation or location during the videos watched. Students should state that the ground momentarily moved, but did not visibly change” (Teacher Edition, page 73).

Suggestions for Improvement

None

II.C. BUILDING PROGRESSIONS

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

- i. Explicitly identifying prior student learning expected for all three dimensions
- ii. Clearly explaining how the prior learning will be built upon.

Rating for Criterion II.C. Building Progressions

Extensive
(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials identify and build on students’ prior learning in all three dimensions because the materials make clear the expected level of proficiency students

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should have with all three dimensions for the core learning and clearly articulate the connections to prior learning and how the prior learning will be built upon. Additionally, when appropriate, the materials explain where students will likely express scientifically inaccurate ideas as they are learning and provide guidance for how to address them.

The materials specify a learning progression for the three dimensions addressed and used in the unit.

- **Teacher Background:** A table for the Focal DCIs and CCCs shows how the unit “builds upon ideas from earlier grades while also preparing students for ideas they will encounter in high school” (Teacher Edition, pages 18–19). An explanation is provided for parts of the DCI and CCC elements that are not directly addressed in the unit.

Teacher Background: The materials list SEP elements and CCC elements from the 3–5 grade band that would benefit students in the current unit. For example, “Students would benefit from having prior experience doing the following focal science and engineering practices (SEPs) at the 3–5 grade-band level” (Teacher Edition, page 20). The materials also explain how students engage with the focal SEPs, CCCs, and DCIs over the course of the unit (Teacher Edition, pages 16–17).

The materials provide guidance for the learning to progress logically in case units are taught out of sequence, or in case students have not experienced particular PEs or standards in elementary school:

- **Lesson 2:** “If you have not taught the Cup Design Unit, consider changing the prompts to focus around testing a single variable in an experiment that has been done in science class prior to this unit, and making parallels between the single variable use, to determine if a single potential cause has an effect on our mountains” (Teacher Edition, page 59).
- **Lesson 8:** “If your students have not experienced OpenSciEd Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit) and/or OpenSciEd Unit 6.3: Why does a lot of hail, rain, or snow fall at some times and not others? (Storms Unit), you may need to add a little time to this discussion to support your students in developing the key ideas of this discussion” (Teacher Edition, page 200). Key ideas from previous units are listed in the materials.
- **Lesson 14:** “Prior to middle school students will have had some experiences with fossils and begun to figure out some things about fossils [i.e., **3-LS4-1**, **4-EES1-1**, and **4-ESS2-1**]. If your students have not experienced these PEs in elementary school, you will need to build in time to support them in making sense of 1. What fossils are and why are found where they are found, and 2. What erosion and weathering are and the effects they have on the land” (Teacher Edition, page 295).
- **Teacher Background:** “It is important to note that this unit is reinforcing some elementary mathematics standards in a new context [...] thus, we anticipate that while some of the mathematics in this unit is aligned to upper elementary math development, it may be a new challenging context for students to apply the mathematics ideas” (Teacher Edition, page 21).

Across lessons, the “Where We Are Going and NOT Going” explains prior student learning and how the prior learning will be built upon. For example:

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- Lesson 2: “In the previous lesson, students created models and identified potential causes for mountain movement and growth. In this lesson, students will create a Potential Causes for Mountain Movement chart, where all potential causes from the initial models are listed” (Teacher Edition, page 59).
- Lesson 2: “In this lesson, students begin to develop an understanding of the words correlation and causation. While students may have a superficial understanding of these words at this moment, students will work to conceptually distinguish between these words as they begin to investigate the possible causes for mountain movement” (Teacher Edition, page 59).
- Lesson 4: “In this lesson, students build on their model of what it is like under the surface of Earth by revisiting the earthquake that occurred in Ridgecrest, California in 2019. [...]. In this lesson, students figure out there are sections of land that scientists call plates on Earth’s surface, and these plates are bounded between long lines of earthquake fault lines” (Teacher Edition, page 105).
- Lesson 10: “In the previous lesson, students considered whether the oceanic plate material has always existed in between Africa and South America. In this lesson, students will determine that the plate material may not have always existed, and consider what data they might need to show evidence of the two continents touching at some point in the past” (Teacher Edition, page 220).
- Lesson 13: “Students are using what we know about erosion and weathering from elementary grades to figure out how erosion affects land on Earth, specifically mountains, over time (i.e., **ESS1.A** and **ESS1.C**). [...] In this lesson students work with two rates, erosion rates and uplift rates” (Teacher Edition, page 270).

The materials provide brief explanations for how the lesson builds upon prior learning in the three dimensions in some of the “Supporting Students” callout boxes.

- Lesson 1: “SUPPORTING STUDENTS IN ENGAGING IN ANALYZING AND INTERPRETING DATA. [...] This is the first time students will begin thinking about causal and correlational relationships using data. In this first pass, students are only expected to be thinking about what causes mountains to change. But through the initial discussions in this lesson and the eventual investigations and discussions through the rest of the unit, students will progress in their ability to analyze data and identify causal vs. correlational relationships” (Teacher Edition, pages 39–40).
- Lesson 2: “SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY: [...] By spending a moment to discuss how looking at larger scales and elevations, and later depths and magnitudes, can contribute to our understanding of earthquakes, students will be better prepared later in the unit to use scale in a meaningful way to explain plate scale and changes to Earth’s surface as those plates interact” (Teacher Edition, page 66).
- Lesson 5: “SUPPORTING STUDENTS IN DEVELOPING AND USING SCALE, PROPORTION, AND QUANTITY. In prior lessons, representations of smaller areas of land have been studied, such as the land at Ridgecrest. [...] At this point in the lesson, this movement is being analyzed on a much larger scale. By looking at the earthquake lines and determining that these are plate boundaries, we can scale up the movement from an individual location or line to the section of

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entire tectonic plates, moving from the analysis of events, such as earthquakes, to the larger scale movement of entire plates” (Teacher Edition, page 133).

- Lesson 6: “SUPPORTING STUDENTS IN DEVELOPING AND USING STABILITY AND CHANGE. In this moment of the lesson, after students have made the connection between plate movement and earthquakes, the class pauses to reflect on how the event of an earthquake is usually sudden yet is a result of changes that have been occurring over a longer period of time (plate movement). This idea of sudden events we experience and see change the Earth that are due to mechanisms that happen over a longer period of time at a scale that we can't always see is new for students in middle school. This discussion will help begin to set the foundation for students to think in this new way” (Teacher Edition, page 160).

When appropriate, the materials describe that certain concepts will be developed in future lessons or in the next grade band.

- Lesson 5: “This lesson helps students see that the movement of mountain peaks and ranges on Earth is caused by plate movement. Though some students may ask, the fact that some mountains can also grow taller, while others shrink, is addressed in a later lesson. Also, though students may begin to infer that plate movement is due to temperature variation and bedrock creep, this concept will not be explored now as it is further developed in a later lesson” (Teacher Edition, page 130).
- Lesson 7: “There are a number of concepts and skills related to the content of this lesson that are beyond the scope of this lesson and the unit. Students describe the interaction and the resulting effects of an oceanic plate colliding with a continental plate. However, students should not be required to use scientific terms to name this type of interaction. To understand why an oceanic plate moves below a continental plate when they interact, students focus on the relative density of the bedrock that makes up each type of plate, and not on the composition” (Teacher Edition, page 168).
- Lesson 8: “Hotspots will not be discussed until high school, as the mechanisms for explaining them is above grade band. Scientists debate whether Iceland could be designated as a geological hotspot, or whether it's [sic] geologic activity is due to the plate boundary. We focus on activity that can be associated with plate boundaries, which tend to occur on the surface in the Southern region of Iceland” (Teacher Edition, page 168).

The materials point out common alternative conceptions that students may have and explains how the unit addresses these inaccuracies. For example:

- Teacher Background: “Students may also believe that plates are made of only one kind of crust, such as oceanic crust or continental crust, when in reality many of the plates have a combination of both. Because of that, this unit defaults to the term land masses when talking about places that have a combination of crustal types” (Teacher Edition, page 21).
- Teacher Background: “Many students may come to the unit thinking the inside of the Earth is liquid lava. This is because all the images they see of hot stuff coming out of the Earth is liquified rock, in the form of lava. In actuality, the mantle is made of molten rock (magma) that is more

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solid than liquid, but it behaves as a very thick semi-solid, similar to putty” (Teacher Edition, page 21).

- Lesson 2: The materials state “some students may believe that a mountain range needs to span countries or continents to be considered not just a string of mountains, but a range. A mountain range is simply a series of mountains connected by high ground, and even something as large as mountain ranges can vary in scale. If some students are intrigued or confused by the small scale of these mountain ranges, it may be worth stopping to operationally define the word mountain range as a class before proceeding with the lesson” (Teacher Edition, page 67).
- Lesson 6: The materials state “we are consciously choosing to use the term ‘oceanic crust’ and ‘continental crust’ in lieu of ‘oceanic plate’ and ‘continental plate’ with students in this lesson and future lessons to support them in figuring out the different properties and behaviors of each. While these terms have been used by others interchangeably, we believe it is important to help students understand that a plate can have both material (oceanic and continental crust) present, and when they are part of a plate they move together” (Teacher Edition, page 146).
- Lesson 8: “This storymap utilizes a flat map that can distort actual sizes of locations, leading some students to believe that some continents, countries, or regions are larger or smaller than in reality [...] Explain that our storymap was formed by taking the map of Iceland, which is located on a round globe, and was flattened to make it three dimensional, which may cause parts to be stretched” (Teacher Edition, page 192).
- Lesson 11: “Investigate the inaccuracies of a flat map. [...] Ask students to turn and talk about the differences between a flat map and a globe by considering the question on the slide. [...] Have them share what they saw. They should understand that while a flat map is easier for us to work with in this activity, it distorts the shape and size of the continents” (Teacher Edition, page 241).

Suggestions for Improvement

N/A

II.D. SCIENTIFIC ACCURACY

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

Rating for Criterion II.D. Scientific Accuracy

Extensive
(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials use scientifically accurate and grade appropriate scientific information because the science ideas and representations included in the materials are accurate.

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The materials draw data and information from reputable sources. For example, in Lesson 6, the materials state that “We used recommendations around these terminology as suggested in this reference: <https://pubs.usgs.gov/gip/dynamic/tectonic.html>.” In Lesson 13, the materials state that “References used in determining the approximations for erosion and uplift rate include: [...] <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2013JF002955>” and <https://www.npr.org/2020/11/24/938736955/how-tall-is-mount-everest-hint-its-changing>” (Teacher Edition, page 270).

Suggestions for Improvement

None

II.E. DIFFERENTIATED INSTRUCTION

Provides guidance for teachers to support differentiated instruction by including:

- i. Supportive ways to access instruction, including appropriate linguistic, visual, and kinesthetic engagement opportunities that are essential for effective science and engineering learning and particularly beneficial for multilingual learners and students with disabilities.
- ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.
- iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.

Rating for Criterion II.E. Differentiated Instruction

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials provide guidance for teachers to support differentiated instruction because the materials anticipate areas in which students might struggle and provide a variety of learning strategies that can support students as they strive to make sense of the phenomena during many of the critical learning activities. However, the strategies, resources, and guidance for supporting the different groups of students are not always explicit or consistent throughout the materials and extensions for students with high interest or who have already met the performance standards are not provided consistently.

The materials state that “Each unit includes strategies which are integrated throughout the OpenSciEd routines and are intended to increase relevance and provide access to science learning for all students. [...] Many of these strategies are discussed in the teacher guides in sidebar callout boxes titled

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'Attending to Equity' and subheadings such as 'Supporting Emerging Multilingual Learners' or 'Supporting Universal Design for Learning.' Other callout boxes with strategies are found as 'Additional Guidance', 'Alternate Activity,' and 'Key Ideas' and various discussion callouts" (Teacher Edition, pages 21–22).

The materials provide consistent guidance in each lesson to support the needs of students struggling to meet expected performances in the three dimensions. **However, the specific dimensions or elements are not always called out in the guidance.** Related evidence includes:

- Lesson 1: "If a student is struggling to get started on their model, remind them that our initial model is just that — our first attempt at explaining what we think is causing the changes to the mountains. Use Alternate: Initial Model to help students begin to develop their model so they have a scaffold to use as they think about the large and small scale causes for Mt. Everest to move and grow" (Teacher Edition, page 35). **However, the materials do not directly provide guidance for determining student progress towards a specific element of the three dimensions.**
- Lesson 2: "If students are not able to narrow the focus of their research to specific mountains, guide students to identify each mountain and range, and help students zoom into the data specific to those ranges. If students are having trouble discerning the data, help students adjust the earthquakes by magnitude to limit the amount of data shown, and reference the key to show differences in magnitude and depth. If there is too much data for students to analyze, instruct students to narrow the year range for their data by only playing a certain portion of the data slider" (Teacher Edition, page 76). **However, the materials do not directly provide guidance for determining student progress towards a specific element of the three dimensions.**
- Lesson 5: "Push students to then think more about what happens to some of the bedrock when it gets warmer. Ask, What happens to some of the bedrock as it gets warmer? If students struggle to respond, continue to use the image of the model from Slide B to encourage them to think about what we figured out in Lesson 3, specifically about how the temperature increases the further below the surface we go" (Teacher Edition, page 132). **However, the materials do not directly provide guidance for determining student progress towards a specific element of the three dimensions.**
- Lesson 5: "If students struggle to connect the idea of the deeper, warmer bedrock creeping and everything sitting on this bedrock moving as a result, remind students of what they saw happen with the cooler and warmer clay. Ask them what they suspect would happen if cooler clay pushes down on warmer clay. Explain, or show, that the cooler clay pushing down from above begins to deform the warmer clay below, causing the entire clay block to move or slide in one direction" (Teacher Edition, page 136). **However, the materials do not directly provide guidance for determining student progress towards a specific element of the three dimensions.**
- Lesson 8: "If students are uncertain about the evidence from each mountain supporting volcanic activity, revisit the cards for evidence of volcanic activity at each mountain card" (Teacher Edition, page 198). **However, the materials do not directly provide guidance for determining student progress towards a specific element of the three dimensions.**
- Lesson 11: "If students struggle to identify what support is stronger, have them consider which land masses have the most data supporting them, and therefore were easier to move and place.

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The more data they have that supports their positions, the stronger that support is. They should carefully record strengths and weaknesses since they will use this information when they join a jigsaw group to compare models” (Teacher Edition, page 242). However, the materials do not directly provide guidance for determining student progress towards a specific element of the three dimensions.

- Lesson 12: “If students struggle to make these connections, use questions, such as the following, to guide this part of the discussion [then ask]: As you developed your models using the continents, what helped you make decisions about where to place the continents?” (Teacher Edition, page 256). However, the materials do not directly provide guidance for determining student progress towards a specific element of the three dimensions.
- The Assessment System Overview color codes which dimensions are being assessed in all lessons. However, the specific grade-appropriate elements of the three dimensions are not referenced in the guidance for interpreting student progress with the three dimensions.

The materials provide some guidance to support the needs of multilingual learners. For example:

- Teacher Background: “...each unit includes the development of a Word Wall as part of students’ routines to ‘learning’ or ‘encountering’ scientific language” (Teacher Edition, page 22). The materials provide instructions for using a Word Wall with students (Teacher Edition, page 23). Guidance is provided to support students in developing vocabulary and adding to the Word Wall in Lessons 1, 2, 3, 4, 6, 7, and 13. For example, in Lesson 13, the teacher prepares “index cards, or half pieces of paper ready to add two words to the Word Wall” and an example is provided in the materials with the word definition of “erosion rate” and “uplift rate” along with images that illustrate the meaning of the word (Teacher Edition, page 269).
- Lesson 3: “If students need additional support as they examine the given sources of information—video, images, and information on Data Cards for Other Mountains and Mt. Everest—you can have them work in pairs or triads to discuss and document information they gather from the data sources. [...] This would be especially helpful for emergent multilingual students and those who need additional scaffolding for reading and/or writing” (Teacher Edition, page 88).
- Lesson 4: “Supporting Emergent Multilinguals: These three words have multiple meanings in English depending on how they are used, therefore including an image on the Word Wall card will support emergent multilingual students. To take this support one step further, you could ask for a student to add a definition for these three words in their native language. Teachers can support all students, particularly emerging multilingual students, in forming a deeper understanding of newly ‘learned’ vocabulary by representing the new term in multiple ways. For example, students can 1) write the term, 2) draw a representation of the term, 3) use their own words to write an explanation for what the term means, and 4) use the new term in a sentence” (Teacher Edition, page 118).
- Lesson 4: “Encourage students to express what they’ve learned using a mode that makes sense for them. For some emergent multilingual students, encourage them to use this space to make sense in the language that they feel most comfortable using. The individual Progress Tracker is a space for students to be creative and to synthesize learning in their own words. It is not

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supposed to follow a prescriptive plan or structure and should be a low-stakes opportunity for students to make sense of what they are learning without the worry and anxiety that comes with knowing their work will be graded. Use the Progress Tracker for formative assessment only” (Teacher Edition, page 121).

- Lesson 6: “Supporting Emergent Multilinguals: It is important to support all students, particularly emerging multilingual students, in forming a deeper understanding of newly ‘learned’ vocabulary by representing the ‘new’ term in multiple ways. For example, students can 1) write the term, 2) draw a representation of the term, 3) use their own words to write an explanation for what the term means, and 4) use the new term in a sentence. All of these representations would be appropriate to add to the Word Wall. [...] A pictorial representation could capture all the relevant characteristics in a way that is more accessible to emergent multilingual students and others” (Teacher Edition, pages 147–148).

One example was found where the materials provide strategies for students who are struggling with reading:

- Lesson 3: “Simplify the vocabulary in the text ahead of time and assign this revised version to those who struggle with reading. Video yourself or another student reading the text aloud, then upload the video to a site that students can access easily from home using a smartphone or other device. You can also choose to allow students to download the video (or an audio file) directly onto their portable devices while in class, since some students may not have internet access at home. Encourage students to use close reading strategies to help them annotate and better understand the text as they read. You can provide directions for students who need them, or you may already be using this type of strategy with some or all of your students. If the latter is the case, simply reminding students to use close reading strategies might be all that you need to do” (Teacher Edition, page 92).

Some of the strategies in the “Universal Design for Learning” callout boxes may be appropriate for students with special needs. **However, the materials do not specify for which students these strategies may be appropriate and do not provide consistent explicit support for students with special needs.**

Related evidence includes:

- Lesson 1: “Providing physical objects and spatial models to convey perspective can help support representation, according to the UDL framework,” and help “to support students in map reading” (Teacher Edition, page 32)
- Lesson 1: If students are struggling to start with their models, the teacher can provide students an “Alternate: Initial Model [which] has a mountain template from a side perspective. This handout can be used as an alternative to Explain How Mt. Everest Moves And Grows by providing a representation that allows students access to a place to represent their ideas about how Mt. Everest is changing” (Teacher Edition, page 34).
- Lesson 2: “As mentioned in the Materials Preparation section of this lesson, it may be beneficial for students who have enhanced visual needs to create a high-resolution, digital version of this map to share with them to help them better access the material. [...]” (Teacher Edition, page 66).

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- Lesson 10: “Universal Design for Learning[.] Some students may benefit from extra support in the perception of their data and need to physically move the continents back together. By providing pre-cut versions of the continents containing their datasets, we can support students in finding patterns between the two plates. This will allow students to move two static images together to determine if patterns of data hold between the two continents” (Teacher Edition, page 232).
- Lesson 12: “Universal Design for Learning[.] The maps from slides E–F can also be found in Satellite and Relief Maps. If students are having difficulty seeing the images being projected, or need assistance visually, consider increasing the accessibility of the images by printing these materials for students who could benefit from them. These maps can also be scaled up to be presented on 11x17 paper” (Teacher Edition, page 253).

Some of the strategies in the “Universal Design for Learning” callout boxes may be appropriate for students who have already met the PE or one of the targeted elements of the three dimensions. Related evidence includes:

- Lesson 3: “To optimize challenge and promote high expectations for your students, you may want students to revise their models prior to having them share the data they collected from the mining video, the images on the Earth Materials Found at the Mountain Sites cards, and the information and images on the Data Cards for Other Mountains and Mt. Everest from Lesson 1. This will give students the opportunity to think critically about their observations and apply what they learned. This, in turn, will give you the opportunity to see what kinds of earth materials each student observed in the various resources and how they are applying the data they gathered individually. If you choose to do this, you can also choose to let students revisit their models a second time after the class share-out and documentation of key ideas from the various sources of data” (Teacher Edition, page 89). **However, the materials do not specify for which students these strategies may be appropriate.**
- Lesson 6: “Universal Design for Learning: Whichever set of plate/crust rock types they are modeling, each group will observe basically the same patterns of movement when the plate sections are moving apart or sliding past each other. However, there may be multiple distinct patterns when plate sections move together. This is especially true for groups that are working to model the two different types of plates interacting, continental crust material and oceanic crust material. Because groups using two different types of plates will have more complex interactions to observe and record, consider assigning this model type to groups of students that have greater comprehension of developing and using models. This will provide them with a more challenging activity while allowing students in other groups to focus more directly on the practice of modeling itself, since they will have fewer variables to represent” (Teacher Edition, page 150).
- Lesson 7: “Universal Design for Learning: Some students may be ready to write a more extended response to question Question 2 at this point. The question refers to manipulables [sic] students used in both Lesson 6 and this lesson to allow those students who are ready to extend their engagement beyond just this lesson to synthesize what they have figured out up to this point in the unit in regards to causal and correlational relationships. If students are ready to make this

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connection, add in another question after Question 2 that asks how the changes that occur to cause volcanoes are similar or different than the processes that cause earthquakes to occur, and how this is related to the scale of the changes observed. Extend the existing second question on the slide to encompass earthquakes as well” (Teacher Edition, page 178).

Suggestions for Improvement

- Consider specifying for which students the strategies in the UDL callout boxes may be appropriate (e.g., students with special needs or students who have already met the targeted learning in the three dimensions).
- Rather than, or in addition to, providing generic strategies for students who may struggle with reading, offer scaffolding (e.g., strategies, graphic organizers, teacher prompts, and guidance) specific to the texts in the lessons.
- Consider explicitly identifying opportunities in the materials to extend learning for students who have already met the performance expectations in the three dimensions.
- For an extensive rating, consider providing specific and consistent examples and guidance throughout the lessons that support reading, writing, listening, and speaking alternatives for all groups of students. Include guidance on how to determine student understanding in the lessons and how the suggested supports will help students demonstrate progress toward the targeted element of the three dimensions.

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

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

- i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.).
- ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions.

Rating for Criterion II.F. Teacher Support for Unit Coherence

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials support teachers in facilitating coherent student learning experiences over time because frequent guidance or tools are provided to teachers to support linking student engagement across lessons, particularly in the Navigation Routines in each lesson. However, the materials provide few strategies for teachers to help students see how their learning in the three dimensions is relevant to their sense-making and progress toward explaining phenomena.

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Frequent guidance is provided in the Navigation Routines for teachers to support linking student engagement across lessons by providing explicit connections between lessons. However, in some cases there is little guidance for teachers to support linking student engagement from lesson to lesson or the guidance is unclear. For example:

- Lesson 2: “Say, Last class, we had several potential causes on our consensus models that could be leading or contributing to those changes and were wondering about which of these causes was most likely to cause these changes. Let’s take some time to remind ourselves about some of our ideas” (Teacher Edition, page 60).
- Lesson 3: “For home learning, you made some observations about what you found on the surface around where you live. What were some examples of things you recorded as finding on the surface near where you live? [...] Do you think you would find the same types of materials, or sediments, on the surface at the top of Everest? What about if you could dig down below the surface at the top of Everest?” (p Teacher Edition, age 86).
- Lesson 4: “If we could use the information we have from Lesson 2 about the Ridgecrest earthquake to develop a model of what the land looked like before and after the earthquake, how might that help us figure out what is happening at Mt. Everest to cause it to be growing? [...] Continue by saying, Let’s get ready to draw a cross section, or side view of the area within the rectangle, showing the elevation changes at the surface and what we would find below the surface, much like you did for your Everest model in Lesson 3” (Teacher Edition, page 115). However, there isn’t guidance for the teacher to help students understand why a model of Ridgecrest before and after the earthquake may be helpful or why developing a cross section model would be necessary.
- Lesson 5: “Revisit the Potential Cause for Mountain Movement chart. Display the Potential Cause for Mountain Movement chart. Say, Let’s revisit our chart and remember what we had concluded at the end of our last class. We listed a number of potential causes for mountains moving, growing, or shrinking on our chart. One of the potential causes we listed was plates” (Teacher Edition, page 131). However, the students may not see how this next step regarding plates connects to their learning from previous lessons.
- Lesson 6: “Say, So, we have been figuring out a lot about what plates are and how they move, and we’ve seen that mountains are near the edges of plates. We need some evidence to figure out whether plate movement causes mountains to get taller or shorter.” However, there isn’t guidance for the teacher to facilitate discussions or support students in understanding why plate movements would be related to mountains getting taller or shorter or why plate movements would be helpful to investigate.
- Lesson 12: Students examine Data Cards about other mountains. The teacher says “Let’s revisit what we have figured out about what causes mountains, like Mt. Everest, to continue to grow and move. [...] Okay, so we still want to figure out what causes a mountain to decrease in elevation and we think investigating more about the Appalachian Mountains and the Ural Mountains can possibly help us figure this out. So, let’s begin by looking back at some of our data cards that might help us explain why these mountains are not growing” (Teacher Edition, page 231).

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- The class also develops a DQB in Lesson 1 (Teacher Edition, page 50). Students revisit the board in Lesson 6 to “celebrate how many questions we can now answer from the DQB” (Teacher Edition, page 14). Students also revisit the board in Lesson 9 “to see what questions we can answer” (Teacher Edition, page 205). In Lesson 9, the class uses the DQB to generate the question, “What causes mountains and the land beyond them to move, grow, or shrink?” However, this question does not directly connect to the investigation of the Mid-Atlantic Ridge in the next lesson. Although the class revisits the DQB multiple times to see what questions they can answer, the materials do not regularly provide strategies for using students’ questions from the DQB or new questions that may arise during the lesson to drive the learning in the next lessons.

Many of the call out boxes in the materials provide strategies to support teachers in seeing how the learning in the unit is connected to the three dimensions. Strategies are also provided to support students with the SEPs and CCCs. However, few strategies are provided to help ensure that students see how their learning in all three dimensions is linked to the progress they make toward explaining phenomena. Related evidence includes:

- Lesson 3: “Tell students that these models they initially develop will be revisited and revised at strategic points throughout the lesson. This will give them the opportunity to engage in the Science Practice of **Developing and Using Models** in the same way as scientists as they investigate a phenomenon” (Teacher Edition, page 87). However, students are not supported to consider how their use of the SEP helps them to make progress towards explaining the phenomenon.
- Lesson 4: In the “Supporting Students in Developing and Using Scale, Proportion, and Quantity” callout box, the materials explain that “As students are working on this model, emphasize how the landscape might be changing or what changes would be felt or visible during the interaction of the foam pieces. Using this representation will allow students to study this interaction at a scale much more manageable for classroom purposes, and create a mental representation of what can happen to cause an earthquake, as well as subsequent potential changes that occur on the land” (Teacher Edition, page 111). However, students are not supported to consider how their use of the CCC helps them to make progress towards explaining the phenomenon.
- Lesson 7: Students are asked to reflect on the question “How did working with materials at a much smaller scale (the foam pieces, map data) help you be able to answer the question above?” (Lesson 7, Slide R). This reflection can support students in deepening their understanding of how the CCC — **Scale Quantity, and Proportion**: *Phenomena that can be observed at one scale may not be observable at another scale* — can help them to make progress towards explaining phenomena.
- Lesson 10: In the “Supporting Students in Engaging in Planning and Carrying Out Investigations” callout box, the materials suggest that “As students are comparing rates of change, ask students to consider if the changes over 10 years, 100 years, or 1,000 years would be noticeable on the larger world map” (Teacher Edition, page 223). However, how this suggested strategy supports students in seeing the connection between the SEP and what they are trying to figure out is not made clear.

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- Lesson 14: Students are asked to reflect on the DQB: “Which questions have we made the most progress on? What have we figured out?” The materials explain that “Revisiting the DQB at the end of the unit helps students see the progress they have made toward answering the questions that were important to them at the onset of the unit” (Teacher Edition, page 291). However, students are not supported to reflect on how their use of Asking Questions helped them to make progress towards explaining the unit phenomenon.

Suggestions for Improvement

- Consider including strategies that directly support students in seeing how their use of the SEPs, CCCs, or DCIs helps them to make progress towards explaining phenomena. For example, consider incorporating more prompts, reflections, and reminders strategically throughout the unit — such as the example illustrated above from Lesson 7 — where students are explicitly asked to reflect on how their learning and use of the CCCs, SEPs, or DCIs have helped them to make progress towards explaining phenomena in science. In Lesson 10, consider relabeling the “Planning and Carrying Out Investigations” callout box to help students explicitly consider the CCC element *Phenomena that can be observed at one scale may not be observable at another scale*.
- Consider including additional strategies for the teacher to use students’ questions, ideas, or reasoning to motivate the next step in the lesson to ensure that students see how what they are learning connects to what they figured out in previous lessons.

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

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

Rating for Criterion II.G.
Scaffolded Differentiation Over Time

Adequate
(None, Inadequate, Adequate,
Extensive)

The reviewers found adequate evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjust supports over time because although scaffolding for some SEP elements is introduced across different lessons, the scaffolding is not always reduced over time in a logical way that supports students in using the elements more independently over the course of the unit.

The materials clearly state where 11 targeted SEP elements are used or developed through specific lessons in the unit (Teacher Edition, pages 16–20). However, the initial scaffolding of the targeted SEP element is sometimes unclear, and the scaffolds are not always reduced gradually over time. For example:

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- **Developing and Using Models:** *Develop and/or use a model to predict and/or describe phenomena.* Students have some opportunities in the unit to increase their individual responsibility with this element, **although specific supports to learn about this element explicitly are not present.** Related evidence includes:
 - Lesson 1: Students develop initial models for the possible causes for the increase in elevation of Mt. Everest and for Mt. Everest moving. Students are asked to “discuss your ideas for what might be causing a mountain to be changing” with a partner (Teacher Edition, page 34) and are provided a partially completed model if needed as a scaffolding (Teacher Edition, page 34). **However, there may be a missed opportunity to support students in developing an understanding of this SEP.**
 - Lesson 3: Students develop models to represent what might be found at and below the surface at the top of Mt. Everest and are asked to “use symbols and words to label what they are representing in their model” (Teacher Edition, page 87).
 - Lesson 4: The materials provide specific instructions for the teacher to guide the class to construct a model of the Ridgecrest earthquake. For example, the materials instruct the teacher to “Add an arrow facing downward labeled ‘a few miles below the surface’ going from a spot on the surface of the Sierra Nevada Mountains downward” (Teacher Edition, page 106). **Since the teacher leads the class in developing the model, students do not take increasing responsibility for this practice. The materials also do not provide reflective prompts or strategies that would support students in developing their skills and knowledge with the SEP.**
 - Lesson 11: Students are provided cutouts of the continents in baggies (Teacher Edition, page 237) which they assemble in their groups to develop a model for where they think the continents would have been located millions of years ago based on data. The teacher asks students to define the pieces of their model “Let’s look at these pieces. What are these pieces we are seeing? What do they represent?” (Teacher Edition, page 240). Students then work in groups to “consider their positioning of the land masses based on the data type they are analyzing” (Teacher Edition, page 242). **However, there is no evidence that the element-specific strategies used in the lesson are reduced over time in the unit.**
 - Lesson 14: Students develop a model to show how sea lily fossils are found naturally exposed at the top of Mt. Everest (Lesson 14, Fossil Assessment). The assessment includes blank spaces for students to develop their models and brief instructions, such as “Include in your model how this could account for there being a sea organism found here.” Compared to the scaffolds provided in the Lesson 1 models, this assessment is evidence of scaffolds being removed by the end of the unit.
- **Engaging in Argument from Evidence:** *Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.*
 - Lesson 2: Students have five minutes to respond to the prompt “Do you think earthquakes are causing changes in mountain elevation, or just correlated with the changes?” and then “share their ideas with a partner and receive feedback on the

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evidence they have used to support their argument” (Teacher Edition, page 73).

However, there may be a missed opportunity to support students in developing an understanding of this SEP.

- Lesson 6: Students make claims about which of their plate interactions models best explains the changes in Mt. Everest and “write a few sentences explaining why this model best represents what is happening at Mt. Everest.” Students are asked to include “evidence from their notebook and/or artifacts in the classroom as part of their explanation to support the claim.” Compared to Lesson 2, students work independently on this task.
- Lesson 8: Students cite evidence from the Mid-Atlantic Ridge storymap to support or refute their claims and create a written argument about what is happening between where two plates are moving apart. Students share their claims and evidence with a partner using a protocol in which “Partner A will share their claim and their evidence used to support or refute their claim. Partner B will listen and give feedback to Partner A about: Whether their evidence supports or refutes the claim. What evidence could also be used by Partner A to help make their argument stronger?” (Teacher Edition, page 195). Since students work in pairs and use a structured protocol to discuss the strengths of their claims, scaffolds do not appear to be gradually reduced over time in this lesson as compared to Lesson 6.
- **Using Mathematics and Computational Thinking**
 - Students engage with **Using Mathematical and Computational Thinking** in two lessons across the unit. First students use a digital tool (Seismic Explorer) in Lesson 2 (*Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends*) and then perform calculations using proportions in Lesson 13 (*Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems*). Since students engage with two different elements of the SEP in two different lessons, students may not have sufficient opportunities to build proficiency with each element of this focal SEP category.

Teacher supports are sometimes, **but not consistently**, provided to help students (including those with special needs and abilities) explicitly build an understanding and proficiency in specific elements of the SEPs over time through a variety of approaches over the course of the unit. For example:

- Lesson 1: A partially completed model is provided as a scaffolding for students who might need a scaffold for **Developing and Using Models** (Teacher Edition, page 34).
- The materials include multiple callout boxes that **sometimes** provide strategies for supporting students with the SEP **Developing and Using Models**. As an example, one of the callout boxes says “Here are some additional prompts to help students develop their cross section model or make their ideas more explicit: How are you representing the differences in elevation across the country in your model? Can you label the different locations on the map that are represented in your model?” (Teacher Edition, page 114).
- Lesson 1: Sentence starters are introduced that can support students in the practice of **Engaging in Argument from Evidence**. For example, “Give evidence for your idea or claim: My evidence is

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____. The reason I think that is ____” (Teacher Edition, page 36). Students are asked to refer back to this chart in Lesson 12 when they “construct a scientific explanation of how the Appalachian and Ural Mountains were formed” (Teacher Edition, page 264).

- Lesson 11: Sentence stems are provided for students to determine the strengths and weaknesses of their group models. For example, “The data shows that _____. This position is supported by that evidence because _____. The data from land mass _____ is less strong because _____” (Lesson 11, Slide F). *However, this scaffolding is introduced late in the unit and does not appear to be gradually reduced over time.*
- There are many callout boxes that provide strategies for scaffolding the SEPs. *However the materials do not have any callout boxes for **Engaging in Argument from Evidence**, although this SEP is claimed as a focal SEP.*

Suggestions for Improvement

- For SEPs being developed and used in the unit (or for the focal SEPs), consider introducing mini-lessons, strategies, or scaffolding at the beginning of the unit when students first engage with an SEP element. For example,
 - This NSTA [article](#) provides clear examples of explicit scaffolding for **Developing and Using Models** that could be introduced to students at the beginning of the unit. Then consider strategically reducing these scaffolds in the materials whenever students re-engage with that SEP element. Consider also including an explanatory note for the teacher about the fading of these scaffolds to increase awareness that students should be taking increasing ownership and responsibility for the SEPs over time.
 - If the unit focuses on supporting students in developing part of the SEP category **Using Mathematical and Computational Thinking**, students will ideally have multiple and sufficient opportunities to engage with each element from the practice over time rather than just having students engage with a different element from the practice in each lesson.
- Consider adding additional and clear guidance for supporting all students (including students with disabilities) for the SEP elements being developed and especially the focal SEPs claimed.
- Consider leveraging the callout boxes to support teachers in scaffolding the SEPs that are claimed as focal SEPs in the unit. For example, the first few callout boxes for the SEP could introduce students to appropriate scaffolding such as sentence stems, graphic organizers, or manipulatives, etc. Later in the unit, the callout boxes could instruct the teacher to gradually reduce this scaffolding to increase student ownership and responsibility for the practice.

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

CATEGORY III

MONITORING NGSS STUDENT PROGRESS

III.A. MONITORING 3D STUDENT PERFORMANCES

III.B. FORMATIVE

III.C. SCORING GUIDANCE

III.D. UNBIASED TASK/ITEMS

III.E. COHERENT ASSESSMENT SYSTEM

III.F. OPPORTUNITY TO LEARN

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III.A. MONITORING 3D STUDENT PERFORMANCES

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

Rating for Criterion III.A. Monitoring 3D Student Performances

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials elicit direct, observable evidence of students using practices with core ideas and crosscutting concepts to make sense of phenomena or design solutions because the materials routinely elicit direct, observable evidence that students are integrating the three dimensions in service of sense-making or problem solving in varied ways, *However, not all tasks require students to use grade-appropriate elements of the SEPs or CCCs.*

The Assessment System Overview specifies the observable student evidence of three-dimensional learning in each of the lessons. *However, students do not always fully use the grade-appropriate elements of the three dimensions in the assessments.* For example:

- Lesson 1: Students are expected to “**Develop a model** showing what is happening at a scale larger than we can see (**patterns**) to help explain **what happened to the different mountains to (cause)** them to **change (in elevation and/or location).**” The materials tell the teacher to “Collect students’ initial models on Explain How Mt. Everest Moves And Grows and Explaining other mountains that shrink at the end of day 1 and day 3” (Teacher Edition, page 302) as the assessment artifact.
- Lesson 4: Students are expected to “**Develop a profile model across the North American plate to explain the changes seen in bedrock after an earthquake** by showing what is found **at and below the observable surface**” and evidence of this learning can be found in the “Constructing Profile Model West and East of Ridgecrest” handout from Day 2 (Teacher Edition, page 304). In the task, students answer the question “What do you think happened to the solid bedrock just under the surface across this entire area that could help explain why we saw a shift and change in elevation in the surface of the land at the time of the earthquake?” (Teacher Edition, page 111). The CCC element claimed for this assessment is **Scale, Quantity, and Proportion: Phenomena that can be observed at one scale may not be observable at another scale.** Although students are asked to make claims about what they believe might happen under the surface of the area at Ridgecrest, *students are not directly asked to reason or think about what is observable or unobservable at the different scales.*
- Lesson 6: Students are expected to “**Construct an argument supporting a model of how plate interactions could cause mountains and earthquakes.**” The materials specify that evidence of this learning can be found when students construct two explanations on Day 3 of the lesson: “(1) After students have written their arguments supporting the model they think best explains what is happening at Mt. Everest and (2) how earthquakes happen” (Teacher Edition, page 305).

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The SEP element claimed for this assessment is **Engaging in Argument from Evidence**: *Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. However, students are not directly asked to include scientific reasoning in their arguments.*

Formal assessment tasks in the materials are driven by phenomena and require students to use the three dimensions. For example:

- The “Assessment System Overview” states that Lessons 1, 11, 13, and 14 include summative assessments opportunities that can be used to evaluate student performance (Teacher Edition, page 300).
- Lesson 11: Students are expected to use “models they have co-developed of where the continents might have been in the past based on multiple data sets” in order to “explain why the evidence they have from the data sets supports the model they created and where the continents will be in the future” (Teacher Edition, page 300). The materials specify that this assessment can be used as an opportunity to formally assess student learning. *However, the three-dimensional targets are not specified for this particular piece of student evidence.*
- Lesson 13: Students are expected to “Apply mathematical concepts (proportional relationships and unit rates) from the unobservable processes of erosion and plate movement over time to figure out how much Mt. Everest and Mt. Mitchell are changing now and use these to predict how much they would change in the future.” The materials specify that evidence of this learning can be found in the “Erosion Rates vs. Uplift Rates” at the end of the lesson (Teacher Edition, page 314).
- Lesson 14: Students are expected to “Construct an explanation based upon prior investigations and evidence that gradual changes have caused marine fossils to become exposed on mountains due to erosion (accumulating) over time and those gradual changes will lead to the destruction of the marine fossils due to erosional processes over time” (Teacher Edition, page 308). The materials specify that the “Fossil Assessment,” in which students develop a model and explanation for how sea lily fossils can be found naturally exposed at the top of Mt. Everest, can serve as evidence of student learning in **MS-ESS2-2** (Fossil Assessment Answer Key, page 333).

Suggestions for Improvement

- Consider modifying assessment tasks, questions, prompts, or scaffolding so that students use the grade-appropriate elements of the three dimensions. In cases where students may develop part of an element in a lesson, the materials could explain that only a part of the element is being assessed and how the remaining parts of the element will be assessed in a later lesson.
- Consider specifying the three-dimensional targets for all assessment opportunities, and especially the summative assessments, that are called out in the materials as student evidence for monitoring three-dimensional learning. For example, see Lesson 14 where specific targets and elements are mentioned at the end of the final summative assessment (Teacher Edition, page 333). This could support teachers to see the connection more clearly between the student artifacts and the targeted elements of the three dimensions.

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III.B. FORMATIVE

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

Rating for Criterion III.B. Formative

Extensive
(None, Inadequate, Adequate, Extensive)

The reviewers found extensive evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction. The materials include explicit, frequent, and varied support for formative assessment processes. However, **the formative assessments do not routinely attend to issues of equity for different learners.** The “Assessment Opportunity” sections in all lessons state the three-dimensional learning goals and include specific guidance for “What to look/listen for” and “What to do” if students do not fully meet the learning target along the three dimensions. For example:

- Lesson 2 Assessment Opportunity: Students are expected to “**Use digital tools to examine a large data set** at different **spatial and temporal scales** to compare **global earthquake activity to local activity.**”
 - **“What to look and listen for:** Look for students to locate mountain regions identified in case site information and narrow focus to earthquake data that applies to those areas that would not be discernible at a larger scale. Students should filter through earthquake data and analyze the large sets of earthquake data for any patterns in depth, location, frequency, or magnitude at the regional scale for evidence of earthquakes being causal or correlational to mountain movement and growth.”
 - **“What to do:** If students are not able to narrow the focus of their research to specific mountains, guide students to identify each mountain and range, and help students zoom into the data specific to those ranges. If students are having trouble discerning the data, help students adjust the earthquakes by magnitude to limit the amount of data shown, and reference the key to show differences in magnitude and depth. If there is too much data for students to analyze, instruct students to narrow the year range for their data by only playing a certain portion of the data slider” (Teacher Edition, page 76).
- Lesson 10 Assessment Opportunity: Students are expected to “**Analyze maps displaying patterns of large sets of data** to determine that **Africa and South America could have been touching at the Mid-Atlantic Ridge (spatial relationship) between roughly 125 and 146 million years ago.**”
 - **“What to look/listen for:** Look for students to state in their claim that the two continents were once touching at the Mid-Atlantic Ridge. Students should cite all datasets to show that the plates were touching. Students should include the following reasons when justifying how the data supports their claim: [reasons are listed e.g.]

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Evidence of past glaciers: glacier data fits like a puzzle piece if the continents were moved together. [...]

- **What to do:** [...] Use the pre-cut pieces of continents with the data on them to move the continents back together so that they touch. Ask students if the data shown on the cards presents any patterns that span the two continents. After students have identified that the data shows a pattern across the two continents, allow students to revise their work” (Teacher Edition, page 223).

Formative assessments *sometimes, but not regularly* attend to issues of student equity and access by including strategies to help interpret and respond to the different ways students may demonstrate their thinking related to the learning targets.

- Lesson 1: Students who are struggling can be provided a partially completed model “so they have a scaffold to use as they think about the large- and small-scale causes for Mt. Everest to move and grow” (Teacher Edition, page 35).
- Lesson 5: The materials provide three different ways for students to show their predictions using foam boards, a projected map, or by manipulating an image on a slide. “There are numerous ways for students to physically or digitally show where the North American plate segment may be located in the future [...]” (Teacher Edition, page 135).
- Lesson 4: Students are allowed to express their learning in different modes in their progress tracker: “Encourage students to express what they’ve learned using a mode that makes sense for them. For some emergent multilingual students, encourage them to use this space to make sense in the language that they feel most comfortable using. [...]” (Teacher Edition, page 121). *However, the materials do not provide guidance for interpreting or responding to the different modes in which students may express their learning.*
- Lesson 8: Students are asked to “Support or refute a claim in writing and orally” and guidance is provided on how to help with students who may be struggling: “If students have listed irrelevant evidence in their chart, revisit the evidence collected with the student, and ask if the evidence helps the student try to explain what is happening at the ridge, or if it is a disconnected observation. Push students to explain the connection and how it could be used to support or refute a claim” (Teacher Edition, page 194). *However, students are not provided multiple ways to demonstrate their thinking and strategies are not provided for the teacher to attend to the different ways students might express their understanding.*
- Lesson 13: “Depending on when in the year you teach this unit, your students may need more or less scaffolding with the mathematics used in this assessment. [...] Some students may need some scaffolding in these conversions. See ‘Erosion Rates vs. Uplift Rates’ for more guidance” (Teacher Edition, page 285). *However, the materials only suggest the teacher “pause and talk through this (i.e., calculations) with the class” (Teacher Edition, page 328) and alternative strategies or ways for students to express their learning are not provided.*
- Lesson 14: In the summative Fossil Assessment, students need to read five paragraphs of text, develop a model, and construct written explanations for the phenomenon presented in the text. *However, strategies for making this assessment accessible to all students are not presented.*

Suggestions for Improvement

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- For an extensive rating, consider routinely adding guidance for attending to issues of equity whenever an assessment opportunity is called out, especially if the assessment requires reading or writing to demonstrate learning. Strategies could be provided particularly for assessments that are critical learning steps in the unit and summative assessments.
- Consider specifying which SEP, CCC, or DCI elements are being assessed in each assessment opportunity and providing a clear way for teachers to interpret students’ progress in the three dimensions. For example, the materials could describe which element students are engaging with in the assessment and provide examples of students’ responses that show the different levels of proficiency with that element.

III.C. SCORING GUIDANCE

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

Rating for Criterion III.C. Scoring Guidance

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials include aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions because assessment targets are clearly stated and grade-appropriate elements of the dimensions being assessed are incorporated into the scoring guidance throughout the unit. **However, assessments do not always provide guidance on assessing multiple possible levels of student responses or student proficiency along the three dimensions.**

Example student responses are provided for three-dimensional student performances in each lesson. For example:

- Lesson 2: “Look for students to locate mountain regions identified in case site information and narrow focus to earthquake data that applies to those areas that would not be discernible at a larger scale. Students should filter through earthquake data and analyze the large sets of earthquake data for any patterns in depth, location, frequency, or magnitude at the regional scale for evidence of earthquakes being causal or correlational to mountain movement and growth” (Teacher Edition, page 76).
- Lesson 3: “Look for students to adjust their models to include solid rock at or just below the surface of Mt. Everest, and they should also indicate that the temperature of the rock deep below the surface is increasing with depth. They might include a thin layer of loose sediments (soil, dirt, broken rocks) at the surface, but may not, since the image they have seen of Mt. Everest shows exposed rock at the surface” (Teacher Edition, page 91).

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- Lesson 12: “Students’ scientific explanation should include the following key ideas: [e.g.] The Appalachian Mountains were formed approximately 470 million years ago and the Ural Mountains were formed more than 300 million years ago by the same processes that continue to cause the formation and growth of mountains today—the collision of plates [...]” (Teacher Edition, page 264).

Scoring guidance tools provide the teacher with enough information to enable modification of instruction for each Assessment Opportunity in all lessons. For example:

- Lesson 2: “If students try to create a causal relationship [rather than a correlational relationship] between the events [i.e., earthquakes and mountain growth and movement], ask students if any ground cracked or changed in elevation or location during the videos watched. Students should state that the ground momentarily moved, but did not visibly change” (Teacher Edition, page 73).
- Lesson 3: “If students’ revisions to their models do not reflect the things we have figured out from the information we gathered from video, images, and readings, have students revisit the following: ‘Materials Found At and Below the Surface,’ Images on Slides I–M or ‘Earth Materials Found at the Mountain Sites’ cards, ‘Data Cards for Other Mountains and Mt. Everest’ from Lesson 1” (Teacher Edition, page 91).
- Lesson 5: “If students struggle to make this connection [i.e., establishing a causal link between plate movement and mountain movement], consider giving students more time to investigate plate movement using Seismic Explorer. Prompt students to pay particular attention to the direction of the arrows near the specific mountain peaks from the case studies. Ask students whether it seems like the mountain peak is moving in the same direction indicated by the arrows on the map” (Teacher Edition, page 139).
- Lesson 12: “If students’ scientific explanation does not include the key ideas listed above, you can: [e.g.] Revisit the simulation, stopping at strategic points and ask students to describe what they observe and how it can be used as evidence to explain how and when the Appalachians and the Urals were formed. [...]” (Teacher Edition, page 264).

Scoring guidance is not provided for assessing multiple possible levels of student responses or student proficiency. For example:

- Lesson 1: The materials state that the teacher should “Listen for questions that are open (how/why) and testable versus closed (yes/no) in the classroom. Also listen for questions that are specific to Mt. Everest, the mountain case sites, and related phenomena involving land and landforms changing over time. See the related Assessment callout box for additional guidance” (Teacher Edition, page 302). Although success criteria are specified, **the materials do not provide guidance for how to assess multiple possible levels of student proficiency. In the scoring guidance, it is not clear which dimension or element of the three dimensions claimed is being assessed through each of the criteria.**
- Lesson 6: The materials state that the teacher should look in students’ models for “connections between the components and relationships in students’ models and the real-world phenomena they represent, such as the following: Referring to the foam pieces as ‘plates’ as they work with

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them; Describing a change in height of a foam piece as a ‘change in elevation’; [...]” (Teacher Edition, page 305). Although success criteria are specified, **the materials do not provide guidance for how to assess multiple possible levels of student proficiency and do not specify which criteria are aligned to an SEP or CCC element claimed in the assessment.**

- Lesson 9: The materials specify that as the class constructs a causal chain model for how a mountain changes, the teacher should check that students explain that “Magma is moving, liquidy rock that is found far below the surface; Magma moving makes the plates on the surface of Earth move; Plate movement changes the surface of Earth when they interact or spread apart” (Teacher Edition, page 306). Although success criteria are specified, **the materials do not provide guidance for how to assess multiple possible levels of student proficiency and do not specify which criteria align to the targeted SEP or CCC elements.**

Summative assessments do not provide guidance on assessing levels of student proficiency in the three dimensions. Related evidence includes:

- Lesson 11: In the assessment, students construct explanations for where Earth’s land masses (plates) were located millions of years ago (Teacher Edition, page 307). The answer key provides examples of acceptable student responses (Teacher Edition, pages 324–326). **However, the scoring guidance does not refer to specific elements of the three dimensions being assessed and does not support teachers in determining the extent to which students are meeting the expected performance in each of the three dimensions.**
- Lesson 13: In the “Erosion Rates vs. Uplift Rates” assessment, students use computational reasoning about rates of erosion and plate movement to “figure out how much Mt. Everest and Mt. Mitchell are changing now and use these to predict how much they would change in the future” (Teacher Edition, page 308). The answer key provides guidance for how to score student responses (Teacher Edition, pages 328–329). **However, a rubric or a range of sample student works that would support the interpretation of student progress in relation to the three dimensions is not provided.**
- Lesson 14: In the summative assessment, students develop a model and explain how “how and why marine fossils are exposed on many of the mountain ranges” such as the sea lily fossils on Mt. Everest (Teacher Edition, pages 330–332). The answer key provides scoring guidance such as “Explanation should include: Over time. Forces such as rain, wind, and ice break down the landscape; After the materials are broken down, they are moved to a new location through erosion [...]” and the elements being assessed in the three dimensions are listed (Teacher Edition, page 332). Although a rubric or range of sample student works would support the interpretation of student progress in relation to the three-dimensional elements being assessed, **these supports are not provided.**

Suggestions for Improvement

- Consider including scoring guidance in all formative assessments for how to determine the extent to which students are accomplishing or achieving proficiency along each of the three dimensions claimed. For example, a simple table or rubric that describes criteria for “meeting” and criteria for “approaching” might be included for these assessment opportunities.

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- Consider including culturally responsive strategies to help elicit, interpret, and respond to student thinking related to the learning targets in more of the formative assessment opportunities.
- In the Assessment Guidance in all lessons, consider clarifying or distinguishing which criteria could be used to assess the specific SEP, CCC, and DCI elements claimed in the assessment. This could support teachers in interpreting student progress along each of the three dimensions.
- Considering including scoring guidance for summative assessments that specify criteria that would constitute a response that “meets,” “approaches,” or “exceeds” the LLPE. This could be supported by sample student responses that show levels of student use of each dimension.

III.D. UNBIASED TASK/ITEMS

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

Rating for Criterion III.D. Unbiased Task/Items

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because assessments are generally fair and unbiased. However, teacher guidance, scaffolds, strategies, or notes are not consistently provided to help all students complete the tasks successfully and demonstrate their learning, and students do not have a choice of response modalities for any major assessment tasks.

Vocabulary, representations, and scenarios in assessments are generally fair and unbiased. However, there are missed opportunities to provide explicit appropriate scaffolds and multiple modes of communication to help students complete the task successfully. Related evidence includes:

- The materials provide guidance for developing and using a Word Wall in the unit (Teacher Edition, page 23). However, the materials do not specify how or if the Word Wall may be used as scaffolding during assessments.
- Lesson 2: “When developing new vocabulary, strategies that may benefit emergent multilingual learners are to use student-friendly definitions, make connections to cognate words when possible, and include a visual representation of the word. Use these strategies throughout the unit for both ‘words we earn’ and ‘words we encounter’” (Teacher Edition, page 61). However, the materials do not specify how or if this strategy may be used as scaffolding during assessments.

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- Lesson 2: The materials suggest that students can be provided scaled up versions or digital versions of the map in order to analyze the “Satellite and Relief Maps” data in the lesson (Teacher Edition, page 253).
- Lesson 3: Strategies are provided to support students struggling with reading: “Simplify the vocabulary in the text ahead of time and assign this revised version to those who struggle with reading. Tell students that they are to complete the reading at home and to be prepared to share additional key ideas about the things that we would find below the surface where we live. Video yourself or another student reading the text aloud, then upload the video to a site that students can access easily from home using a smartphone or other device. [...]” (Teacher Edition, page 92). However, the materials do not specify how or if this strategy may be used as scaffolding during assessments.
- Lesson 13: The assessment requires students to use computational thinking to determine “What will Mt. Mitchell and Mt. Everest look like in the future?” (Teacher Edition, pages 328–329). However, the assessment only includes words and blank boxes for students to record their answers. There may be a missed opportunity to incorporate multiple modes of communication in the assessment such as presenting the scenario in a diagram, video, simulation, or model or providing scaffoldings such as graphic organizers or manipulatives to support students with computational thinking (about rates and proportions).
- Lesson 14: The assessment requires students to read a five-paragraph text to understand what the phenomenon is about and the text includes vocabulary such as “tropical organism,” “crinoid,” and “fragments.” While the text is appropriate for the grade level, scaffolds or alternative representations are not provided to on-ramp students to the novel phenomenon in the assessment. Additionally, although images are provided of the fossil, there is potentially a missed opportunity to label the images with the appropriate vocabulary word to provide multiple representations of key words from the text.

The assessment opportunities across lessons offers a structured variety in the modalities expected for students' responses. For example:

- Lesson 1: Students develop questions about what causes could lead to land and landforms, such as mountains, to change over time. Students record their answers on sticky notes and place them on the DQB (Teacher Edition, page 49).
- Lesson 2: Students “Present an oral and written argument that earthquakes either caused or are correlated to the elevation and location changes of the mountain cases and Ridgecrest, California” (Teacher Edition, page 73).
- Lesson 2: Students show their ability to use digital tools to examine large data set by manipulating the Seismic Explorer simulation to show “patterns in depth, location, frequency, or magnitude at the regional scale for evidence of earthquakes” (Teacher Edition, page 76).
- Lesson 4: Students analyze plate movement data and use the “North American Plate” manipulative to show their understanding by predicting “where the North American plate segment may be located in the future” (Teacher Edition, page 135).
- Lesson 4: The materials note that students should be allowed to express their learning on the Progress Tracker in a mode that makes the most sense to them (Teacher Edition, page 121).

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- Lesson 7: Students construct an explanation for where Earth’s continents were located millions of years ago through writing and modeling (Teacher Edition, page 245).
- Lesson 10: Students make a claim with evidence and reasoning to answer if “Africa and South America could have been touching at the Mid-Atlantic Ridge (spatial relationship) between roughly 125 and 146 million years ago” (Teacher Edition, page 233). *However, there may be a missed opportunity to provide students with multiple modalities for expressing their learning and understanding in this assessment.*
- Lesson 14: Students construct an explanation for a fossil that is found exposed on a mountain top through writing and modeling (Teacher Edition, pages 331–332).

Suggestions for Improvement

- For an extensive rating, consider including at least one significant task that provides students with a choice of responses across multiple modalities. Although students are given a choice of response modality in their Progress Tracker (Teacher Edition, page 121), this is unrelated to scoring.
- For all of the assessment opportunities in the unit, and especially on summative assessments, consider explicitly pairing the task with specific strategies (e.g., scaffolds, multiple modes of communication, graphic organizers, alternative representations) that are likely to increase access for students to comprehend the task and complete the assessment successfully.
- Whenever possible, consider providing suggestions for ways that assessments or scenarios in assessments can capitalize on the funds of knowledge students bring to the classroom. This strategy could potentially increase engagement for all students and help students understand why the science matters to them. For example, earthquakes are significant in many cultures and to many communities. A potential assessment task could have students examine earthquakes in a region that they are interested in or that they connect with locally or personally.

III.E. COHERENT ASSESSMENT SYSTEM

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

Rating for Criterion III.E. Coherent Assessment System

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning because most assessments connect to learning goals and require students to apply grade-appropriate elements of at least two of the three

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dimensions to make sense of phenomena or solve problems. However, specific elements of the three dimensions are not specified for all assessments.

The materials contain pre-, formative, summative, and self-assessment that measure three-dimensional learning. For example:

Pre-Assessment

- The materials mention one pre-assessment opportunity in Lesson 1. In the lesson, “The student work in Lesson 1 available for assessment should be considered a pre-assessment. [...] The initial models developed on the first and third days of Lesson 1 are a good opportunity to pre-assess student understanding of Earth’s systems, including how land can move and change” (Teacher Edition, page 300). The materials note that in the assessment, students should “include a variety of mechanisms for the changes to Mt. Everest,” which may align to the CCC, **Cause and Effect**. However, the notes do not explicitly mention how the assessment connects with all of the three dimensions in the three-dimensional learning target or provide criteria that align with all three dimensions.

Formative

- The “Lesson-by-Lesson Assessment Opportunities” outlines the three-dimensional formative assessment opportunity for each lesson in the unit. As an example, in Lesson 6, the opportunity to assess three-dimensional student performance — “Develop and use models showing what is happening at varying spatial and time scales to describe how plates interact at plate boundaries” — is when students “develop representational models of plate interactions on day 2 [of the lesson]” (Teacher Edition, page 305). Assessment Guidance accompanies each of these opportunities. While the scoring guidance can sometimes be matched to a specific element of the three dimensions, the Assessment Guidance notes do not indicate how the assessment connects with the three dimensions.
- The materials state that “the Progress Tracker can be used to formatively assess individual student progress or for students to assess their own understanding” (Teacher Edition, page 301). Students add to the Progress Tracker throughout the unit. However, the materials do not explain how the Progress Tracker can be used to assess learning progress with the three dimensions.
- The materials highlight formative assessments that are particularly important to assess readiness for upcoming lessons or performances. For example, in Lesson 13, “Students use erosion rate data and uplift rate data to predict how Mt. Everest and Mt. Mitchell will potentially be changed over time into the future. This could be used formatively informing whether students are ready for the assessment in the following lesson where students will need to apply this idea that there are opposing processes affecting changes to the surface of Earth” (Teacher Edition, page 300).

Summative

- The materials describe three opportunities for summative assessment in the unit. In Lesson 11, students use models to “explain why the evidence they have from the data sets supports the model they created and where the continents will be in the future.” In Lesson 13, students “use erosion rate data and uplift rate data to predict how Mt. Everest and Mt. Mitchell will

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potentially be changed over time into the future.” In Lesson 14, students use what they know about “plate tectonics and the processes of weathering and erosion, they develop a model and explain how this fossil can be at the top of Mt. Everest and how it can be seen at the top of Mt. Everest without having to dig to find it” (Teacher Edition, page 300). However, the materials do not explicitly mention how each of the summative assessments connects with all three of the dimensions in the three-dimensional learning target or provide criteria that align with all three dimensions.

Self-Assessment

- Assessment System Overview: The materials mention that “The student self-assessment discussion rubric can be used any time after a discussion to help students reflect on their participation in the class that day. Choose to use this at least once a week or once every other week” (Teacher Edition, page 301). The rubric includes criteria such as “Shares one’s own thinking by contributing new ideas, questions, and additional clarification” (Teacher Handbook, page 63). However, students are not asked to reflect on their progress with the three dimensions or the three-dimensional learning goal.
- Assessment System Overview: The materials mention that the self-assessment rubrics in the “Peer Feedback Facilitation: A Guide” can be “very valuable for their three-dimensional learning and for learning” (Teacher Edition, page 301). The rubric includes criteria such as “Gave feedback that was specific and about science ideas” and “Used evidence from investigations, observations, activities, or readings to support the feedback or suggestions I gave” (Teacher Handbook, page 66). However, students are not asked to reflect on their progress with the three dimensions or the three-dimensional learning goal.
- The Handbook includes an Example Modeling Rubric and an Example Argument Rubric that can be used as a template for teachers to develop rubrics to use in the unit (Teacher Edition, pages 67–68). However, these rubrics aligned to the SEPs are not used in the assessments in the unit.
- Lesson 4: Students self-reflect on the use of different models so far in the unit: “What were the challenges for you of developing this representation of such a large section of land on the Earth? What are some ideas you have for materials or layout to use in future models like this that would make representing the system easier?” (Teacher Edition, page 122). However, there is no scoring guidance or support for students or teachers to determine the degree to which the intended learning in the three dimensions was accomplished.

The assessment system components present are generally coherent, working together to provide information about student learning. However, how the focal SEPs, CCCs, or PEs are measured across the unit in a coherent way is not clear in the materials. Related evidence includes:

- The materials state that the unit builds towards four PEs: **MS-ESS1-4**, **MS-ESS2-1**, **MS-ESS2-2**, and **MS-ESS2-3** (Teacher Edition, page 16). The answer key for Lesson 14 indicates that the assessment potentially assesses **MS-ESS2-2**. A note is provided in Lesson 13 that students will need to use **MS-ESS2-1** in the lesson in order to “reason out where the energy source must be that is causing the magma in the mantle to move which in turn moves the plates and results in changes to the surface” (Teacher Edition, page 283). Additionally, all fourteen lessons claim to build towards all four PEs (Teacher Edition, pages 25, 55, 81, 101, 125, 141, 165, 185, 205, 217,

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235, 247, 267, and 287). However, the materials do not directly explain where there are opportunities to assess each of the PEs claimed in the unit or how to know the degree to which students can successfully perform these PEs.

- The “Assessment System Overview” indicates assessment opportunities for each lesson; together these assessments provide information about student learning across the unit. For example, the materials mention that the assessment in Lesson 4 focuses on **Developing and Using Models** and **Scale, Proportion and Quantity** and that the teacher should check students’ models include “differences in elevation across the North American plate” and “some type of sediment at the surface in the lower elevation areas” (Teacher Edition, page 304).
- Although Focal SEPs and CCCs are claimed — for example, “**Using Mathematical and Computational Thinking**” (Teacher Edition, page 15) and “**Stability and Change**” (Teacher Edition, page 16) — the materials do not provide an explanation of how these focal dimensions are assessed or measured across the materials or by the end of the unit.

Suggestions for Improvement

- Consider explaining where and how the students’ progress or proficiency with the PEs, focal SEPs, and focal CCCs claimed in the unit is assessed. For example, consider providing an explanation, table, and additional criteria or guidance that conveys how and in which assessments the focal SEPs, CCCs, and PEs can be measured across the unit in a progressive way.
- Consider providing explicit opportunities for students to self-reflect their progress toward specific learning goals. Additionally, consider aligning the self-assessment rubrics with the three dimensions or the three-dimensional learning goals to better support students and teachers to assess progress with three-dimensional learning.
- Consider aligning the criteria in the Assessment Guidance (“What to Look/Listen For”) to the dimensions being targeted for all assessment opportunities. As an example, in the Assessment Guidance for Lesson 4, consider indicating which element of the three dimensions is being assessed when looking to see if students include the criteria “differences in elevation across the North American plate” (Teacher Edition, page 304) in their models.
- Although Lesson 11 is suggested as a mid-unit checkpoint, this lesson occurs toward the end of the unit. Consider embedding another formative/summative checkpoint earlier in the unit so students have increased opportunity to improve.

III.F. OPPORTUNITY TO LEARN

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

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Rating for Criterion III.F. Opportunity to Learn

Adequate
(None, Inadequate, Adequate, Extensive)

The reviewers found adequate evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts because there are clear assessment opportunities for students to demonstrate their growth in proficiency over time with **some, but not all**, of the claimed focal SEPs, CCCs, and DCIs.

The materials claim four focal SEPs (**Developing and Using Models, Using Mathematics and Computational Thinking, Constructing Explanations and Designing Solutions, and Engaging in Argument from Evidence**) and three focal CCCs (**Cause and Effect; Scale, Proportion and Quantity; and Stability and Change**) (Teacher Edition, page 1).

Assessment opportunities for **Developing and Using Models** are claimed in Lessons 1, 3, 4, 6, and 14. In Lessons 3 and 14, students have opportunities to demonstrate growth in proficiency over time with the claimed SEP. In Lesson 1, students develop an initial model to explain how Mt. Everest moves and grows and explaining other mountains that shrink. In Lesson 3, students “revisit their [initial] models and make changes using data as evidence to support their thinking” (Teacher Edition, page 303). In Lesson 14, students develop a time-series model to show how fossils appear naturally exposed at the top of Mt. Everest (Teacher Edition, page 308).

Assessment opportunities for **Using Mathematics and Computational Thinking** are claimed in Lessons 2 and 13. In Lesson 2, students use a digital tool, Seismic Explorer, to “locate mountain regions identified in case site information” and “filter through earthquake data and analyze the large sets of earthquake data for any patterns in depth, location, frequency, or magnitude at the regional scale for evidence of earthquakes being causal or correlational to mountain movement and growth” (Teacher Edition, page 302). In Lesson 13, students perform calculations such as “If erosion rates stay at 9.3 mm/year and uplift rates stay at 20 mm/year, how much will the elevation of Mt. Everest potentially change in” in order to figure out what Mt. Everest (and Mt. Mitchell) will look like in the distant future (Teacher Edition, pages 328–329). However, because one of the tasks requires students to manipulate a digital tool and the other lesson requires students to perform calculations using proportional reasoning, **these two lessons do not provide evidence that students are receiving feedback on this practice and have opportunities to demonstrate their growth in proficiency with this practice over time.**

Assessment opportunities for **Cause and Effect** are claimed in Lessons 1, 2, 5, 6, 8, and 9. In Lesson 1, students identify factors that may be causing mountains to shrink or grow (Teacher Edition, page 48). In Lesson 2, students learn about the difference between causal and correlational relationships. The class uses “lines that are dotted to represent correlational connections between the potential causes and events” and “solid lines to show causal relationships between the causes and events” (Teacher Edition, page 60). In Lesson 5, students update the “Potential Cause for Mountain Movement” chart and “should suggest changing the lines connecting ‘plates’ to the movement of Mt. Everest and all other mountains,

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from dashed lines to solid lines.” The teacher asks students to then “explain what this change represents by asking, Why is it important that we change this from a dashed line to a solid line? What does this say about our thinking at this moment?” (Teacher Edition, page 139). In Lesson 8, students continue to update the chart as a class as they realize that “We also see magma and volcanoes at some locations at the Ridge, but it is not always correlated with increases in elevation in the landscape that it is currently in” (Teacher Edition, page 198). In Lesson 9, students develop a class model representing the causal and correlational relationships that explain mountains growing or shrinking (Teacher Edition, page 215). At the end of the lesson, students record their response to the question “What causes a mountain to change in height or location?” (Teacher Edition, page 214). While not explicitly mentioned in the student-facing prompt, the Assessment Guidance tells the teacher to check that students distinguish causal versus correlational relationships in their response: “Some students may include correlational events as part of their causal explanation, such as earthquakes or volcanoes. If they do, encourage them to [...]” (Teacher Edition, page 215).

Students have opportunities to receive and use teacher feedback on key claimed learning in the unit. In all of the formative assessment opportunities, the Assessment Guidance tells teachers to provide hints, prompts, or scaffolding to students as feedback if they are struggling with a particular performance. The materials also suggest that “For this unit, Peer Feedback works best for Lessons 8, 10, 13, and 14 during the consensus moments where students are sharing their consensus models, or after an investigation where students share what they figured out with peers” (Teacher Edition, page 301). *However, because the recommendations for peer feedback are generic and not linked to the three dimensions, students may or may not receive peer feedback on their progress with the claimed focal SEPs, CCCs, or DCIs.*

The materials claim that each lesson builds towards four of the PEs addressed in the unit. *However, as noted previously, the assessment opportunities for each of the PEs are not clearly indicated in the materials and where students have multiple opportunities to demonstrate their growth in the claimed PEs are unclear.*

Suggestions for Improvement

- Consider ensuring that the assessment opportunities called out in the materials allow students to demonstrate growth in a logical manner in the focal SEPs, CCCs, and DCIs, as well as the PEs claimed in the materials. For example, if students are expected to demonstrate proficiency with proportional reasoning in Lesson 13, opportunities would ideally be called out in the materials for students to develop, receive feedback, and improve on this practice before the assessment (as opposed to performing a separate skill like using a digital tool in Lesson 5). The materials might also explain how the assessment opportunities allow students to receive feedback and demonstrate growth with specific elements of the three dimensions claimed in the unit.
- Consider providing more opportunities for students to receive and apply peer feedback on the claimed focal elements of the three dimensions across the assessment opportunities over time. For example, the Gallery Walk could be used multiple times throughout the unit as an opportunity to have students look for and provide feedback to each other on particular success

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criteria derived from specific elements of the SEPs, CCCs, or DCIs. Students could then have opportunities to revise their work based on peer (and teacher) feedback.

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

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SCORING GUIDES

SCORING GUIDES FOR EACH CATEGORY

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

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

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

OVERALL SCORING GUIDE

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Scoring Guides for Each Category

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

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

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

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