Where Do Natural Hazards Happen and How Do We Prepare for Them?

DEVELOPER: OpenSciEd

GRADE: Middle School **|** **DATE OF REVIEW:** August 2021

Where Do Natural Hazards Happen and How Do We Prepare for Them?

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
3	2	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	Extensive	**A.**	Monitoring 3D Student Performances	Extensive
B.	Three Dimensions	Extensive	**B.**	Student Ideas	Extensive	**B.**	Formative	Adequate
C.	Integrating the Three Dimensions	Extensive	**C.**	Building Progressions	Inadequate	**C.**	Scoring Guidance	Adequate
D.	Unit Coherence	Extensive	**D.**	Scientific Accuracy	Extensive	**D.**	Unbiased Tasks/Items	Extensive
E.	Multiple Science Domains	Extensive	**E.**	Differentiated Instruction	Extensive	**E.**	Coherence Assessment System	Extensive
F.	Math and ELA	Extensive	**F.**	Teacher Support for Unit Coherence	Extensive	**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, and it is strong in several areas such as anchoring student learning around a relevant and engaging phenomenon and incorporating three-dimensional learning outcomes and tasks to drive sense-making. The unit provides a high-quality series of tasks where students increase their proficiency in the three dimensions such as in differentiating correlation and causation.

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

- **Scoring Guidance and Feedback:** Consider providing guidance at the element level for CCCs and SEPs to assist with teacher feedback and modification of instruction.
- **Differentiation:** Consider providing additional supports or leveled texts for students who read well below grade-level.
- **Scaffolded Development of SEPs:** Consider providing explicit support and guidance for teachers around how specific targeted SEPs are developed over the course of the unit.

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.

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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 and/or designing solutions. An intriguing phenomenon of tsunamis anchors the lessons in this unit. Students return to the phenomenon throughout the unit, adding new learning to their understanding of what causes tsunamis, where tsunamis occur, how to detect tsunamis, and how to communicate risks of tsunamis and other natural hazards to the community. In addition to the anchoring phenomenon, students also engage in two engineering tasks and design solutions to problems. The engineering task of developing a process to communicate the risks of natural hazards requires students to develop elements of the science DCI as well as ETS DCIs. However, the engineering task of selecting the best solution to mitigate the effects of a tsunami does not require grade appropriate elements of the targeted science DCI (**ESS3.B**).

Students return to the anchoring phenomenon throughout the unit and add new understandings to further explain the phenomenon.

- Lesson 1: The anchoring phenomenon of a tsunami in Japan is presented with video and reading selections.
- Lesson 2: Students use data in the form of maps to investigate where tsunamis occur and how tsunamis are generated.
- Lesson 4: An explanation that describes the geologic forces that cause a tsunami is written and students use their understanding of this science idea to complete an assessment task based on a novel scenario.
- Lesson 5: Students evaluate methods that are used in Japan and other places to mitigate the effects of a tsunami.
- Lesson 6: A tsunami detection system is investigated by students.
- Lesson 7: Students read first-hand accounts of tsunami survivors from Japan and then consider the different stakeholders that need to be warned in the event of an approaching tsunami.

- Lesson 8: The class co-constructs a model of systems necessary to put into place a communication plan for communities.

Student questions and prior experiences are used to drive learning and make sense of the phenomenon and solve the engineering problem. Student questions arise at the beginning of the unit and are arranged in a Driving Question Board (DQB) that is organized by the teacher and the class. The class returns to answer these questions in Lessons 3, 4, and 9. However, because driving questions are included in the Student Edition, students may not feel that their questions are driving learning throughout the unit.

- Student questions about the phenomenon are generated in the beginning of the unit and these questions guide initial investigations. Lesson 1: "Connect to related phenomena. Ask students to turn and talk to a neighbor about natural hazards they've experienced, been affected by, have read or heard about, or are simply interested in. Give them 2 minutes to discuss" (Teacher Edition, page 31).
- Lesson 1: Students generate questions individually, then with a partner, and finally in a scientist circle to create a DQB.
- Lesson 1: "Develop the unit question. Ask students to come up with an overarching question that could drive the whole unit. Say, We first looked closely at one tsunami that devastated Japan in 2011, and we thought about solutions to help people who may experience a tsunami in the future. Then we began to think about other natural hazards--ones that may happen close to us, ones we have heard about, and ones our family members experienced. Based on our thinking around tsunamis, we began thinking about how we can detect when other hazards occur, how we can warn people about them, and what we can do to reduce the damage. Can anyone share an idea for a main question that puts all our questions together? What is a question that will help us capture this? Call upon several students to share their ideas. Listen for any question similar to Where do natural hazards happen and how do we prepare for them? and then repeat it aloud, asking the class if that sounds like a useful main question for the unit. When there is general agreement, write that question as the title at the top of the DQB, using the wording the class came up with" (Teacher Edition, page 36).
- Lesson 1: "Connect to local hazards. Display slide M. Say, In the last unit we noticed that earthquakes tend to happen more frequently in certain places. Does anyone remember where? Call on a volunteer to show the locations on the World Map and explain that earthquakes tend to occur most frequently along the boundaries of plates on Earth's surface. Say, This means that communities in those areas are more at risk for experiencing an earthquake. Ask students to think about which natural hazards are more likely to happen in their communities, and whether there are things they know about those hazards that may help us think about designing solutions for the tsunami hazard. Give them 4 minutes to individually complete the remaining prompts in Part 5. Remind them to be prepared to share these ideas and examples with the class" (Teacher Edition, pages 31–32).
- Lesson 2: After looking at patterns in where tsunamis occur and what types of geological processes occur in these areas, the following suggested prompt is provided during a building understanding discussion: "After looking at this data, do you have any new questions?" (Teacher Edition, page 44)
- Lesson 2: "Encourage students to ask their family or friends what natural hazards have happened in their local area in recent years (or any area the students have lived in previously, if

they are new to the community). If this investigation already occurred during Lesson 1, it does not need to be repeated" (Teacher Edition, page 55).

- Lesson 2: At the beginning of Lesson 2, support for navigating from the previous lesson is provided. "Use these ideas to motivate the need to look at tsunami data. Say, Last time we were wondering where tsunamis happen in the world. Scientists have been tracking tsunamis for a while, and we are going to look at that data today. So our question is, 'Where do tsunamis happen and what causes them?' …Say, Before we look at any data, what ideas do you have about where tsunamis happen? Why do you think they happen there?"
- Lesson 4: Students revisit the DQB to see what questions they are able to answer and what questions remain to be answered.
- Lesson 5: At the end of Lesson 5, a connection to the next lesson comes from a class discussion. "Determine next steps. Project slide V. Bring students back together and have them discuss the following prompts with a partner: We looked at 8 different solutions for Ryoishi. Each solution seemed like it would work, but both the seawall and breakwater failed to fully protect the towns. If a solution fails, like if a seawall breaks, what else can be done to protect the people in the community from the tsunami? Are there other design features you brainstormed from the tsunami phenomenon in Lesson 1 that we could look into? Make a connection to the anchoring phenomenon. Allow students to share ideas for protecting citizens from their initial ideas on Tsunami: Japan 2011. Many of these will include warning systems to let people know about the tsunami. Use those ideas to navigate by saying, So, it sounds like we have some ideas of how we can still detect and warn people in case a solution fails to protect a community. Let's look at that next." Printed in the Student Edition (page 19) is the question, "How are tsunamis detected and warning signals sent?" Students may look ahead and read the driving question, therefore leading to students feeling that their questions are not driving the learning.
- Lesson 7: "Assign Home Learning. Display slide G. Say, As you experience communication outside the classroom between now and the next class, pay attention to all the ways you send and receive communication. Think about whether there are any ideas from your experience that we should consider. Jot these down and bring these ideas with you to class next time" (Teacher Edition, page 137). These ideas are then considered to be added to as new ideas the next day. "Add new ideas from Home Learning. Remind students of their home learning assignment and ask them if they noticed any new information, we should consider regarding ways we send or receive communication. Ask, Did you notice where you send and receive communication outside of school? For example, what information did you notice on signs, through talking, or on an app?" (Teacher Edition, page 137).
- Lesson 9: "The intention of this lesson is to have students investigate local hazards that their own community is at risk for or a natural hazard that sparks their interest or curiosity. While it is important for students to understand how to prepare for and respond to a hazard in their own community, some students might have high interest in other natural hazards that they hear about on the news or have affected family or friends. Students may also have past experiences with learning about and preparing for their local hazards, and may already know what to do and how to respond in the event that a hazard strikes. The lesson is written as though the hazard is a local hazard, but this lesson can be modified to include other hazards that impact other communities in the US (based on students' experiences and/or interests)" (Teacher Edition, page 164).
- Lesson 9: Students revisit the DQB to mark questions on which they have made progress.

In the engineering talk in Lesson 9, students develop science ideas from grade-appropriate DCIs; however, students develop science ideas from Grade 3–5 DCIs in the engineering task in Lesson 5.

- Lesson 9: The engineering task requires student understanding of the ESS DCI element stating how the history of natural hazards in an area can be used to predict future risk. Students use maps of historical occurrences of a chosen natural hazard in developing their communication plan (Handout, Hazard Communication Plan).
- Lesson 5: The science ideas necessary for the engineering task involve an understanding of waves and energy of waves. (**PS4.A**: **Wave Properties**) This is at the 3–5 grade band and does not incorporate more sophisticated science ideas about waves from the 6–8 grade band, including using mathematical representations to describe how the amplitude of a wave is related to the energy.

Suggestions for Improvement

- Consider communicating with teachers the rationale for returning to the DQB a limited number of times during the unit. Consider clarifying the engineering problems in the unit.
- Consider developing a routine for generating student questions that will authentically lead to the next lesson.
- Consider providing guidance to teachers on the use of the Student Edition. Withholding the pages for the next lesson until the class has completed the end of lesson navigation will increase student's perception that their ideas are driving the unit.

I.B. THREE DIMENSIONS

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

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

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

The reviewers found extensive evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because students regularly engage in the three dimensions to make sense of the anchoring phenomenon and design solutions to problems.

Science and Engineering Practices (SEPs) | **Rating: Extensive**

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The reviewers found extensive evidence that students have the opportunity to use or develop the SEPs in this unit because students are engaged in SEPs for a sufficient amount of time based on the length of this unit, and there is a strong match between the SEPs claimed and the evidence of development and use of SEPs in the materials. The following SEPs have been identified as the targets for this unit:

Analyzing and Interpreting Data

- *Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.*
  - Lesson 2: Students look at maps of where tsunamis have occurred to look for patterns in their locations. The following guidance is provided for teachers to assist in providing scaffolding for students: "Maps are tools used to display data to reveal important spatial patterns. This first map provides an overall indication of where tsunamis happen (and where they don't) and information about related causal geologic forces. Consider students' familiarity with map reading and orient them to the map so they can interpret it appropriately. Use slide D to help scaffold this. The map denotes different causes for tsunamis with colors and shapes, allowing students to access the categories of data in different formats. Here are some helpful prompts: What is the title of this map? What do the symbols mean? How would you describe the pattern for where most tsunamis occur? What about where they do not occur? Could we describe that too?" (Teacher Edition, page 44).
  - Lesson 2: Students analyze a data set to figure out why some earthquakes cause tsunamis and others do not. Students work in groups of two to three on this activity, and a handout is provided. "The handout, Connecting Earthquakes and Tsunamis, has questions to guide student construction and analysis of the graphs, particularly focused on choosing independent and dependent variables, and then to guide observation and interpretation of the results. It might be helpful to read Step 1's instructions aloud as a whole class so students are clear about the analysis task. Detailed instructions with screenshots from the Tuva dataset are provided in Tuva Graphing Instructions" (Teacher Edition, page 50).
- *Analyze and interpret data to provide evidence for phenomena.*
  - Lesson 3: Students collect data from three different models in order to gather information to answer their questions about tsunamis. Students are provided with a handout to record their observations (What I see column) and how it helps explain tsunamis (What it means column). "Students will make "What I see" and "What it means" statements for each model used in this lesson. This is similar to the Identify and Interpret (I^2) sensemaking strategy (used for numeric data and graphs) in helping students break down information-rich data into smaller pieces to interpret, enabling them to use the data to provide evidence for a phenomenon" (Teacher Edition, page 62). In this task, students are using skills previously learned in a prior OpenSciEd unit.
  - Lesson 3: "Share interpretations to make sense of the model. Display slide C. Say, Now let's pause and reflect on how what we saw happen with the waves in the pan can help us understand how tsunamis form and move. We'll do this for each of our three models. Give students 5 minutes to work with a partner to complete the first row of Wave Investigations with their interpretations of the model" (Teacher Edition, page 64).

- *Distinguish between causal and correlational evidence for phenomena.*
  - Lesson 2: During a discussion about historical tsunamis and earthquake location, teachers are supported with the following: "This is a good place to highlight that correlation does not always mean causation. In a real sense, just because an earthquake happens does not mean a tsunami will form. Ask students, If an earthquake happens anywhere in the world, can we predict whether a tsunami will form? What evidence can support our ideas?" (Teacher Edition, page 47).
  - Lesson 2: "Revisit how we talk about apparent relationships between things or events. Remind students of previous words they earned in the Everest Unit: correlation, or when two things seem to be related to each other, and causation, when one thing causes another thing to happen. Place these words on the Word Wall if they are not there. At this point, students have figured out that earthquakes and tsunamis are related, but they must keep in mind that correlation does not always mean causation. Although not all earthquakes are associated with tsunamis, it seems that some are. The next step is to investigate the causal link between earthquakes and tsunamis. Similarly, tsunamis seem to occur on colliding plate boundaries, but we have not established a causal relationship, so this is also only a correlation" (Teacher Edition, page 48).
  - Lesson 2: After examining more data, the class constructs a cause-and-effect diagram to determine if a causal relationship exists (Teacher Edition, page 52).
  - Lesson 2: Causal relationships found in data sets about earthquakes and tsunamis are summarized (Teacher Edition, page 53)

Using Mathematics and Computational Thinking

- *Use mathematical representations to describe and/or support scientific conclusions and design solutions.*
  - Lesson 2: Data sets are represented in maps and graphs. Students analyze the maps and graphs to understand the relationship of tsunamis and earthquakes (Teacher Edition, pages 43–51).
- *Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends*
  - Lesson 9: Students use a digital map to determine the risk for specific natural hazards in their area. The following teacher guidance is provided: "Orient students to the data provided within the digital tool and the expectations for analyzing the large data set. Model one hazard together as a class to help students understand how they can use the large data set to identify general regional patterns of risk as well as their local level of risk. If students have worked with many large data sets, less orientation and scaffolding may be necessary" (Teacher's Edition, page 165). While digital tools are used to view the data, they are not used to assist with the analysis of the data.

Constructing Explanations and Designing Solutions

- *Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.*
  - Lesson 4: Students use the Tsunami Chain of Events which was created as a class as well as the information from reading to individually construct an explanation for a tsunami

event. On the assessment, students are provided with information about various earthquakes and locations with the intention of using the relationships between these variables to explain which areas would be most at risk.

- *Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.*
    - Lesson 1: As part of the introduction of the phenomenon, students brainstorm and then make a model of ideas about how to detect tsunamis, warn people of an oncoming tsunami, and reduce the damage caused by tsunamis (Teacher Edition, page 26).
    - Lessons 2–4: The class collaboratively creates a "Tsunami Chain of Events" that provides a visual explanation of the geologic forces that create tsunamis.
    - Lesson 4: Students use the Tsunami Chain of Events which was created as a class as well as the information to individually construct an explanation for a tsunami event. On the assessment, students are provided with information about various earthquakes and locations with the intention of using the relationships between these variables to explain which areas would be most at risk.
- *Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system.*
    - Lesson 8: The "Tsunami Chain of Events" created by the class is used to design a process for detection of tsunamis and mitigation of the harmful effects of a tsunami (Teacher's Edition, pages 150–151).
- *Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.*
    - Lesson 5: Students prioritize criteria based upon Ryoshi's needs. Students engage in a discussion regarding what might be most important to Ryoshi and students individually identify primary and secondary criteria and constraints. Students then work with a partner to reanalyze their solutions and update their choice for which solution they believe is the best.

Engaging in Argument From Evidence

- *Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.*
    - Lesson 1: Students evaluate designs by writing down the idea that has the most promise and the one that seems most challenging and explaining why (these prompts are provided by the teacher). Students then use the responses to engage in a class discussion to find patterns in what makes solutions promising or challenging in order to begin the process of developing design criteria. "Purpose of this discussion: To identify patterns in what makes some engineering ideas more promising or challenging than others. As students may be unfamiliar with tsunamis or with evaluating engineering designs by considering criteria and constraints, responses during this discussion will vary. Listed below are some patterns which students may notice. However, it's important at this point not to point these out. They will likely emerge as students progress through the storyline in this unit. At the end of the discussion, return to the ideas that we reached consensus around (e.g., this group of solutions may be easier to deploy quickly, these may be cheaper, these may save more lives or protect more property, and so forth). Take this opportunity to introduce the terms criteria and

constraints that can be used to evaluate solutions for tsunamis and related phenomena. This will encourage students to think about tsunamis from an engineering perspective, and may support them in asking more engineering-related questions when they construct the DQB" (Teacher Edition, page 31).
    - Lesson 5: Students use a systematic approach to "evaluate the designs and their performance by analyzing a video of the existing solutions in a wave tank" by determining a rating scale. Later they use a decision matrix to weigh "the evidence for each solution and comparing the evidence across solutions to figure out which solution may or may not be most appropriate for this community" (Teacher Edition, page 98).
    - Lesson 7: Students use class developed criteria and constraints to evaluate communication systems from five different communication case studies. Teachers are advised: "As groups engage in this discussion, center their focus on how their evidence can be useful for evaluating claims and persuading others about the validity of their ideas. When students are engaged in the work of argumentation, they should explicitly build from evidence, past experiences, and/or shared observations to support their conclusions" (Teacher Edition, page 138).
- *Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.*
    - Lesson 5: Students watch a video of engineers demonstrating models of different solutions to lessen the impact of tsunamis and evaluate their effectiveness using the criteria they have developed in order to rank their solution using the evidence collected from their observations. Students then engage in a class discussion. "Once the rankings are complete, ask, So, based on what we saw happen with each of the suggested solutions, what should we recommend to Ryoishi and why? In addition to the amount of water that made it past each type of solution, are there other considerations we need to account for? Let students share some ideas and explain why they would choose one over the other based on what they saw on the video and the criteria they have in place" (Teacher Edition, page 98). However, this argument is not based upon the advertised performance of a solution.

Obtaining, Evaluating, and Communicating Information

- *Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).*
    - Lesson 6: Students use a close reading strategy to read the "How are tsunamis detected and warning signals sent?" Students begin the reading by identifying the purpose for the reading, and are provided with prompts to use while reading in the associated slide to help them identify the key ideas of the reading. Students use the ideas from this reading to discuss the following prompts: (Lesson 6, Slide D)
        - What do people need to know in order to prepare for a tsunami?
        - What must a tsunami detection and warning system be able to do?
        - How can we make a diagram of a tsunami detection and warning system working together?

- Lesson 9: Students read internet references to gain information about a natural hazard of their choosing. They read with the purpose of gathering information that will be used in their final project. (Teacher Edition, pages 150–151)
- Lesson 9: "At this point in this final lesson, students will focus on critically obtaining important information from a text adapted for classroom use, alongside some additional resources. They will need to integrate that information and decide how to communicate it with others in a relevant, effective, and/or engaging way. To support this practice, use questions like: What is the main idea about how this hazard impacts people? Or, What are the three most critical pieces of information to communicate about ______." (Teacher Edition, page 171).

- *Communicate scientific and/or technical information (e.g., about a proposed object, tool, process, system) in writing and/or through oral presentations.*
  - Lesson 9: Students individually respond to the following prompt: "Explain which hazard you are at most risk for in your local community. Use evidence from the maps to support your explanation. If there are additional sources of data that you would want to study, also include those ideas in your explanation" (Lesson 9, Slide D)
  - Lesson 9: Students communicate the results of their research on a natural hazard to a targeted group of stakeholders.

The following SEPs are used by students in the unit. They are not indicated as focal SEPs to be both developed and used throughout the unit.

Asking Questions and Defining Problems

- *Ask question that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.*
  - Lesson 1: Students work individually to generate questions about tsunamis and other natural hazards based upon their earlier reading, pictures and video, their previous home learning and discussions, as well as questions regarding the engineering designs for these hazards. After constructing questions individually, students work with a partner to refine their questions.
- *Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.*
  - Lesson 1 (page 26): Students brainstorm ideas to detect tsunamis, warn people of their approach, and reduce damage caused by a tsunami. Then they begin a discussion of possible criteria and constraints for their solutions and begin to evaluate the effectiveness of different design ideas. While students are provided with a problem that can be solved, they do not define the design problem on their own.

Developing and Using Models

- *Evaluate limitations of a model for a proposed object or tool.*
  - Lesson 3: After interacting with three wave models, students reflect on the benefits and limitations of each model. Concluding the activity, the class is asked "How did looking at

more than one model help us in our analysis of an earthquake-driven tsunami? Students should say something about how each model helped us figure out some things about water waves and how they move, but that we were able to get a more complete understanding of the behavior of water waves when we considered all three models" (Teacher Edition, page 72).

- *Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.*
    - Lesson 8: The class creates a system model showing the subsystems of the tsunami chain of events and the ways to protect people and property. Colors are used to show the subsystems and arrows are used to show interactions between the subsystems. However, this model is not used to generate data (Teacher Edition, pages 150–151).
    - Lesson 8: Supporting Students in **Developing and Using Models**: "Students gain experience with this practice through multiple opportunities to construct a model of a system and its interactions, including first categorizing the parts of the subsystems and then working together as a class to develop a consensus system model of the whole system" (Teacher Edition, page 50).

Disciplinary Core Ideas (DCIs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the DCIs in this unit because students have multiple opportunities to use and develop grade appropriate DCI elements to make sense of phenomenon and design solutions to problems.

ESS3.B: Natural Hazards

- *Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.*
    - Lesson 1: "Connect to local hazards. Display slide M. Say, In the last unit we noticed that earthquakes tend to happen more frequently in certain places. Does anyone remember where? Call on a volunteer to show the locations on the World Map and explain that earthquakes tend to occur most frequently along the boundaries of plates on Earth's surface. Say, This means that communities in those areas are more at risk for experiencing an earthquake. Ask students to think about which natural hazards are more likely to happen in their communities, and whether there are things they know about those hazards that may help us think about designing solutions for the tsunami hazard. Give them 4 minutes to individually complete the remaining prompts in Part 5. Remind them to be prepared to share these ideas and examples with the class" (Teacher Edition, pages 31–32).
    - Lesson 1: The following suggested prompt is provided for a class discussion: "How do you think people determine which places are at risk for a natural hazard?" Suggested responses include: "Maybe look at some maps that show where natural hazards have occurred in the past" (Teacher Edition, page 34).
    - Lesson 2: Maps of the occurrence of tsunamis and the locations and magnitudes of earthquakes are analyzed to establish a cause-and-effect relationship. That relationship

is then used to forecast places on Earth that may be at risk for future tsunamis. Understanding geologic forces is the focus of Parts 6 and 7 of the lesson and in the handout "Connecting earthquakes and tsunamis".

- Lesson 3: "Revisit Tsunami Chain of Events. Point to the Tsunami Chain of Events and say, In the last few days, we've figured out how tsunamis form. Now that we understand the Tsunami Chain of Events, we can use what we know to forecast which communities are most at risk for tsunamis. Pass out Forecasting Risk to Communities" This is followed by a full class discussion in which students discuss what locations are at most risk of a tsunami resulting from an earthquake in the Pacific Ocean.
- Lesson 4: Students make a prediction for which of four locations is most in danger from a tsunami based on the location of an earthquake; however, students do not use historical mapping to make this prediction.
- Lesson 9: Students use a digital map to determine the risk for specific natural hazards in their area.
- Lesson 9: Students individually respond to the following prompt: "Explain which hazard you are at most risk for in your local community. Use evidence from the maps to support your explanation. If there are additional sources of data that you would want to study, also include those ideas in your explanation" (Lesson 9, Slide D).

ETS1.A: Defining and Delimiting Engineering Problems

- *The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.*
  - Lesson 1: Students evaluate designs by writing down the idea that has the most promise and the one that seems most challenging and explaining why (these prompts are provided by the teacher). Students then use the responses to engage in a class discussion to find patterns in what makes solutions promising or challenging in order to begin the process of developing design criteria.
  - Lesson 2: Students create a three-column chart which includes the heading "How can engineers use these ideas?" to begin generating ideas for how scientific principles can be utilized in designing solutions to minimize the effects of tsunamis.
  - Lesson 5: The different solutions to mitigating tsunamis are evaluated using a class agreed upon list of criteria and constraints. "At this point of the lesson, we talk about the specific criteria that solutions must meet, such as not letting water from a wave pass it" (Teacher Edition, age 96).
  - Lesson 5: Students read about a tsunami which occurred in Ryoshi, Japan and watch a video of a fisherman describing the event. Students then engage in a class discussion which includes the following prompt: "Why would it be important for engineers to consider other solutions to reduce or prevent tsunami damage?" (Teacher Edition, page 94).
  - Lesson 5: Students develop criteria and constraints which can be to evaluate solutions using the "Evaluating Solutions to Protect Communities from Tsunamis" handout. Students begin by completing each part of the handout individually, and then engaging in a discussion as a class to come to a consensus.

- Lesson 7: The class develops a list of criteria and constraints for a communication system to warn residents about an oncoming tsunami. “Define criteria and constraints for the communication system. Say, OK, now that we have an idea of what the problem is and the goals of the system, let’s figure out what the system has to do to work and what potential limitations or constraints we might need to consider. Let’s think about one criterion and one constraint together, and then you and your partner can brainstorm one or two more” (Teacher Edition, page 135).
- Lesson 5: “Ask students to turn and talk briefly to consider: If we only consider our criteria when evaluating existing solutions, will we be picking the best overall solution for Ryoshi? Why or why not? Allow students to share their ideas. Students should respond that while we might pick the best device based upon our criteria, it might not work for the citizens who live there, and might impact their lives and jobs as fishermen. Tell students that we have a reading that tells a bit more about Ryoishi and the surrounding areas that might help us understand more about the community’s needs when choosing the best solution” Students then engage in a reading which guides them to develop a list of constraints based on the characteristics and needs of Ryoshi.
- Lesson 6: “Consider design constraints. Ask students to share their thoughts regarding the “Stop to Wonder” prompt near the end of the reading. Say, What might be some constraints that engineers need to consider when designing a tsunami detection system, like the one in the reading?” (Teacher Edition, page 119).
- Lesson 7: Students gather information about individuals who survived tsunamis in order to identify the needs of stakeholders to further identify criteria and constraints. Students are provided with a handout (Community Stakeholders) in order to begin identifying the needs of individuals during an emergency. Students work with a partner and then engage in a class discussion to identify these needs and identify criteria and constraints of communication warning systems. Students are also provided with guidance when brainstorming criteria and constraints with a partner, after this one example is brainstormed as a class. “To help facilitate student thinking about possible criteria or constraints for a system, display slide F. This slide provides students with ideas for what might be a criterion or a constraint for communication. However, it is fine for students to think outside of this list. Below are some possible ideas that might emerge from the students’ brainstorm” (Teacher Edition, page 135).
- Lesson 9: As part of the final project, students identify stakeholder criteria and constraints. “As students develop their projects, facilitate three-dimensional learning by encouraging students to seek out information from different sources, evaluate the quality of the information, and decide how best to communicate about levels of risk of a hazard and the systems in place to mitigate the effects. Students should use criteria and constraints for stakeholders to refine the information they choose to communicate” (Teacher’s Edition, page 173).

ETS1.B: Developing Possible Solutions

- *There are systemic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.*

- Lesson 1: Students evaluate designs by writing down the idea that has the most promise and the one that seems most challenging and explaining why (these prompts are provided by the teacher). Students then use the responses to engage in a class discussion to find patterns in what makes solutions promising or challenging in order to begin the process of developing design criteria.
- Lesson 5: Students watch a video of engineers demonstrating models of different solutions to lessen the impact of tsunamis and evaluate their effectiveness using the criteria they have developed in order to rank their solution using the evidence collected from their observations. Students then engage in a class discussion. "Once the rankings are complete, ask, So, based on what we saw happen with each of the suggested solutions, what should we recommend to Ryoishi and why? In addition to the amount of water that made it past each type of solution, are there other considerations we need to account for? Let students share some ideas and explain why they would choose one over the other based on what they saw on the video and the criteria they have in place" (Teacher Edition, page 98).
- Lesson 5: "Discuss a rating scale to compare existing solutions. Display slide H. Say, We have observed several different existing solutions. How could we rate these solutions in a way that clearly communicates to others how well they meet the criteria and constraints? From your experience, What systems do other individuals and companies do to rate solutions that can be easily understood and shared with others? Students will respond with a variety of ideas. Students will likely identify a 5-star rating system used by many retailers and consumers, with 5 being best and 1 being worst. If not, prompt students with, When you or a caregiver buy a product, have you ever seen a star rating scale? What would a five-star rating indicate? What would one-star rating indicate? Compare performance using a rating scale. Work with students to determine ratings out of 5 for each existing solution on the chart paper. These ratings will allow for a relative comparison of each solution for each criterion" (Teacher Edition, page 98).
- Lesson 7 (page 138): Students work in small groups to evaluate five different communication options. Groups complete an evaluation matrix for a specific communication option and come to an agreement with another group evaluating the same option, focusing on what the option does well and its limitations.
- Lesson 8: Students develop a representation of how the sub-systems in the tsunami detection system model work together in a more complex hazard response system to protect communities. Students are directed to talk to a partner about how the systems got developed, whether it was developed by just one person, and what processes were needed to figure out which system worked best.

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

The reviewers found extensive evidence that students have the opportunity to use or develop the CCCs in this unit. Students engage in an appropriate number of CCCs, and the CCCs are used to make sense of the phenomenon and to solve the engineering design problem. Students have numerous exposures to focus CCC elements and are able to develop proficiency in those elements.

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

The following CCC elements are claimed in the materials as focus CCCs that are developed and used by students in the unit.

Cause and Effect

- *Cause and effect relationships may be used to predict phenomena in natural or designed systems.*
  - Lesson 2: At the end of the lesson, students use the cause-and-effect relationships about the location of tsunamis and the types of earthquakes which occur to refine their original predictions about which areas of the world are most at risk for tsunamis.
  - Lesson 3: During this lesson, students view several models of waves to determine what happens when the ocean floor moves. At the end of the lesson (Teacher Edition, page 75), students add to their tsunami chain of events to show the cause-and-effect relationships shown in the wave models. However, the focus is on explaining not predicting.
  - Lesson 4: In the assessment, students are asked to use scientific data to predict places in Japan most at risk for a tsunami.
- *Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.*
  - Lesson 2: During this lesson, large data sets are analyzed to first determine correlation and then to determine causation between tsunamis and earthquakes. "Although it is not the focal element of this practice for this lesson, this is a good opportunity to distinguish between causal and correlational relationships in data. At this point, students know that earthquakes and tsunamis are correlated and some earthquakes seem to cause tsunamis, but they have not figured out the entire causal relationship." Later in the lesson, the class starts the tsunamis chain of events chart that establishes the causal relationship between earthquakes and tsunamis (Teacher Edition, page 51).
  - Lesson 2: "Revisit how we talk about apparent relationships between things or events. Remind students of previous words they earned in the Everest Unit: correlation, or when two things seem to be related to each other, and causation, when one thing causes another thing to happen. Place these words on the Word Wall if they are not there. At this point, students have figured out that earthquakes and tsunamis are related, but they must keep in mind that correlation does not always mean causation. Although not all earthquakes are associated with tsunamis, it seems that some are. The next step is to investigate the causal link between earthquakes and tsunamis. Similarly, tsunamis seem to occur on colliding plate boundaries, but we have not established a causal relationship, so this is also only a correlation" (Teacher Edition, page 48).

Systems and System Models

- *Systems may interact with other systems; they may have subsystems and be part of larger complex systems.*
  - Lesson 6: Students read about tsunami warning systems and identify the main parts of the system (Teacher Edition, page 121). They add knowledge of tsunami warning systems to the tsunami chain of events chart.

- Lesson 6: After engaging in reading about tsunami warning and detection systems, students are instructed to discuss the following prompt: “How can we make a diagram of a tsunami detection and warning system working together?” (Lesson 6, Slide D).
- Lesson 7: Throughout this lesson, students experience (through readings and audio recordings) different parts of the long-term and short-term communication systems for tsunamis in Japan. At the end of the lesson, the tsunami chain of events chart is updated with the communication subsystem.
- Lesson 7: “Pause here to discuss the use of the word “system.” Students have used this word before in previous units, but it takes on a new meaning at this point when referring to hazard communication systems. Ask students to come to a shared understanding of how the word “system” is being used. An example might be: “A system is a set of parts that work together to perform a particular function/job. And sometimes larger systems have smaller subsystems that work together.” In this case, a hazard communication system includes ways to both alert people to what is happening and also help them respond in the safest possible way. Add “system” to the Word Wall” (Teacher Edition, page 134).
- Lesson 8: “Revisit systems and subsystems. Say, Throughout this unit, we have been analyzing and investigating these three areas of a tsunami protection system and figured out how different parts work. Why do you think it is called a system? Students might say because it is made of parts that work together to protect people. Say, We know that these areas we identified from Lesson 1 are systems. These systems are all part of our larger tsunami protection system. When we have these smaller systems that are part of a larger system, we call them subsystems. These subsystems interact to help meet the overall criteria for the larger system. Add the term subsystem to the Word Wall. Say, Let’s see if we can explain how these subsystems work together to protect communities when tsunamis happen” (Teacher Edition, page 149).
- Lesson 8: The class creates a consensus model of the tsunami system, showing the interaction between the parts. “This is the moment in the unit where students will build a larger, more complex system that connects the functions of the subsystems to show how they interact within one another to protect communities at certain points in the Tsunami Chain of Events.” (Teacher Edition, page 150)
- Lesson 9: Students are asked to select a new natural hazard and “understanding what parts of the system are in place to protect communities while it is stable and what parts of the system are in place to detect and respond to sudden changes, such as the rapid onset of a natural hazard.” (Teacher Edition, page 172). They are not asked to create a model of the system with its subsystems for the new natural hazard similar to what the class has done with the natural hazard of tsunamis and to use this model to decide on mitigating strategies.

Stability and Change

- *Stability might be disturbed by either sudden events or gradual changes that accumulate over time.*

- Lesson 1: Students observe photographs and a video of a tsunami in Japan, showcasing a sudden event and the disturbances caused by the tsunami.
- Lesson 4: Students identify those tsunamis that are caused by sudden changes on the ocean floor produced during certain earthquakes.
- Lesson 4: "In this assessment, students will incorporate ideas about how sudden events, such as a high magnitude, shallow ocean floor earthquake, can suddenly disrupt the stability of a region. Depending on proximity to the earthquake, communities will have more or less time to respond. This crosscutting concept is a key concept for understanding why we forecast which communities are at risk for tsunami hazards and develop different mitigation strategies to protect those communities from damage" (Teacher Edition, page 82). However, it is not clear that students will consider gradual changes.
- Lesson 9: Students investigate local hazards or other hazards of interest. Part of this investigation is to determine if the hazard is caused by a sudden change or a gradual change over time.

The following CCC elements are not claimed as focus CCCs in the materials, but reviewers have found evidence of their use.

Patterns

- *Patterns can be used to identify cause and effect.*
    - Lesson 2: "Interpret the relationship between geologic forces and tsunamis. The data reveal three primary geologic forces that lead to tsunamis: earthquakes, volcanic eruptions, and landslides. Navigate to each pre-filtered map and have students study the patterns found for each of these forces that can lead to a tsunami forming. Then ask them to rank the forces by which ones cause the most to least tsunamis" (Teacher Edition, page 44). Students then engage in a building understanding discussion to determine how the patterns they have observed can assist in determining the cause of tsunamis.
    - Lesson 2: Students investigate maps of the locations of different types of earthquakes/plate boundaries in the world, and compare it to a map of locations of tsunamis. The following teacher guidance is provided: "As the class explores the swipe map, distribute Comparing All Earthquakes to Earthquakes that Cause Tsunamis to each student, and have them capture and describe 1-2 patterns they notice using their handout. Once they have done this, ask whether they see any difference between all earthquakes and tsunami-generating earthquakes in terms of the type of nearby plate boundary. They should record these observations on the handout as well" (Teacher Edition, page 45).
    - Lesson 2: "The digital tools (maps, graphs) in the large data sets allow students to look for patterns and trends between earthquakes and tsunamis, and in particular, spatial and linear relationships. To support development of this practice with digital tools, use prompts like these: As ____ changes, does ____ change? Are there places where ____ occur together? Are there places where they don't occur together? What does the data

show us about ____? What evidence from the data supports your idea?" (Teacher Edition, page 45).
  - Lesson 2: "As students work through the set of graphs and their handout, encourage them through prompts and questions to describe the patterns they notice and their interpretations of these patterns. This will help develop their understanding of the cause-and-effect relationship between certain types of earthquake and tsunamis. Here are example prompts…" (Teacher Edition, page 50).
  - Lesson 3: Students use video data of waves showing differences in the depth of the ocean floor and the height of the wave. They identify patterns and relate this to causes of tsunamis and the damage they inflict.
- *Graphs, charts, and images can be used to identify patterns in data.*
  - Lesson 2: Maps are used to help students identify patterns of where tsunamis and earthquakes occur around the globe to begin to determine the cause of tsunamis.
  - Lesson 9: Students use a digital map to look for patterns in the amount of risk for specific natural hazards in different areas. The following teacher guidance is provided: "Use this opportunity to emphasize how maps can be used to see general overall patterns of risk for a natural hazard and also identify the level of risk for a local community. This allows students to see that levels of risk for different hazards vary for communities across the US" (Teacher Edition, page 165).

Matter and Energy

- *The transfer of energy can be tracked as energy flows through a designed or natural system.*
  - Lesson 3: Students look at models to make observations that can help them explain how tsunamis form. The following teacher guidance is provided: "This is a good opportunity to highlight and encourage students to consider the crosscutting concept of Energy and Matter as they analyze data from the different wave models. It is important to understand that the wave forms from a transfer of energy from the ocean floor, and that how the wave moves is connected to energy transfer as it approaches shore. Students will reconsider these ideas later in the unit as they evaluate design solutions" (Teacher Edition, page 73).
  - Lesson 3: After looking and discussing the foil pan model, the following teacher prompt is provided: "Tell students, When waves interact with and reflect off an object, some of their energy is transferred to that object, just as we noticed when the waves interacted with the edge of the pan. So with less energy, the waves get smaller over time. As you analyze the next two models, watch for what happens as the waves interact with other objects to see whether there is evidence of energy transfer" (Teacher Edition, page 64).

Structure and Function

- *Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.*
  - Lesson 5: Students view structures of various wave barriers to see how much water each barrier allows into a reservoir and evaluate how the shape of the structure affects waves

- Lesson 5: "Supporting Students In Developing And Using Structure And Function: The structures of the existing tsunami solutions have specific features that can lead to the dissipation of energy from a wave. While a wave striking any solution will inherently have some energy dissipated in the collision, some design solutions function to direct the remaining energy in the wave in all different directions (including some toward the shoreline). Students should identify structures that are shaped in ways to direct this energy back out to the ocean or dissipate enough energy to reduce the impact on the shore" (Teacher Edition, page 98).

Suggestions for Improvement

Science and Engineering Practices
None

Disciplinary Core Ideas
None

Crosscutting Concepts
After spending many lessons creating the model "Tsunami Chain of Events", consider having students create a similar chain of events for their chosen natural hazard that is the subject of the final project. The chain of events for the chosen hazard can serve as a basis for identifying mitigating devices.

I.C. INTEGRATING THE THREE DIMENSIONS

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

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

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena and/or designing solutions to problems because there are numerous insances that require students to integrate the three dimensions to figure something out. The section titled "What Students Will Do" at the beginning of each lesson highlights the three-dimensional learning goals and the specific elements of the dimensions that will be used in the lesson.

Related evidence includes:

Where Do Natural Hazards Happen and How Do We Prepare for Them?

- Lesson 2 (page 39): In the "What Students Will Do" section, it states "Integrate quantitative and qualitative information to connect cause-and-effect relationships to predict communities at risk for future tsunami occurrence."
  - In this lesson, students, analyze tsunami data from maps (SEP), compare earthquake and tsunami data (SEP), identify patterns in the earthquake/tsunami data (CCC), and begin developing a "Tsunami Chain of Events" (CCC) (DCI). Students use these understandings to predict where tsunamis may occur in the future (DCI).
- Lesson 6: The expected performance is "Critically read scientific text to understand how a system designed to detect tsunamis follows specific criteria (related to earthquake activity) and constraints (related to signal transmission)".
  - In this lesson, students read and summarize the main ideas of the text "How are tsunamis detected and warning signals sent?" (SEP), consider constraints that engineers need to consider when designing a tsunami detection system (DCI), and update the tsunami chain of events poster (DCI) (CCC).
- Lesson 8: The expected performance is "Construct a system model to represent the interactions of subsystem designed to detect, warn communities, and reduce damage from a tsunami hazard."
  - The class completes the tsunami chain of events (**Developing and Using Models**, SEP), incorporating several systems to show relationships between the systems (**Systems and System Models**, CCC). The completed chart is used to develop a plan for communicating about this natural hazard (**Natural Hazards**, DCI) at several places in the chain of events.

Suggestions for Improvement

None

I.D. UNIT COHERENCE

Lessons fit together to target a set of performance expectations.

i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences.

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

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

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

The reviewers found extensive evidence that lessons fit together coherently to target a set of performance expectations because the lessons follow a logical sequence from the students' perspectives and students have multiple opportunities to build proficiency in the targeted PEs by using elements of the three dimensions. Student questions and ideas are used in a variety of ways to determine current student understanding, as well as ideas that need to be further investigated.

The lessons are designed to build towards the following PEs:

- **MS-ESS3-2**: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
    - Lesson 2: Students utilize maps and data to determine where tsunamis are most likely to occur and what causes them.
    - Lesson 3: Students look at three wave models to analyze how they move.
    - Lesson 4: Students construct an explanation regarding the causes of tsunamis and consider what can be done to protect people.

- **MS-ETS1-1**: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, considering relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
    - Lesson 5: Students develop criteria and constraints which can be to evaluate solutions using the "Evaluating Solutions to Protect Communities from Tsunamis" handout. Students begin by completing each part of the handout individually, and then engaging in a discussion as a class to come to a consensus.
    - Lesson 7: Students gather information about individuals who survived tsunamis in order to identify the needs of stakeholders to further identify criteria and constraints. Students are provided with a handout (Community Stakeholders) in order to begin identifying the needs of individuals during an emergency. Students work with a partner and then engage in a class discussion to identify these needs and identify criteria and constraints of communication warning systems. Students are also provided with guidance when brainstorming criteria and constraints with a partner, after this one example is brainstormed as a class. In this lesson, students use their prior experiences defining criteria and constraints to determine criteria and constraints of a new system.
    - Lesson 9: As part of the final project, students individually evaluate criteria and constraints of communicating with an identified stakeholder group (Handout, Determining Stakeholder Needs).

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

- Lesson 5: Students watch a video of engineers demonstrating models of different solutions to lessen the impact of tsunamis and evaluate their effectiveness using the criteria they have developed in order to rank their solution using the evidence collected from their observations. Students then engage in a class discussion. "Once the rankings are complete, ask, So, based on what we saw happen with each of the suggested solutions, what should we recommend to Ryoishi and why? In addition to the amount of water that made it past each type of solution, are there other considerations we need to account for? Let students share some ideas and explain why they would choose one over the other based on what they saw on the video and the criteria they have in place" (Teacher Edition, page 98)

Students have regular opportunities to engage in asking questions based upon what they have learned so far and revisit these questions in later lessons. These questions are often used to drive learning in future lessons. For example:

- Lesson 1: After reading *Tsunami: Japan 2011* and viewing photographs and videos of tsunamis, students generate questions.
- Lesson 1: Students categorize their questions onto a teacher determined matrix into tsunami questions about science, tsunami questions about engineering, and questions about other natural hazards, forming a DQB. The purpose of the DQB is further defined on page 36, "The DQB can be referred to at any point during the unit. Often new ideas are considered and added to a classroom consensus model during the 'putting the pieces together' lessons within a unit (Lessons 5 and 8 in this unit); these moments offer ideal opportunities for students to consider new questions and document them on the DQB. However, they may also articulate questions at other times (e.g., when completing individual Progress Trackers). To help recenter each unit as an experience driven by student questions, it's important to record any new questions on the DQB as they come up. Additionally, consider revisiting the DQB as the class reaches consensus in answering one or more questions. This helps students visualize the progress made in finding answers" (Teacher Edition, page 35).
- Lesson 1: Student questions are used to figure out what needs to be investigated in the next lesson. "Brainstorm ideas for investigation or additional information needed. Display slide U. Stay in a Scientists Circle to brainstorm the types of information or investigations that may help to answer the questions on the DQB. Say, *Let's look back at our questions and figure out what information we still need. Whether we are thinking about tsunamis or other hazards, what kinds of information do we need to better understand them and to evaluate technologies designed to reduce their impact?*" (Teacher Edition, page 37).
- Lesson 1 (page 37): The teacher focuses students on certain questions as they determine the next step. "Suggest to students that before we can tackle the engineering aspects of this unit, the part about how to prepare for a hazard, we need to know more about where they happen. Point to the questions on the DQB related to tsunami location or geography. Say, We have a lot of great ideas for ways to investigate natural hazards so we can design ways to protect the people and communities they affect. Let's start with the questions we have about the tsunami. We seem to have questions about where they occur. Maybe we can use what we figure out about the locations of tsunamis to help us figure out more about other hazards" (Teacher's Edition, page 37).
- Lesson 2: A class Science Ideas Chart is started with the following columns: What was our question? What science ideas did we figure out? How can engineers use these ideas? This chart is updated by adding new science ideas in Lesson 3 (Teacher Edition, page 54). The chart helps students organize and summarize the ideas developed in the first three lessons about how tsunamis are generated by earthquakes.
- Lesson 4: The class looks at the DQB to determine which questions have been answered (Teacher Edition, page 84).

- Lesson 5: After evaluating different solutions to protect a town from tsunamis, students reflect on their initial design solutions generated in Lesson 1. Sharing of student ideas leads to the next lesson on methods to detect and warn people about an oncoming tsunami (Teacher Edition, page 111).
- Lesson 6: Student ideas are considered when thinking about how to communicate a warning about an approaching tsunami (Teacher Edition, page 125).
- Lesson 9: The class returns to the questions on the DQB and marks the questions that have been answered. “It is important to revisit the DQB to ensure students feel as though their questions are valued and recognized. While not all questions will have been addressed (it’s more likely that most will be at least partially answered), this helps students see that they have done hard work to help answer many of their own questions” (Teacher Edition, page 174).

Student questions are also used to navigate within lessons.

- Lesson 2: Student questions are considered within the lesson to help navigate to the next part of the lesson. After looking at data sets of the occurrence of tsunamis and earthquakes, the students have an opportunity to ask new questions. “After looking at this data, do you have any new questions?” (Teacher Edition, page 44). These questions lead to the next part of the lesson, where the locations of earthquakes and tsunamis are compared.
- Lesson 3: After viewing a simple model of a tsunami, student questions lead to what needs to be investigated next. “Identify questions to investigate with additional models. Ask students, Okay, what are some questions we still have about tsunamis that we would want to model and analyze more closely? “ After viewing a second model, students are asked to “Identify questions for further investigation. Say, So the second model helped us figure out a little bit more about tsunamis, but we still have some unanswered questions. What are some things we’re still wondering about?” (Teacher Edition, pages 66 and 68).

As students move throughout the unit, part of what they figured out is used to drive learning in the next lesson. For example:

- Lesson 2: “Use these ideas to motivate the need to look at tsunami data. Say, Last time we were wondering where tsunamis happen in the world. Scientists have been tracking tsunamis for a while, and we are going to look at that data today. So our question is, ‘Where do tsunamis happen and what causes them?’” (Teacher Edition, page 43).
- Lesson 3: “Recall conclusions from the previous lesson. Display slide A and say, Last class, we figured out that a major cause of tsunamis are certain types of earthquakes that happen under the ocean. So what are your predictions for the answer to our next lesson question, ‘What causes a tsunami to form and move?’” (Teacher Edition, page 61).
- Lesson 4: “Motivate the need to revisit engineering designs with new science ideas in mind. Say, we have a pretty good understanding of what causes tsunamis, where they happen, how they move, and the types of places where they impact people and property. If we can forecast where tsunamis are more likely to cause damage to people and property, then we can do something about it. We can try to prepare and protect people and property from this natural hazard. Show slide E and ask students to turn back in their notebooks and find Tsunami: Japan 2011. Give them a few moments to find the handout, then say, Take a few moments to look back at your own ideas and the ideas you recorded from others for tsunami detection, warning, and reducing damage. Think about what we now know about tsunamis. Which designs for detection, warning,

and reducing damage do you think are still promising? Place a sticky dot next to any ideas you think might be worth investing time and resources into. Give students a minute or two to work individually. Say, Turn to a partner and share one idea you marked with a sticky dot in your handout. As students finish sharing, summarize the lesson by saying, Our next steps will include examining and evaluating existing solutions to determine how well they protect people and property during a tsunami" (Teacher Edition, page 86).

- Lesson 7: "Motivate the reason to take stock of ideas. Say, It looks like many coastal regions in Japan use more than one of these systems simultaneously. For example, Ryoishi had a seawall and warning system, and so did Kamaishi. It had breakwaters, sirens, and the schools did hazard education training. I wonder what it looks like when all these systems are put together. How do you think they work together? Display slide N. Give each student a notecard and give them a few minutes to consider: How do all these systems work together to protect communities from tsunamis?" (Teacher's Edition, page 142).

Coherence across the unit is emphasized by the development of the tsunami chain of events poster. The chart develops through the unit by adding subsystems as new learning occurs, documenting the relationships between the subsystems.

- Lesson 2: The class starts the tsunami chain of events poster by showing connections between earthquakes and tsunami formation.
- Lesson 3: The poster is updated with added information about what happens to a tsunami as it reaches the shore.
- Lesson 4: The poster is updated and used to create an explanation of the relationship between earthquakes and tsunamis.
- Lesson 5: The tsunami chain of events poster is updated to include systems that are used to mitigate harm from tsunamis.
- Lesson 6: Information about communicating tsunami warnings to people is added to the poster.
- Lesson 8: A consensus model, showing all subsystems and their interactions is completed by the class.

Suggestions for Improvement

None.

I.E. MULTIPLE SCIENCE DOMAINS

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

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

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

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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 phenomena of tsunamis and developing a solution to lessen their impact can be fully addressed with the targeted Earth and Space Science (ESS) domain. Although the unit focuses on one scientific domain, the developers have included references to prior units where science ideas from other domains (e.g., physical science) have been developed. These concepts are noted in the teacher notes in the unit. Crosscutting concepts are used to connect to the ESS ideas developed in the unit to physical science ideas about waves.

The tsunami phenomenon is fully addressed using the identified DCI of **ESS3.B**. Additional necessary prior learning is clearly identified in the teacher materials: For example:

- The "What additional ideas will my student have or know from earlier grades or OpenSciEd units?" (Teacher Edition, page 11) section clearly identifies which DCIs from previous grade levels (including **PS4.A**) will be utilized in the unit and in which lessons they will be addressed.
- "Building upon waves. Tsunami hazards build directly upon Disciplinary Core Ideas from 4th grade in which students learned about physical waves. Students will directly apply these DCIs to the tsunami hazard in Lessons 3-5 as they explain how the waves form and move across the ocean floor, what happens as they approach shore, and what engineering design solutions need to do to protect communities" (Teacher Edition, Page 11).
- Page 12: "Building upon the distribution and impact of natural hazards. Tsunami hazards build directly upon the grades 3-5 Disciplinary Core Ideas regarding the present and impact of natural hazards. Students will use these DCIs to build a more sophisticated understanding of where natural hazards occur and why in those places versus other places. This allows them to forecast future risk of hazards for specific communities."
- Page 12: "Building upon geologic processes. Tsunami hazards also directly build upon Disciplinary Core Ideas from grades 6-8 regarding geologic processes and changes in Earth's surface. Students will use ideas about motion in the ocean flood along colliding plate boundaries as the primary causal mechanism for the tsunami hazard. While specific earthquake events cannot be predicted, we can use historical data of earthquake activity to narrow our forecast to which places in the world are most at risk for the tsunami hazard based on these DCIs."

Teacher guidance is provided to support students in using CCCs to make connections to previous learning of **PS4.A** DCI in previous grade levels. For example:

- Lesson 3: "Tell students, When waves interact with and reflect off an object, some of their energy is transferred to that object, just as we noticed when the waves interacted with the edge of the pan. So with less energy, the waves get smaller over time. As you analyze the next two models, watch for what happens as the waves interact with other objects to see whether there is evidence of energy transfer" (Teacher Edition, page 64).
- Lesson 3: Students use the CCC of **Energy and Matter** as they make a connection between the movement of the ocean floor and the wave produced (Teacher Edition, page 63).

- Lesson 3: As students observe a computer-generated visualization of tsunami formation, they identify patterns in waves and the effect of changes in wave amplitude (Teacher Edition, pages 66–68).
- Lesson 3: Students use the CCC of **Cause and Effect** to evaluate different models of how tsunamis move across the ocean and approach the shore (Teacher Edition, pages 72–73).
- Lesson 4: "This is a good opportunity to highlight and encourage students to consider the crosscutting concept of Energy and Matter as they analyze data from the different wave models. It is important to understand that the wave forms from a transfer of energy from the ocean floor, and that how the wave moves is connected to energy transfer as it approaches shore" (Teacher Edition, page 63).

Suggestions for Improvement

Consider explicitly pointing out to students how additional CCCs such as **Patterns** and **Cause and Effect** can be connected to both ESS and physical science DCIs utilized in the unit.

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive 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. Specific standards for both ELA and mathematics are noted at the end of the lessons. Mathematics topics are used at appropriate times when needed and writing experiences are used for students to show their understanding. Varied grade-appropriate reading materials are used throughout the unit and students have multiple opportunities to meaningfully engage in speaking and listening practices.

Common Core State Standards are listed at the end of the appropriate lessons where they are used or developed (Teacher Edition, pages 37, 55, 111, 125, and 142). Some of the listed standards include a short description of what students are doing in support of the standard, while others simply list the standard with no associated description of the student activity.

Connections to CCSS mathematics standards are made when appropriate. For example:

- The following teacher guidance is provided to teachers regarding mathematics required by students in this unit:

- "This unit requires students to triangulate data across different units of measurement and symbology as they work with a series of maps and graphs in Lesson 2. It also references units of measurement throughout the unit, such as magnitude or wave height. There are no required math concepts for this unit. However, prerequisite math concepts that may be helpful include:
    - **CCSS.Math.Content.4.MD.A.1:** Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb., oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table.
    - **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.

  It is important to note that this unit is reinforcing some elementary mathematics standards in a new context and at scales which students may have not considered before; thus, we anticipate that while some of the mathematics in this unit are aligned to upper elementary, it may be a new challenging context for students to apply these mathematics ideas" (Teacher's Edition, page 13).

- Lesson 2: Supporting Students in Making Connections in Mathematics (Teacher Edition, page 55).
    - **CCSS.MATH.CONTENT.6.SP.B.4**: Display numerical data in plots on a number line, including dot plots, histograms, and box plots.
    - **CCSS.MATH.CONTENT.6.SP.B.5.B**: Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
    - Students display and interpret data on scatter plots and are asked what is represented by the "magnitude" and "depth" of an earthquake, as well as the "wave height" that results.

Grade-appropriate CCSS ELA standards are referenced at the end of each lesson when appropriate. For example:

- Lesson 2: Supporting Students in Making Connections in ELA (Teacher Edition, page 55).
    - **CCSS.ELA-LITERACY.SL.6.2**: Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
    - This lesson engages students in interpretation of text and data from interactive maps to determine the pattern of tsunami occurrence and establish a cause-and-effect relationship between related geologic forces and the resulting hazard.
- Lesson 5: Supporting Students in Making Connections in ELA (Teacher Edition, page 111). The texts in this lesson supports students in developing the following reading standards:
    - **CCSS.ELA-LITERACY.RST.6-8.1**: Cite specific textual evidence to support analysis of science and technical texts.
    - **CCSS.ELA-LITERACY.RST.6-8.4**: Determine the meaning of symbols, key terms, and other domain specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

- **CCSS.ELA-LITERACY.RST.6-8.7**: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Students use grade appropriate reading, writing, and speaking skills throughout the unit. For example:

- General guidance for teachers is provided on the topics of using text in science (Teacher Handbook, pages 55–60).
- Reading selections are incorporated into Lessons 1, 5, 6, 7. Lexile ratings of the reading selections show that they are grade-level appropriate.
- Students are provided with an opportunity to engage in a variety of reading materials which go beyond textbooks. Strong support is provided for students to develop literacy skills which developing understanding of the phenomena. For example:
    - Lesson 1: Students engage in a short reading about tsunamis in Japan and Indonesia, which includes pictures of the 2011 tsunami in Japan. The following teacher guidance is provided: "For the reading, ask students to mark the text using your typical classroom annotation protocol, such as underlining or circling. Remind them to take notes or write questions about any unfamiliar words on their handout" (Teacher Edition, page 22).
    - Lesson 5: Students engage in reading and watch a video about different solutions to lessen the impact of tsunamis. Students engage in the reading with a partner and use the information in the reading to answer questions provided such as:
        - What are some general characteristics of a tsunami?
        - What characteristics must this tsunami have had in order to cause this damage?
        - Why would people continue to live in Ryoshi if it had been struck by a bad tsunami in the 1930s?
        - Why would it be important to consider other solutions to reduce or prevent future tsunami damage? (Lesson 5, Slide C).
    - Lesson 6: Students use a close reading strategy to read "How are tsunamis detected and warning signals sent?" Students begin the reading by identifying the purpose for the reading, and are provided with prompts to use while reading in the associated slide to help them identify the key ideas of the reading.
    - Lesson 6: "Remind students of the close reading strategies. If necessary, remind students that close reading requires reading more than once with different purposes and using strategies to interact with the text. Review the steps with the students that are listed on slide C. Then give them twenty minutes to read the article with a partner" (Teacher Edition, page 118).
    - Lesson 7: Students engage in reading several articles, include accounts of survivors of tsunamis and an account of students' experiences during a tsunami when warning systems failed. Students use these readings to gather information about possible responses to tsunamis.
    - In Lesson 9, students are expected to use websites to read about a natural hazard of their choosing.

Suggestions for Improvement

None

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world because students are provided with experiences to engage in the phenomenon of tsunamis as firsthand as possible while making numerous connections to their own lives and communities. The unit is anchored by an interesting phenomenon and brings up linked engineering design problems. The phenomenon is authentic to students when they hear first-hand accounts of the tsunami and then consider the needs of stakeholders in their communication plans. The unit provides guidance for teachers on how to address anxiety that may arise when talking about natural hazards.

Students experience the phenomenon through photographs, reading selections, and videos. They have opportunities to connect the phenomenon to their lives. Related evidence includes:

- Lesson 1: Students view photographs of the tsunami that hit Japan in 2011 and read an article about the tsunami. They view videos of the Japan tsunami and others that have occurred in various places.
- Lesson 1: In a home learning assignment, students talk with their families about natural hazards they have experienced and what they did when the natural hazard occurred. This home discussion continues in Lesson 2 when students ask about local hazards.
- Lesson 7: "Prepare students for what they will hear. Display slide A. This lesson begins with an audio clip of Japan tsunami warning signals, including alerts from cell phones, TVs, loudspeaker announcers, and sirens. Say, We are about to listen to the signals that people receive after a tsunami is detected. As we listen, think about what the community residents might be feeling, seeing, or hearing during the moments before a tsunami arrives. We will listen one time through without writing—just close your eyes and listen. The second time through, we will make notes about what we Notice and Wonder. Consider as you listen: Who are the people hearing this warning? What will they do next?" (Teacher Edition, page 131).

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

First-hand accounts and considering the needs of stakeholders make the unit phenomenon more authentic. For example:

- Lesson 7: Students listen to an audio clip of tsunami warning system sounds and experiences of survivors of the Japan earthquake and tsunami. Then they read stories of peoples' experiences. (Teacher Edition, pages 131–132).
- Lesson 7: Students analyze the first-hand accounts of the tsunami and generate a list of different stakeholders (Teacher Edition, page 133). The activities in Lesson 7 create an authentic scenario for students.
- Lesson 9: As part of the final project, students consider the needs of different groups of stakeholders in developing their communication plan.

Students are provided with multiple opportunities to connect the phenomenon to their own experiences. The teacher is supported with any issues which could arise from these connections:

- Lesson 1: "Although your students may not have experienced a tsunami, point out that some of them may have experienced other natural hazards or have close family or friends who have been affected by such events. Explain that, though we may not be able to stop these events, we can use science to understand them better, predict when they may occur, and make more informed decisions about what to do when they happen" (Teacher Edition, page 24).
- Lesson 1: "Connect to local hazards. Display slide M. Say, In the last unit we noticed that earthquakes tend to happen more frequently in certain places. Does anyone remember where? Call on a volunteer to show the locations on the World Map and explain that earthquakes tend to occur most frequently along the boundaries of plates on Earth's surface. Say, This means that communities in those areas are more at risk for experiencing an earthquake. Ask students to think about which natural hazards are more likely to happen in their communities, and whether there are things they know about those hazards that may help us think about designing solutions for the tsunami hazard. Give them 4 minutes to individually complete the remaining prompts in Part 5. Remind them to be prepared to share these ideas and examples with the class" (Teacher Edition, pages 31–32).
- Lesson 2: "Encourage students to ask their family or friends what natural hazards have happened in their local area in recent years (or any area the students have lived in previously, if they are new to the community). If this investigation already occurred during Lesson 1, it does not need to be repeated" (Teacher Edition, page 55).
- Lesson 7: "Acknowledge that alarm and warning signals can be scary. Let students know these signals are often loud and scary, and that they are designed that way so that people are alerted to potential danger. Say, It can be a scary thing to get a warning signal like that. Have you ever experienced that before? Let students share their experiences to surface-related phenomena, such as tornado warnings on the TV; "Amber alerts" on the phone; and fire/tornado/active shooter drills in the school" (Teacher Edition, page 131).
- Lesson 7: "Assign Home Learning. Display slide G. Say, As you experience communication outside the classroom between now and the next class, pay attention to all the ways you send and receive communication. Think about whether there are any ideas from your experience that we should consider. Jot these down and bring these ideas with you to class next time" (Teacher Edition, page 137). These ideas are than considered to be added to new ideas the next day. "Add new ideas from Home Learning. Remind students of their home learning assignment and ask them if they noticed any new information we should consider regarding ways we send or

receive communication. Ask, Did you notice where you send and receive communication outside of school? For example, what information did you notice on signs, through talking, or on an app?" (Teacher Edition, page 137).

- Lesson 9: "The intention of this lesson is to have students investigate local hazards that their own community is at risk for or a natural hazard that sparks their interest or curiosity. While it is important for students to understand how to prepare for and respond to a hazard in their own community, some students might have high interest in other natural hazards that they hear about on the news or have affected family or friends. Students may also have past experiences with learning about and preparing for their local hazards, and may already know what to do and how to respond in the event that a hazard strikes. The lesson is written as though the hazard is a local hazard, but this lesson can be modified to include other hazards that impact other communities in the US (based on students' experiences and/or interests)" (Teacher Edition, page 164).

The materials provide support in addressing students' emotional responses to the unit phenomenon. For example:

- The section "Supporting Empathy and Emotions" on page 14 describes places in the unit where students may experience emotional responses.
    - Lesson 1: "Supporting empathy and emotions: A unit on natural hazards is likely to elicit emotional stress from some students, whether from their empathy for those affected or from experiencing a natural hazard directly or through the experiences of family and friends. Emotional stress from a disaster can often be great in students who feel they do not understand the situation or have no control over it. Although natural hazards often bring impacts that students cannot control, the aim of this unit is to help students consider what is happening before, during, and after such events, and to empower them to use what they learn to respond in ways that can keep them and their loved ones safe in the event of a disaster. If you have students who have traumatic experiences from natural hazards, a recommended source is: https://www.cdc.gov/childrenindisasters/schools.html" (Teacher's Edition, page 22)
    - Lesson 4: "Supporting empathy and emotions: It is important to make sure that students develop an understanding that when it comes to natural hazards, the triggering event is often out of people's control. Natural processes occur on Earth all the time, such as the earthquakes in the Pacific Ocean in the anchoring lesson (Lesson 1) and again in this assessment task. The reason these events are hazardous is because the outcomes impact people and property. It is through forecasting and assessing risk that we can prepare people and respond quickly." (Teacher's Edition, page 83)
    - Lesson 7: "Supporting empathy and emotions: Listening to sirens and alarming alerts can trigger a stress response in students. They are purposely designed that way to alert people to danger. However, it is important for students to experience the sounds they can expect to hear in a dangerous event, so that they can respond appropriately when they hear the sound. If students don't have experience hearing warning signals, they could become scared or panicked during the event. The Kamaishi case study on day 2 is a good example of how practicing listening to and responding to warning signals can help students be prepared in the event a natural hazard event occurs." (Teacher's Edition, page 131)

- The materials state “Tsunamis have not had a direct impact on US communities in recent years and students in the US have likely not experienced one directly. This is an important consideration in choosing a natural hazard for in depth investigation since a distal hazard is least likely to elicit direct emotional response from students who may have experienced direct devastation from other types of hazards, such as flooding, tornadoes, earthquakes, and/or hurricanes” (Teacher Edition, page 9). This guidance is not fully accurate since students living along the west coast, Alaska, and Hawaii have constant reminders about tsunamis in the form of “Tsunami Evacuation Route” signs and tsunami alerts in the news.

Suggestions for Improvement

None

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)*

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. The unit offers multiple instances where students can express their ideas, clarify and justify their thinking, and revise their thinking based on input from the teacher and peers.

Opportunities for students to express their thinking occur throughout the unit. For example:

- Lesson 1: After viewing video, photographs and completing a reading selection, students share noticings and wonderings with the class. They start a noticings and wonderings poster that is visible to all in the classroom (Teacher Edition, pages 25–26).
- Lesson 1: Students engage in an initial ideas discussion. “An Initial Ideas Discussion is used to encourage students to share their prior knowledge on a topic and generate divergent thinking.” (Teacher Edition, page 27).
- Lesson 2: Students share ideas from an exit ticket completed at the end of the prior lesson. “Share ideas from exit tickets. Display slide I again. Ask students to share with the class their initial ideas for why some earthquakes cause tsunamis, but not all earthquakes cause tsunamis” (Teacher Edition, page 49).
- Lesson 3: The unit materials provide teachers with many prompts to elicit students thinking when making sense of a complex tsunami wave model. Sample student responses are given, along with ideas for follow-up questions (Teacher Edition, page 71).
- Lesson 3: Students record their ideas about different wave models by noting “What I see” and “What it means” (Handout: Wave Investigations).

- Lesson 5: Before sharing ideas about constraints that might limit possible solutions to mitigate tsunami damage, students "turn and talk briefly to consider: If we only consider our criteria when evaluating existing solutions, will we be picking the best overall solution for Ryoshi? Why or why not?" Then, students share their ideas with the class (Teacher Edition, page 99).

Students have opportunities to clarify and justify their thinking. Related evidence includes:

- Lesson 1: Students justify their thinking about the best engineering design. "Prompt students to turn to Part 4 of their handout. Tell them to individually write down the idea they think shows the most promise and explain their rationale; then, to write down the idea that seems most challenging to implement and explain why" Teacher Edition, page 29). In a whole class discussion, students "share one idea they identified as most promising or most challenging and then to explain their reasoning" (Teacher Edition, page 29).
- Lesson 1: In the Additional Guidance section, teachers are advised "During this discussion, when students disagree on an idea, ask for clarification on why some think an idea is promising and why others think it may be challenging." Teachers are provided with prompts and follow-up questions to help students clarify their thinking (Teacher Edition, page 30).
- Lesson 1: Peer feedback is used to clarify questions for the DQB. "Have students turn and talk for 2 minutes with a partner to ensure that their questions for the DQB are clear and productive. Remind them that partners should act as critical peers and ask clarifying questions if they don't understand a question. Students can edit their questions before sharing with the class in the Scientists Circle" (Teacher Edition, page 34).
- Lesson 7: Sample questions are provided to help students clarify their thinking about the connection between stakeholder needs and criteria and constraints of communication systems (Teacher Edition, page 137).

Guidance is provided throughout the unit for the teacher to provide feedback; however, most of the feedback is directed to the class and there are few places where the teacher provides individual feedback. For example:

- In many of the places in the unit where the teacher is provided prompts to elicit student ideas, there is a chart with the headings "suggested prompts", "sample student response", and "follow-up questions" (Teacher Edition, pages 70–71). The follow-up question column provides ideas to give feedback to the class during this discussion.
- Each "Assessment Opportunity" tells the teacher what to look and listen for in student responses. A section called "What to do" gives ideas about how to give feedback to the class.
- The OpenSciEd Teacher Handbook devotes a chapter to "Supporting Discussions" (Teacher Handbook, pages 34–39).

Classroom discussions occur frequently throughout the unit. Sample student responses and prompts for teacher responses/questions are provided to guide these discussions. For example:

- Lesson 1: "Share noticings and wonderings as a class. Show slide D. For 10 minutes, facilitate a whole-class discussion by calling on student volunteers to share their noticings and wonderings from the reading, photos, and videos. Be sure to record what is shared on the class Notice and Wonder poster. After 5 minutes, ask students whether they notice any commonalities in what was shared, and ask them to name the categories or themes. For example, observations or

questions regarding what happens as the tsunami contacts structures on land could be categorized as 'tsunami and structures', while those about how it impacts people could be grouped together under 'sunami and people'" (Teacher Edition, page 25).
- Lesson 1: Students meet in groups to share the solutions they have developed to reduce the effects of tsunamis on people. The following teacher guidance is provided: "While students share, walk around the room and listen to as many pairs as possible. As they have very limited time to learn about each other's ideas, this is not the ideal time to interrupt with clarifying questions. There will be opportunities later to probe for understanding and for students to explain their ideas in greater detail. Instead, use this time to note any patterns that emerged from the proposed ideas. For example, are students mainly sharing ideas for detecting tsunamis rather than reducing damage? Or, perhaps many of the ideas for detecting tsunamis also involve simultaneously warning people, so these ideas are often intertwined" (Teacher Edition, page 27).

Throughout the unit, multiple activities exist which allow students to demonstrate their change in thinking. For example:
- Students use a science notebook to record their thinking throughout the unit. "Remind students that the notebook is their tool for recording their observations, evidence, and ideas to share with the classroom community. They should see it as a space to brainstorm and record their thinking, as well as a place to show how their thinking changes as they learn more" (Teacher Edition, page 23).
- Lesson 2: "Ask students to use a different colored pencil to revise the map they made their predictions on Tsunami Predictions to include what they have now figured out about where tsunamis occur. Then, have students write a quick explanation for why they made changes to their initial predictions" (Teacher Edition, page 53).
- Throughout the unit, students create and revise a "Tsunami Change of Event" chart to document their thinking. For example:
    - Lesson 1: Lesson 1: "Share noticings and wonderings as a class. Show slide D. For 10 minutes, facilitate a whole-class discussion by calling on student volunteers to share their noticings and wonderings from the reading, photos, and videos. Be sure to record what is shared on the class Notice and Wonder poster. After 5 minutes, ask students whether they notice any commonalities in what was shared, and ask them to name the categories or themes. For example, observations or questions regarding what happens as the tsunami contacts structures on land could be categorized as 'tsunami and structures', while those about how it impacts people could be grouped together under 'sunami and people'" (Teacher Edition, page 25).

Suggestions for Improvement

Consider places in the unit where teacher feedback to individual student work will help to clarify student thinking. As an example, individual student feedback can be provided on the exit ticket assigned on page 48.

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

II.C. BUILDING PROGRESSIONS	
Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers: i. Explicitly identifying prior student learning expected for all three dimensions ii. Clearly explaining how the prior learning will be built upon.	
Rating for Criterion II.C. Building Progressions	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials identify and build on students' prior learning in all three dimensions. The level of proficiency with which students entered is outlined for teachers, and the materials provide information regarding building proficiency for targeted elements. However, explicit guidance regarding expected proficiency for SEPs and CCCs is not clearly identified.

Related evidence includes:

- A general summary of prior learning in the targeted DCIs is provided (Teacher Edition, pages 11–12). The same guidance is not provided for prior learning in the SEPs and CCCs.
- If the unit will be taught with other OpenSciEd units, but in a different order, suggestions for modifying instruction are shown on pages 12 and 13.
- The "What additional ideas will my students have or know from earlier grades or OpenSciEd units?" (Teacher Edition, page 11) clearly outlines with which DCI elements students will have prior experience within the unit, however, no such guidance is provided for targeted CCC or SEP elements.
- "This lesson is intentionally tied to students' work in the Everest Unit, drawing closely upon ideas related to earthquake patterns. Because earthquakes are the dominant cause of tsunamis (the related geologic force), students can use this information to establish a cause-and-effect relationship between certain types of earthquakes and tsunami formation (and rule out types of earthquakes that do not form tsunamis). This is used to better forecast areas at risk" (Teacher Edition, page 42).
- More detailed information about prior learning and learning progression is provided in the section called "Where We Are Going and NOT Going" at the beginning of each lesson in the Teacher Edition.
    - Lesson 2: "If students have not figured out the various ways plates move, you need to provide additional support, as plate movement is the primary cause of tsunamis and thus knowing about it is necessary to forecast locations at risk. Specifically, students need to know that Earth's surface is made of plates that move in different directions, causing earthquakes that shift the land or ocean floor" (Teacher Edition, page 42).
    - Lesson 3: "Though we analyze what happens when waves interact with one another and notice that their energy seems to change when doing so, we only make sense of what

happens when waves interact with and reflect off land, like the shore or ocean floor. Beyond recognizing that waves reflect off other types of matter, we are not figuring out additional properties of waves, such as the superposition of wave interference, as these are above the grade-band.

- Importantly, fully developing the middle school DCIs for waves is the focus of another OpenSciEd unit, the OpenSciEd Unit 8.2: How can a sound make something move? (Sound Unit). In the present unit, we leverage student understanding from Grade 4 about water waves and build on that to link them to a causal mechanism (a geologic force) and also how their movement impacts communities once a wave interacts with a shoreline. These science ideas are used as a context to build more generalized ideas about how to forecast hazards and mitigate the effects on communities. This lesson is not intended to build more sophisticated ideas about waves; rather, students are applying previous ideas to a new, more sophisticated context" (Teacher Edition, page 60).

- "Also, for this lesson, students should focus on how patterns in data can be used to establish a cause-and-effect relationship between certain types of earthquakes and tsunami formation. Students will build on this to model how these earthquake characteristics lead to tsunami formation in Lesson 3. Because of this, avoid giving away any ideas related to wave formation by the release of energy during an earthquake. Across Lessons 2 and 3, students will figure out that higher-magnitude earthquakes release more energy than lower-magnitude earthquakes. A tsunami wave forms when energy of sufficient magnitude is transferred from the ocean floor to the water above it. The depth of the earthquake is also important because the shift in the crust displaces the water to form a tsunami. Deep earthquakes do not shift the ocean floor like shallow earthquakes do. However, both causal mechanisms will be more fully explored in Lesson 3, so it is not necessary for students to explain this in Lesson 2" (Teacher Edition, page 42)

- At some points in the lesson, teacher guidance is provided to connect learning to previous units. For example:
  - Lesson 2: "Revisit how we talk about apparent relationships between things or events. Remind students of previous words they earned in the Everest Unit: correlation, or when two things seem to be related to each other, and causation, when one thing causes another thing to happen. Place these words on the Word Wall if they are not there. At this point, students have figured out that earthquakes and tsunamis are related, but they must keep in mind that correlation does not always mean causation. Although not all earthquakes are associated with tsunamis, it seems that some are. The next step is to investigate the causal link between earthquakes and tsunamis. Similarly, tsunamis seem to occur on colliding plate boundaries, but we have not established a causal relationship, so this is also only a correlation" (Teacher Edition, page 48).
  - Lesson 7: "Pause here to discuss the use of the word 'system.' Students have used this word before in previous units, but it takes on a new meaning at this point when referring to hazard communication systems. Ask students to come to a shared understanding of how the word 'system' is being used. An example might be: 'A system is a set of parts that work together to perform a particular function/job. And sometimes larger systems have smaller subsystems that work together.' In this case, a hazard

communication system includes ways to both alert people to what is happening and also help them respond in the safest possible way. Add 'system' to the Word Wall" (Teacher Edition, page 134).

Suggestions for Improvement

- Consider providing more explicit guidance regarding student prior proficiency in SEP and CCC elements.
- Consider adding information to the documents "Developing and Using Science and Engineering Practices" and "Developing and Using Crosscutting Concepts" that shows prior proficiency needed for each element present in the unit.

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 all science ideas and representations in the materials are accurate.

Teacher guidance is provided to ensure scientific ideas are accurate. For example:

- The "Where we are going and not going" sections at the beginning of each lesson outline key scientific concepts from each unit and possible misconceptions which may arise.
- Lesson 3: The main concept of the lesson is described. "…we figure out that a tsunami that is really tall, moving pretty fast, and originating in close proximity to a community will more likely cause significant damage to that community. We identify key data needed to determine how to detect future tsunamis, such as an earthquake's strength and distance from shore. We consider generalizing these types of data (how big the causal event is, how fast the hazard is happening, and how far from a community it is occurring) to consider whether they could be used to forecast and minimize damage from other types of natural hazards" (Teacher Edition, page 60).
- Lesson 6: "The purpose of this lesson is to provide students with information about the systems designed to detect tsunamis and send warnings. Tsunami detection systems are complex, with many parts (some on land, some in space, and some on the ocean surface and ocean floor). These systems are designed not only to detect tsunamis, but also to predict whether they will reach land. If certain criteria are met, the system will send out a warning" (Teacher Edition, page 117).

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide guidance for teachers to support differentiated instruction because the unit offers support for multilingual learners and struggling students. Some supports for students with a high level of interest or students who have already met the performance expectation are included. However, there are limited supports in place for students who are reading below grade level.

Guidance is provided for the teacher to differentiate instruction for all learners. For example:

- Support for class discussions is provided for all students: “Before students engage in whole-class discussions it can be helpful to provide them with the opportunity to work with others –either in pairs, triads, or small groups-on ideas related to their reasoning” (Teacher Edition, page 43).
- The Universal Design for Learning (UDL) supports are provided for students who might benefit from expressing their noticings through physical action (Teacher Edition, page 51). In addition, UDL supports are provided for students who find the task of watching and recording observations challenging by providing opportunity to re-watch the video with a new purpose (Teacher Edition, page 66).
- Teachers introduce a close reading strategy (explained on page 56 of the Teacher Handbook). The components of this strategy include identifying questions, reading the text twice, summarizing the main ideas, and recording new questions. It is unclear how students who read far below grade level will be assisted by this process.

Various supports are provided for building vocabulary throughout the unit to support many student groups including multilingual learners and struggling students. For example:

- "Using cognates, teachers can support emerging multilingual students in making connection between new science vocabulary and their native language(s)" (Teacher Edition, page 49)
- "Teachers can support all students in forming a deeper understanding of newly 'earned' vocabulary by representing the new term in multiple ways. For examples, 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's Edition, page 118).
- "Previewing or pausing to discuss technical terms in the text can be particularly helpful for emergent multilingual learners, students with dyslexia, and students who read below grade level. These words include: magnitude, aftershocks, and tsunami" (Teacher Edition, page 20).
- In the "Additional Guidance" section throughout the unit, the teacher is provided with ideas about what to do if students are struggling.

There are opportunities for students who show a high level of interest to move beyond the lessons. For example:

- "To extend or enhance the unit, consider the following:
  - Lesson 3: If the unit is taught after Sound Unit, consider bringing in middle school level DCIs on waves (MS-PS4.A) and model the wavelength, amplitude, and frequency of tsunamis based on stronger or weaker precipitating events (e.g., earthquakes).
  - Lesson 5: Have students jigsaw the different design solutions and research more about them and how they are used in Japan.
  - Lesson 9: Have students present their projects to community members for feedback and revision prior to releasing the final product to the community" (Teacher Edition, Page 13).
- Guidance is provided for all lessons to remove scaffolds with SEPs as a way to give students more independent work with the elements of these practices.
- Lesson 2: "If students have high interest, they can also investigate locations in the world where active hazards are happening using https://disasteralert.pdc.org/disasteralert/. This map displays recent hazards" (Teacher Edition, page 55).
- Lesson 9: "The intention of this lesson is to have students investigate local hazards that their own community is at risk for or a natural hazard that sparks their interest or curiosity. While it is important for students to understand how to prepare for and respond to a hazard in their own community, some students might have high interest in other natural hazards that they hear about on the news or have affected family or friends. Students may also have past experiences with learning about and preparing for their local hazards, and may already know what to do and how to respond in the event that a hazard strikes. The lesson is written as though the hazard is a local hazard, but this lesson can be modified to include other hazards that impact other communities in the US (based on students' experiences and/or interests)" (Teachers Edition, page 164).

Guidance is provided for supporting students who may be struggling. For example:

- Lesson 3: Guidance is provided to teachers to assist struggling students with watching a video. "For some students, the task of watching and recording observations can be challenging, so offering students the opportunity to view the video again supports engagement by providing a new purpose for rewatching it as they will be focused on observing specific elements" (Teacher Edition, pages 57–58).

- Lesson 3: “Supporting Universal Design for Learning: The NOAA Tsunami visualization model is somewhat complicated. It is important to take time to help students make sense of what the different keys and colors represent. Play the video a few times and pause it periodically. It can be helpful to have students share different things they notice and describe what they represent. For example, someone might notice the colorful bar with numbers on the left side, titled ‘Tsunami Wave Amplitude.’ Ask this student to come up, point to the bar, and explain what it is so everyone understands what is being referred to” (Teacher Edition, page 67).
- Lesson 5: “Support for Universal Design for Learning: The five-star rating scale was purposely chosen for this lesson because it is a widely used rating scale that will likely be familiar to many students. For students who may struggle with language or symbolism, they may benefit from a visual reminder in the class that provides additional words to describe one-star versus five-star, such as “Did not perform well” or “Worst performance” and “Performed very well” or “Best performance,” respectively. Additionally, this rating scale can be modified to use another symbol, format, or text to provide greater accessibility through representation” (Teacher Edition, pages 98–99).
- Lesson 5: Alternate Activity: “The reading introduces several devices and technologies involved in tsunami detection. Though students may have limited first-hand experience with such instruments, it is possible for students to access simplified versions of these tools through the use of free applications on digital devices” (Teacher Edition, page 118).
- Lesson 8: Guidance is given to help students who are struggling by breaking a task down into smaller, more accessible parts. "Students may struggle creating a visual representation of the parts of subsystems to a larger system that allows them to perceive the connections between the parts of the subsystems or overall systems. Encourage students to start with a more familiar approach by thinking about what events happen first and what parts of the system are involved in that work. As students consider what happens next, encourage students to begin making connections between components" (Teacher Edition, page 145).
- Lesson 7: “Supporting Universal Design for Learning: As you gather students’ ideas about communication, be mindful of different ways students access communication based on their needs. Some students might receive more communication through auditory processes, whereas others might connect with visual processes. Ask for contributions of ideas that include multiple means of perception and representation” (Teacher Edition, page 137).
- Lesson 9: Students have a choice of both the content (which specific natural hazard) and final product (e.g., brochure, commercial, website, etc.) for their final project. Students consider the needs of various stakeholders (e.g., children, the elderly, language learners, and others) when designing hazard communication systems. While the inclusion of these groups in the lessons does not directly provide evidence for this criterion, the reviewers found it important to acknowledge the explicit inclusion of these groups in the unit because it allows these students to see their needs recognized and considered important. In addition, it provides all students with the opportunity to empathize with and design for differing needs

Differentiation strategies are provided to specifically support multilingual learners. For example:

- Lesson 1: “Previewing or pausing to discuss technical terms in the text can be particularly helpful for emergent multilingual learners, students with dyslexia, and students who read below grade level. These words include: magnitude, aftershocks, and tsunami. At this point, the term magnitude should be included on the Word Wall as a 'word from a previous unit'" (Teacher Edition, page 23).

- Lesson 2: "Supporting Emergent Multilingual Students: Before students engage in whole-class discussion, it can be helpful to provide an opportunity to work in pairs, triads, or small groups on ideas related to their reasoning. These smaller group structures can be especially beneficial for emerging multilingual students as a chance to engage in sensemaking with their peers and a space to use their linguistic and nonlinguistic resources to express their ideas (and learn from other students' uses of these resources)" (Teacher Edition, page 43).
- Lesson 2: "Supporting Emergent Multilingual Students: Cognates are words that are similar in both spelling and meaning in different languages. Many science vocabulary terms have cognates across romance languages (e.g., magnitude in English = magnitud in Spanish). Using cognates, teachers can support emerging multilingual students in making connections between new science vocabulary and their native language(s). This can reduce the vocabulary overload that they may experience in science. Teachers can display cognates on the Word Wall alongside their corresponding vocabulary terms or include cognates in writing using parentheticals" (Teacher Edition, page 49).
- Lesson 2: "Supporting Emergent Multilingual Students: Depending on the goals for an aspect of a lesson, it is helpful to intentionally group emerging multilingual students with certain peers. Sometimes this could be peers who know the same languages they do; other times it could be peers whose English language development is slightly more advanced. It is important that this grouping be thoughtful and varied during the unit so students benefit from working with different peers" (Teacher Edition, page 50).
- Lesson 5: "Supporting Emerging Multilingual Learners: The Lexile Reading estimate of this passage is 810L-1000L. Provide opportunities for emerging multilingual students to break down the meaning of scientific words used in the lesson. Provide an opportunity to discuss any preconceptions about the meaning of the word(s) and draw upon their personal experiences to make sense of them" (Teacher Edition, page 93).
- Lesson 6: "Supporting Universal Design for Learning: Teachers can support all students in forming a deeper understanding of newly "earned" 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. This strategy is particularly helpful for emerging multilingual students" (Teacher Edition, page 118).
- Lesson 7: "Supporting Emergent Multilingual Students: Teachers can support all students, particularly emerging multilingual students, in forming a deeper understanding of newly "earned" 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, or 4) use the new term in a sentence. The representation for stakeholders (people who have an interest or concern or investment in something) should mostly illustrate the people who will be impacted by the design solution (in this case, a warning system that communicates to people how and when to respond)" (Teacher Edition, page 132).

Differentiation strategies are provided for learners with disabilities. For example:

- Lesson 7: "Consider how some students may react to loud or alarming noises. If needed, the clip has lower tones starting at 1:08 through the end of the clip, where there is an announcer with very low sirens heard in the background. This section of the audio might be more appropriate to play for students who are sensitive to loud or alarming noises" (Teacher Edition, page 131).
- Lesson 8: "Universal Design for Learning: Boxes have been color-coded to make explicit the representation of the subsystems that interact within the bigger system along the Tsunami Chain of Events. While color coding is a useful way to quickly reference the parts of the model, you can also use letter or number coding to label the boxes in the system model to help ensure accessibility for all students. Whichever representation is used, create a key to track what colors, symbols, or letter or number codes represent different parts of the system" (Teacher Edition, pages 150–151).

Suggestions for Improvement

Consider providing strategies for teachers to support readers who read well below grade level that focus on reading science informational text. Supplement the section in the Teacher Handbook on close reading with ideas about how to adapt the strategy for students with lower level reading skills.

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time. The navigation across lessons is facilitated by both student questions and by student ideas generated by teacher questions. Teachers are guided to link lessons through the Navigation section at the end of each lesson (or lesson part) and another Navigation section in the subsequent lesson.

Teacher support is provided for linking engagement across lessons:

- At the start of each lesson, teachers are provided a Navigation Routine to facilitate unit coherence. The three elements of the Navigation Routine are described in the Teacher Handbook (pages 15–16). The first part of the routine is “Look Back: How did we get here?” which occurs at the beginning of the lesson and reviews the previous lesson. The second part is “Take Stock: Where are we now?” which occurs in the middle of a lesson to strengthen connections between the activities and the storyline. Finally, the third part is “Looking Forward: Where are we going?” At the end of a lesson, the class looks back over what has been done and then poses questions and ideas about what should come next.
- Lesson 1: “Decide where to go next. Suggest to students that before we can tackle the engineering aspects of this unit, the part about how to prepare for a hazard, we need to know more about where they happen. Point to the questions on the DQB related to tsunami location or geography. Say, We have a lot of great ideas for ways to investigate natural hazards so we can design ways to protect the people and communities they affect. Let’s start with the questions we have about the tsunami. We seem to have questions about where they occur. Maybe we can use what we figure out about the locations of tsunamis to help us figure out more about other hazards” (Teacher Edition, page 36).
- Lesson 2: “Use these ideas to motivate the need to look at tsunami data. Say, Last time we were wondering where tsunamis happen in the world. Scientists have been tracking tsunamis for a while, and we are going to look at that data today. So our question is, “Where do tsunamis happen and what causes them?” (Teacher Edition, page 43).
- Lesson 3: “Recall conclusions from the previous lesson. Display slide A and say, Last class, we figured out that a major cause of tsunamis are certain types of earthquakes that happen under the ocean. So what are your predictions for the answer to our next lesson question, “What causes a tsunami to form and move?”” (Teacher Edition, page 61).
- Lesson 4: “Revisit Tsunami Chain of Events. Point to the Tsunami Chain of Events and say, In the last few days, we’ve figured out how tsunamis form. Now that we understand the Tsunami Chain of Events, we can use what we know to forecast which communities are most at risk for tsunamis. Pass out Forecasting Risk to Communities” (Teacher Edition, page 81).
- Lesson 4: “Motivate the need to revisit engineering designs with new science ideas in mind. Say, we have a pretty good understanding of what causes tsunamis, where they happen, how they move, and the types of places where they impact people and property. If we can forecast where tsunamis are more likely to cause damage to people and property, then we can do something about it. We can try to prepare and protect people and property from this natural hazard. Show slide E and ask students to turn back in their notebooks and find Tsunami: Japan 2011. Give them a few moments to find the handout, then say, Take a few moments to look back at your own ideas and the ideas you recorded from others for tsunami detection, warning, and reducing damage. Think about what we now know about tsunamis. Which designs for detection, warning, and reducing damage do you think are still promising? Place a sticky dot next to any ideas you think might be worth investing time and resources into. Give students a minute or two to work individually. Say, Turn to a partner and share one idea you marked with a sticky dot in your handout. As students finish sharing, summarize the lesson by saying, Our next steps will include examining and evaluating existing solutions to determine how well they protect people and property during a tsunami” (Teacher Edition, page 86).
- Lesson 5: “Ask participants what additional information we might need to obtain to help us decide between design solutions or identify features that are important to include in our

designs. Tell students that we have data on existing solutions that we could use to learn more about different features perform in a tsunami. Ask, How could comparing the performance of existing solutions like walls or barriers to prevent damage from tsunamis help us?" (Teacher Edition, page 93).

- Lesson 6: "Motivate the next step. Display slide F. Guide students to think about what happens once a tsunami is detected and predicted to impact land. Say, So, an earthquake has occurred in the ocean, and the DART II system has accurately and quickly signaled that a tsunami is approaching. The local government is about to issue a tsunami warning to people nearby. What should we be concerned with at this step? Focus on responses associated with the communication of the warning. For example, how soon should the warning be sent? Do they wait for more information? How do they send out the message? What's in the message? All these ideas set students up to think more about the technologies, criteria, and constraints involved in communicating before and during a tsunami" (Teacher Edition, page 125).
- Lesson 8: "Say, Next class maybe we can use all the ideas we have figured out to prepare our own communities or other communities for hazards that might affect them" (Teacher Edition, page 157).

CCC elements are intentionally used to make progress toward understanding the phenomenon. In the unit materials, the **Cause and Effect** element, *Relationships can be classified as causal or correlational and correlation does not necessarily imply causation*, is used to develop the relationship between certain types of earthquakes and tsunami formation.

- Lesson 2: As students view maps of the occurrence of earthquakes and tsunamis, teacher is advised, "This is a good place to highlight that correlation does not always mean causation. In a real sense, just because an earthquake happens does not mean a tsunami will form. Ask students, If an earthquake happens anywhere in the world, can we predict whether a tsunami will form? What evidence can support our ideas?" (Teacher Edition, page 47).
- Lesson 2: Teachers are given the following support to guide students during a consensus discussion: "Purpose: To motivate the need to understand the cause-and-effect relationships between earthquakes and tsunamis and where tsunamis happen and what causes them. Look for/listen for:

    -related incidences of earthquakes and tsunamis, but not all earthquakes cause tsunamis
    -uncertainty about why some earthquakes are related to tsunamis while others are not
    -wonderings about characteristics of earthquakes that can cause tsunamis
    -ideas about how understanding more about earthquakes can help to understand why some communities are more at risk than others" (Teacher Edition, page 48).
- Teachers are supported to co-create a tsunami chain of evidence with the class.
    - Lesson 2: "The class begins building a cause-and-effect diagram in service of identifying locations and causes of tsunamis in order to refine their predictions and improve their forecasting of which communities are at risk for tsunami damage. This causal chain will continue to build throughout the unit as more science and engineering ideas are integrated" (Teacher Edition, page 51).
    - Lesson 2: The class starts a "Tsunami Chain of Events" to show the cause-and-effect relationships (Teacher Edition, page 51).

- Lesson 3: After analyzing several wave models, the class updates the Tsunami Chain of Events to show new information (Teacher Edition, page 74).
- Lesson 4: The tsunami chain of events chart is used as students develop an explanation to describe how sudden geologic forces lead to the formation of a tsunami and to identify places in the chain that are forecasting risks (Teacher Edition, page 82).
- Lesson 5: Students identify places in the Tsunami Chain of Events where engineering solutions can be used to mitigate the harm caused by tsunamis (Teacher Edition, page 110).

Suggestions for Improvement

Much of the navigation between lessons and inside of lessons involves a class discussion of teacher-provided questions. Consider a step where student questions that arise during these discussions are captured and put on the DQB.

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. Teacher provided scaffolds are evident in at least one SEP element where students are required to become more independent in the use of the element over the unit. Scaffolding is not clear for all of the focus SEPs identified in the material. Many of the SEP elements are used only once during the unit; therefore, there are few opportunities for students to become more independent in the use of these elements.

Scaffolding is provided to students to build proficiency in the SEP element of **Analyzing and Interpreting Data**, *Distinguish between causal and correlational evidence for phenomena.* Related evidence includes:

- Lesson 2: The class discusses the historical data of location of earthquakes and tsunamis and notices the correlation. “This is a good place to highlight that correlation does not always mean causation. In a real sense, just because an earthquake happens does not mean a tsunami will form” (Teacher Edition, page 47).
- Later in Lesson 2, the class discusses what needs to be investigated to determine a causal relationship.
- Lesson 2: After examining more data, the class constructs a cause-and-effect diagram to determine if a causal relationship exists (Teacher Edition, page 52).

- Lesson 2: Individual students summarize the causal relationships found in data sets about earthquakes and tsunamis (Teacher Edition, page 53).
- Although this element is scaffolded in this lesson, there is no place in the unit where students use their skills learned about this element independently.

Scaffolds are also provided to build proficiency in the SEP element of **Constructing Explanations and Designing Solutions**, *Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.* Related evidence includes:

- Lessons 2 and 3: The class works together to create the tsunami chain of events. This is a visual explanation of the relationship of earthquakes and tsunamis that creates the basis for an explanation of the relationship between tsunamis and earthquakes.
- In Lesson 4, students individually complete an assessment where they write their own explanations of which locations are most likely to experience a tsunami.

Scaffolds are provided for the SEP of **Analyzing and Interpreting Data**, *Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.* Related evidence includes:

- Lesson 2: Students analyze a data set to figure out why some earthquakes cause tsunamis and others do not. Students work in groups of two to three on this activity, and a handout is provided. "The handout, Connecting Earthquakes and Tsunamis, has scaffolded questions to guide student construction and analysis of the graphs, particularly focused on choosing independent and dependent variables, and then to guide observation and interpretation of the results. It might be helpful to read Step 1's instructions aloud as a whole class so students are clear about the analysis task. Detailed instructions with screenshots from the Tuva dataset are provided in Tuva Graphing Instructions" (Teacher Edition, page 50). Students then engage in a large group discussion to talk through their analysis.
- Although Lesson 2 provides many scaffolds to help students access and understand large data sets, there is no place in the unit where students use that understanding to analyze data sets on an individual basis.

Scaffolds are provided for the SEP of **Engaging in Argument from Evidence,** *Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.* Related evidence includes:

- Lesson 1: Students evaluate designs by writing down the idea that has the most promise and the one that seems most challenging and explaining why (these prompts are provided by the teacher). This is done without a developed list of criteria and constrains. Students then use the responses to engage in a class discussion to find patterns in what makes solutions promising or challenging in order to begin the process of developing design criteria.
- Lesson 5: Students are provided with a decision matrix which is used to evaluate competing design solutions they have read about based upon the criteria and constraints which they developed.
- Lesson 7: Students use an evaluation matrix, which has been constructed from agreed upon criteria and constraints, to evaluate different communication options. The students have more input in developing the criteria and constraints than in Lesson 5.

- Lesson 9: Students identify their own criteria and constraints, based upon their chosen natural hazard, to develop a communication plan to mitigate its effects.

Suggestions for Improvement

- Consider providing clear guidance for teachers around where and how scaffolding is reduced for all three of the key SEPs identified by the unit.
- Consider limiting the number of individual SEP elements, or choosing to focus on a few selected elements, so that teachers can build in scaffolds to ensure that students can become more proficient over time in focus elements.

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials elicit direct, observable evidence of students using practices with core ideas and crosscutting concepts to make sense of phenomena and/or design solutions. The unit provides opportunities for students to show the use of all three dimensions to further their understanding of the phenomenon and to derive a solution to a problem. Artifacts showing understanding of the targeted learning are created through both group and individual efforts in the unit. Students use grade appropriate elements of the DCIs, SEPs, and CCCs to respond to prompts designed to further understanding of the phenomenon. Formal tasks are based on real-world scenarios and require students to extend their understanding to a new scenario.

The materials elicit evidence of students integrating the three dimensions in service of sense-making and solving problems. Related evidence includes:

- Lesson 2: As a class, students begin building a cause-and-effect diagram to determine locations and causes of tsunamis. In this task students use the following elements of the three dimensions:
    - DCI: **ESS3.B:** *Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.*
    - CCC: **Cause and Effect** *Cause and effect relationships may be used to predict phenomena in natural or designed system.*
    - SEP: **Constructing Explanations and Designing Solutions** *Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events.*
- Lesson 4: Students use the Tsunami Chain of Events which was created as a class as well as the information to individually construct an explanation for a tsunami event. On the assessment, students are provided with information about various earthquakes and locations with the intention of using the relationships between these variables to explain which areas would be most at risk. "This is an individual assessment opportunity for the DCI element **ESS3.B: Natural Hazards** (Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.) Tsunami forecasting is a combination of using historical data to know which communities are at risk, using real-time earthquake data to know if a tsunami could result, and then studying how waves

form and move to understand how quickly and severe they may damage communities" (Teacher Edition, page 84). In this task, students use the following elements of the three dimensions:
  - DCI: **ESS3.B:** *Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces, can help forecast the locations and likelihoods of future events.*
  - CCC: **Cause and Effect** *Cause and effect relationships may be used to predict phenomena in natural or designed system.*
  - SEP: **Constructing Explanations and Designing Solutions** *Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events.*
- Lesson 5: Students are asked to fill out a notecard to answer the question "Is keeping water from getting to the community the only criterion we need to consider? Is there anything else we need to consider when determining which solution would work better than others for Ryoshi?" In this task, students use the following elements of the three dimensions:
  - DCI: **ETS1.A:** *The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.*
  - CCC: **Structure and Function** *Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.*
  - SEP: **Constructing Explanations and Designing Solutions** *Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events.*
- Lesson 9: Students develop a communication plan for a hazard to mitigate its effects. Students begin by analyzing maps to determine relative risks in specific areas. In this task, students use the following elements of the three dimensions:
  - DCI: **ESS3.B, ETS1.B, ETS1.B**
  - SEP: **Constructing Explanations and Designing Solutions**; **Analyzing and Interpreting Data**
  - CCC: **Cause and Effect**, **Patterns**

Student artifacts are created in both small and large groups and individually. Related evidence includes:
- Lesson 3: Individual students complete a chart while viewing different models of waves. They describe what they see happening and how it helps to figure out about the movement of tsunamis. In this activity, students use the CCC of Patterns, the SEP of **Constructing Explanations** and part of the Earth and Space Science DCI related to the geologic basis of natural hazards.
- Lesson 4: The class works together to create an explanation that describe the kinds of earthquakes that cause tsunamis and to use that information to forecast tsunami risk. Then, the students work individually to apply this understanding to a novel scenario. In completing this assessment, students use the SEP of **Constructing Explanations**, the DCI relating to using maps to forecast geologic occurrences, and the CCCs of **Patterns** and **Cause and Effect**.
- Lesson 7: Students individually, or in small groups, complete an evaluation matrix to determine the best method of communicating tsunami information to the public. Then students discuss their ideas with the class. This activity requires students to evaluate and come to an agreement

using agreed upon criteria and constraints to communicate how well the design (structure) serves to communicate to the public (function).
- Lesson 9: Students begin by working together to identify other kinds of natural hazards and how they can use maps to determine where those natural hazards may occur. Then, individual students respond to a prompt. (Lesson 9, Slide D) "Explain which hazard you are at most risk for in your local community. Use evidence from the maps to support your explanation. If there are additional sources of data that you would want to study, also include those ideas in your explanation." Students are reminded to "identify and use patterns and trends they obtained from the digital tools of large data sets (i.e., hazard risk maps) as part of their explanations about likely future risk of a hazard for their communities and other communities." (Teacher Edition, Page 166).
- Lesson 9: Students complete a summative project using skills developed in the unit. The class returns to a list of related phenomena generated in Lesson 1. They choose a hazard based on interest, consider the needs of community members, obtain information about the hazard, and develop a communication plan to educate the community. They use a variety of formats to deliver this information. "This project is designed to integrate elements of obtaining, evaluating, and communicating information about the likelihood of hazard in a community and using criteria and constraints identified for the community. This project uses a lens of systems and system models as students consider different aspects to forecast, warn, and communicate with stakeholders. As students develop their projects, facilitate three-dimensional learning by encouraging students to seek out information from different sources, evaluate the quality of the information, and decide how best to communicate about levels of risk of a hazard and the systems in place to mitigate the effects. Students should use criteria and constraints for stakeholders to refine the information they choose to communicate." (Teacher Edition, page 173).

Suggestions for Improvement

None

III.B. FORMATIVE

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

Rating for Criterion III.B. Formative	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction. Formative assessments occur throughout the unit and are accompanied by guidance to the teacher on how to evaluate student responses and how to modify instruction based on the results. However, this guidance is typically only for a single correct response, and element level guidance is not provided for SEPs or CCCs. Assessment opportunities are varied and allow students to express their thinking in a variety of ways. Teachers are provided with support to give feedback and modify teaching if necessary.

The materials include frequent support for three-dimensional formative assessment.

- Students use a science notebook to record their thinking throughout the unit. "Remind students that the notebook is their tool for recording their observations, evidence, and ideas to share with the classroom community. They should see it as a space to brainstorm and record their thinking, as well as a place to show how their thinking changes as they learn more" (Teacher Edition, page 23). While the science notebook can be utilized as a formative assessment opportunity, it is not clear when and how teachers use this to provide feedback and/or make instructional adjustments.
- Lesson Two: "Narrow down ideas about the earthquakes that cause tsunamis. Display slide I and read its questions aloud: What do you think is unique or special about the earthquakes that cause tsunamis? What data would you need to see if you are right? Give an index card to each student and have them write their initial ideas in response to these questions. Gather the exit tickets for the next class to formatively assess students' current thinking. Students will share their thinking at the beginning of day 2" (Teacher Edition, page 49).
- Lesson 5: Students are asked to fill out a notecard to answer the question "Is keeping water from getting to the community the only criterion we need to consider? Is there anything else we need to consider when determining which solution would work better than others for Ryoshi?" The following teacher guidance is provided: "Use this exit ticket to analyze students' thinking." However, no guidance as to what specifically to look for in these answers, or ways to provide feedback or adjust instruction is provided.
- Lesson 8: "Conduct the self-assessment. Project slide E. Distribute Engineering Self-Assessment. Explain to students that this handout has broken down the notecards on the "What We Do as Engineers" chart into smaller, easier to assess pieces. Tell students we can use these areas to check our individual progress on using these engineering ideas to develop a system of solutions. Show students how to use the 1–3 scale to evaluate themselves. Point out that all students should explain their ratings using the last question on the handout. If students are stuck between two ratings, tell the students to pick one and give their reasoning in this space. Tell students they will hand this in when they are finished, and they will be given teacher feedback on the same form. Give students time to complete the handout. Have students turn in the self-assessment when they are finished" (Teacher Edition, page 156). In addition, the following teacher guidance is provided: "Self-assessments are valuable tools to gauge student understanding. Students rely on a feedback loop involving the student and teacher for personal academic growth. Use this assessment to determine any perceived areas of challenges and successes from a student's perspective, and provide timely feedback for the students (either on the front or back of this paper) regarding their perceptions and reality. Remember to give some positive feedback for every critique to help build the student's self-efficacy in the engineering process" (Teacher Edition, page 156).

All Assessment Opportunities include a section called "What to look for/listen for" where possible students responses are noted. No student responses showing alternate ideas are provided. There is a second section, "What to do" giving teachers support for providing feedback and for changing instruction if necessary. Related evidence includes:

- Lesson 1: Teachers analyze individual student designs using these guidelines: "At least one drawing or written description of an idea to either help detect tsunamis, give people more advance warning, or help reduce the damage caused by tsunamis. Ideas that indicate a characteristic of the tsunami wave that would be important to consider in the design, such as the start of the hazard (e.g., earthquake); or how fast, big, or intense the wave becomes; or a method for blocking the wave from reaching a community." If students are struggling with the engineering ideas, teachers are advised to: "Fill a 5-gallon bucket or similar container with water and ask a student to pick it up. Ask them what it might feel like to get hit by that much water. Remind them that a tsunami wave carries millions of times more water than the bucket. Remind them of the cars, airplanes, and helicopters they saw swept away during the second video clip" (Teacher Edition, page 29).
- Lesson 3: Support for teachers on how to modify instruction is provided in the Assessment Opportunity. "If possible, watch the video once as a class and then have students play it again in small groups to make their observations. If students do not develop all the ideas listed above, their engagement with the two other wave models may support the development of these ideas from a different perspective" (Teacher Edition, page 68).
- Lesson 5: Students complete an exit ticket and teachers are advised to "Use this exit ticket to analyze students' thinking regarding additional criteria or constraints that should be under consideration by the class. This thinking will be used to start day 2" (Teacher Edition, page 99).
- Lesson 6: In the Assessment Opportunity, teachers are advised what to look for in student responses "After the third paragraph in the reading, students should understand that the tsunami detection system will only trigger if an earthquake meets specific criteria) and what to do if students are struggling to grasp the ideas in the reading selection (If students are struggling to identify criteria and constraints in the tsunami detection system, pause and reflect back on how criteria and constraints have been discussed up to this point.)" (Teacher Edition, page 122).
- Lesson 7:
  - "**Building towards:** 7.A Integrate written text with multimedia displays of tsunami warning and preparedness systems to clarify additional ways communities at-risk of tsunami can mitigate potential future effects.
  - **What to look for/listen for:** Look for clearly identified stakeholders with particular needs for emergency communication, and then look for corresponding criteria and constraints that address those needs but might limit what can be used to develop or evaluate potential solutions. Use the previous example table to see specific example student responses.
  - **What to do:** If students are struggling to connect stakeholder needs with criteria and constraints of communication systems, use a local or relevant example to walk them through the process. For example, ask students: If there is a fire in our school, how do we, the stakeholders, receive the warning? Would all people in our class receive the alert? What might prevent someone from receiving it? Is there only one alert style or more than one (e.g., sound, lights, vibrations, others)? Using an example familiar to students might help access their knowledge about different criteria and constraints for communication systems. Other examples could be Amber alerts or tornado warnings;

consider also using non-emergency communications, such as the school announcements or announcements at sporting events or theme parks" (Teacher Edition, page 137).

The Assessment System Overview document provides formative assessment guidance for SEPs and CCCS. However, specific grade-appropriate elements are not specified. For example,

- "2.B Mathematics and Computational Thinking; Patterns When to check for understanding: Day 1 as students use the maps and graphs. What to look for/listen for: As students compare recent earthquake data to tsunami-generating earthquakes, their interpretations should include the pattern that earthquakes and tsunamis are related but only some earthquakes cause tsunamis. This helps to motivate looking more closely at what types of earthquakes cause tsunamis" (Assessment System Overview, page 3).
- "7.B Arguing from Evidence; Structure and Function When to check for understanding: On day 2, when students complete Evaluation Matrix in small groups and then as a class. What to look for/listen for: Listen for agreement about what their assigned communication solution does well and its limitations. Across all groups and as a whole class, listen for ideas about how some communication solutions meet some criteria very well, while others meet other criteria well. The purpose of this work is to better understand how combining multiple forms of communication can address multiple stakeholders needs" (Assessment System Overview, page 5).

Suggestions for Improvement

- Consider providing a range of student responses showing varying levels of proficiency.
- Consider providing teacher guidance for modifying instruction based upon a variety of responses reflecting different proficiencies.
- Consider providing specific elements for SEPs and CCCs in the Assessment System Overview guidance.

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 scoring guidance is provided with clear learning outcomes along with sample student responses as well as some guidance for teachers on how to provide feedback and modify instruction. However, element level guidance is not consistently provided, and guidance provided is typically only for a single, exemplary response. Assessment targets are clearly stated for grade-appropriate elements of all three dimensions.

The Assessment Opportunity callout boxes each provide a three-dimensional learning outcome related to each assessment, however grade-appropriate elements being assessed are not specifically identified in the "What to look/listen for" section, where the DCI element is featured.

Scoring guidance is provided for the assessments in Lessons 4 and 9.

- Lesson 4: The key claims to provide scoring based on students' masteries of targeted SEPs, DCIs, and CCCs. Only part of the DCI element is incorporated into the scoring guidance. The key does not address mapping of the history of natural hazards. The key also does not have references to the CCC element of **Stability and Change**. Although the key contains responses, a range of student responses is not included (Answer Key, page 191).
- Lesson 9: The teacher evaluation materials first delineate the elements of the SEP, DCI, and CCC to be assessed. The rubric provides adequate information to teachers to evaluate student progress in those learning goals (Scoring Rubric and Answer Key (pages 211–215).

Sample student responses are provided for most assessments, along with suggestions for feedback and adjusting instruction. However, typically these are only in the form of exemplar student responses, rather than a range of response.

- Throughout the materials, Assessment Opportunity boxes indicate opportunities for formative assessment. These boxes include a "What to Look For" and "What to Do", however, these are typically only provide single response rather than a range of responses. For example:
    - Lesson 8:
      "Building towards: 8.A Construct a system model to represent the interactions of subsystems designed to detect, warn communities, and reduce damage from a tsunami hazard.
      What to look for/listen for: Connections should be determined between various parts of the subsystem. Students should be able to articulate: 1) systems are comprised of subsystems that work together as a system, 2) parts of the subsystem cannot fully protect a community on their own, and some rely on feedback from other parts of the system, and 3) while the system works to meet the needs of the individual community, the system components and interactions may have to be altered when applied to other communities or situations.
      What to do: If students are struggling with:
        1. Subsystems working together as a system to meet the needs of the community, press students to explain how the system would be affected if the larger subsystem was taken out of the system and if the system could still meet the criteria of the community as effectively.
        2. Considering the importance of the subsystems to meet the goals of the larger system, place a hand or a sticky note over a single component of a subsystem. Ask students how the subsystem would change if the component was removed and what effects it would have on the larger system.

3. Seeing the potential changes to the system to address the needs of other communities, push students to consider a change in location, like a crowded tourist destination. Ask students what new constraints would be prioritized, if the system would have new constraints based upon the location, and what parts of the system would most likely have to be altered to meet the constraints of the community" (Teacher Edition, page 154).

Suggestions for Improvement
When elements of the dimensions are referenced in the scoring guidance, ensure that student responses include answers that incorporate aspects of the element.

III.D. UNBIASED TASK/ITEMS

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

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

The reviewers found extensive evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples. Tasks in the unit use vocabulary and text that are grade-level appropriate and students are provided with a variety of ways to respond to assessment tasks, such as drawing, writing, and discussing with peers, along with an opportunity to choose their own modality. Scenarios used in tasks are unbiased and accessible to all students.

Students have choices when engaging in an assessment task. For example:

- Lesson 4: An alternate activity is provided. "Instead of completing Explaining and Forecasting Tsunami Risk individually, students can work in small groups to complete parts of the assessment. Utilize this option if students have struggled with constructing explanations in previous units or if you want to promote discourse within small groups in your class or peer review of explanations. If you select this option, encourage students to use the Communicating in Scientific Ways poster to practice developing and coming to group consensus on their explanation. Also, consider providing the option of completing the assessment orally for students who may need this modification" (Teacher Edition, page 83).
- Lesson 9: Students are provided with choices regarding the type of natural hazard addressed, the stakeholder group for whom they are building a communication plan, and the project format.

The use of a word wall, as well as other guidance for vocabulary ensures all students can access key vocabulary throughout the unit. New words are not used until students have experience with the concept.

- Lesson 2: "Supporting Emergent Multilingual Students: Cognates are words that are similar in both spelling and meaning in different languages. Many science vocabulary terms have cognates across romance languages (e.g., magnitude in English = magnitud in Spanish). Using cognates, teachers can support emerging multilingual students in making connections between new science vocabulary and their native language(s). This can reduce the vocabulary overload that they may experience in science. Teachers can display cognates on the Word Wall alongside their corresponding vocabulary terms or include cognates in writing using parentheticals" (Teacher Edition, page 49).
- Lesson 6: "Supporting Universal Design for Learning: Teachers can support all students in forming a deeper understanding of newly "earned" 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. This strategy is particularly helpful for emerging multilingual students" (Teacher Edition, page 118).

Suggestions for Improvement

None

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	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning because all four assessment types are found throughout the unit. Assessments match the stated learning goals and fit together into a system that allows the teacher to gain information about individual student learning.

Pre-assessment

- Lesson 1: "Pre-Assessment: The student work in Lesson 1 should be considered a pre-assessment, as it is an opportunity to learn more about the ideas your students bring to this unit. Surfacing these ideas early on can help you to be strategic in building upon and leveraging student ideas across the unit" (Assessment System Overview, page 1).

Summative

- Lesson 4: "Summative: The final task for the unit challenges students to first investigate general regional patterns in risk for other natural hazards, as well as the risk of each natural hazard for their local community. Using this data and their wonderings about how other natural hazards impact communities, students make decisions about which natural hazards to investigate further to develop education and communication plans" (Assessment System Overview, page 1).
- The project in Lesson 9 is called the summative task by the developers. Students use project planners that include using relevant science information (DCI), ways to communicate the information (SEP), and the parts of the system as determined in Lesson 8 (CCC).

Formative: Formative assessments occur throughout the unit and are included on pages 3–5 of the Assessment System Overview. For example:

- "2.A Analyzing and Interpreting Data; Patterns When to check for understanding: Day 1, as students interpret the first map showing the spatial distribution of historical tsunami occurrence and related geologic events. What to look for/listen for: Students may notice that the locations of tsunamis are similar to the locations of earthquakes in data from the OpenSciEd Unit 6.4: What causes Earth's surface to change? (Everest Unit). They should notice that tsunamis occur in oceans or other large bodies of water, and that more have occurred in the Pacific Ocean than elsewhere. Tsunamis are most frequently caused by earthquakes" (Assessment System Overview, page 3).

Self-Assessment

- Lesson 8: "Conduct the self-assessment. Project Slide E. Distribute Engineering Self-Assessment. Explain to students that this handout has broken down the notecards on the "What We Do as Engineers" chart into smaller, easier to assess pieces. Tell students we can use these areas to check our individual progress on using these engineering ideas to develop a system of solutions. Show students how to use the 1–3 scale to evaluate themselves. Point out that all students should explain their ratings using the last question on the handout. If students are stuck between two ratings, tell the students to pick one and give their reasoning in this space. Tell students they will hand this in when they are finished, and they will be given teacher feedback on the same form. Give students time to complete the handout. Have students turn in the self-assessment when they are finished" (Teacher Edition, page 156). In addition, the following teacher guidance is provided: "Self-assessments are valuable tools to gauge student understanding. Students rely on a feedback loop involving the student and teacher for personal academic growth. Use this assessment to determine any perceived areas of challenges and successes from a student's perspective, and provide timely feedback for the students (either on the front or back of this paper) regarding their perceptions and reality. Remember to give some positive feedback for every critique to help build the student's self-efficacy in the engineering process" (Teacher Edition, page 156).

Suggestions for Improvement

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

None

III.F. OPPORTUNITY TO LEARN	
Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.	
Rating for Criterion III.F. Opportunity to Learn	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts. Multiple opportunities exist for students to demonstrate their growth in proficiency of key learning and multiple feedback loops are present to allow students to improve their performance. For key claimed learning in the unit there are multiple student performances that provide students with the opportunity to demonstrate their growth in proficiency over time. However, there are few places where students receive individual feedback on a task and can then show increased proficiency on another similar task.

One key claimed learning is **MS-ESS3-2**

- Lesson 2: Students analyze a data set to figure out why some earthquakes cause tsunamis and others do not. Students work in groups of two to three on this activity, and a handout is provided
- Lesson 9: Students use digital maps to look for patterns of where natural hazards occur in order to determine the relative risk in different areas. Students individually respond to the following prompt: "Explain which hazard you are at most risk for in your local community. Use evidence from the maps to support your explanation. If there are additional sources of data that you would want to study, also include those ideas in your explanation" (Lesson 9, Slide D)

Another claimed learning are the elements in **MS-ETS1-1** and **MS-ETS1-2**

- Lesson 1: Students evaluate designs by writing down the idea that has the most promise and the one that seems most challenging and explaining why (these prompts are provided by the teacher). Students then use the responses to engage in a class discussion to find patterns in what makes solutions promising or challenging in order to begin the process of developing design criteria.
- Lesson 5: Students watch a video of engineers demonstrating models of different solutions to lessen the impact of tsunamis and evaluate their effectiveness using the criteria they have developed in order to rank their solution using the evidence collected from their observations. Students then engage in a class discussion. "Once the rankings are complete, ask, So, based on

what we saw happen with each of the suggested solutions, what should we recommend to Ryoshi and why? In addition to the amount of water that made it past each type of solution, are there other considerations we need to account for? Let students share some ideas and explain why they would choose one over the other based on what they saw on the video and the criteria they have in place" (Teacher Edition, page 98)

- Lesson 7: Students use an evaluation matrix, constructed from agreed upon criteria and constraints, to evaluate different communication options.
- Lesson 9: Students evaluate projects using the form "Stakeholder Criteria and Constraints Peer Feedback Form". They use their skills developed in prior lessons to complete this task.

Assessment Opportunity boxes are found in each lesson which provide guidance for teacher feedback on key learning performances.

- Lesson 3: After making observations of and discussing all three models, students have an opportunity to update their science notebooks with new ideas related to how earthquakes on the ocean floor cause tsunamis. These ideas are then shared out in a large group in a scientist's circle. This provides students with a potential opportunity to receive feedback from peers regarding their thinking.
- Lesson 5: Students are asked to fill out a notecard to answer the question "Is keeping water from getting to the community the only criterion we need to consider? Is there anything else we need to consider when determining which solution would work better than others for Ryoshi?" The following teacher guidance is provided: "Use this exit ticket to analyze students' thinking regarding additional". However, no guidance as to what specifically to look for in these answers, or ways to provide feedback or adjust instruction is provided.
- Lesson 7: Students use an evaluation matrix, constructed from agreed upon criteria and constraints, to evaluate different communication options. Students work in a small group to work on the evaluation matrix. Students then meet with another group that evaluated the same option. "Display slide J with new instructions. The two groups assigned to the same communication options will need to meet together and come to consensus on how they rated the option and what constraints the communication option might have" (Teacher Edition, page 138). This consensus discussion provides a valuable tool for peer feedback and revision of thinking.
- Lesson 8: "Conduct the self-assessment. Project slide E. Distribute Engineering Self-Assessment. Explain to students that this handout has broken down the notecards on the "What We Do as Engineers" chart into smaller, easier to assess pieces. Tell students we can use these areas to check our individual progress on using these engineering ideas to develop a system of solutions. Show students how to use the 1–3 scale to evaluate themselves. Point out that all students should explain their ratings using the last question on the handout. If students are stuck between two ratings, tell the students to pick one and give their reasoning in this space. Tell students they will hand this in when they are finished, and they will be given teacher feedback on the same form. Give students time to complete the handout. Have students turn in the self-assessment when they are finished" (Teacher Edition, page 156). In addition, the following teacher guidance is provided: "Self-assessments are valuable tools to gauge student understanding. Students rely on a feedback loop involving the student and teacher for personal academic growth. Use this assessment to determine any perceived areas of challenges and successes from a student's perspective, and provide timely feedback for the students (either on

the front or back of this paper) regarding their perceptions and reality. Remember to give some positive feedback for every critique to help build the student's self-efficacy in the engineering process" (Teacher Edition, page 156).

Students receive written and oral feedback from both the teacher and peers which can be used to improve learning.

Feedback is general and usually directed toward the whole class. There are no places in the unit where students can use individual feedback from the teacher to improve their performance on a later assessment task.

Suggestions for Improvement

- Consider providing places for individual feedback to students during the first four lessons where students can see inaccuracies or deficiencies in their thinking before they take the assessment at the end of Lesson 4.
- Consider adding opportunities for students to receive feedback from the teacher to improve their individual performance.
- Consider having students create a "Chain of Events" model for their chosen hazard for the final project that can receive feedback from the teacher before the project is completed.

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

Where Do Natural Hazards Happen and How Do We Prepare for Them?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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)