Opportunities for ELA/ELD Connections

As part of an investigation about rocks, rock formations, and the components in rocks that provide evidence of changes in a landscape over time, students take notes, paraphrase, and categorize information by creating an *I Am a Rock* book. Students can write the information from the point of view of a rock in their investigation, including a description of what it is made of, how it formed, how it provides evidence of changes in the landscape, etc. Students include pictures throughout, as well as a list of sources at the end of the book.

CA CCSS for ELA/Literacy Standards: W.4.3, 4, 7, 8, 10; L.4.1, 2, 5, 6

CA ELD Standards: ELD.PI.4.6, 10.b

IS4

Grade Four Instructional Segment 4: Earthquake Engineering

All regions of California face earthquake hazards. In this unit, students use the phenomenon of earthquakes to introduce the physical science concept of waves. The CA NGSS emphasize waves because electromagnetic waves play a fundamental role in modern technology (communications and medical imaging, among other applications). Grade four students do not yet study abstract electromagnetic waves, but instead **develop models [SEP-2]** of more tangible waves that cause objects to have a repeating **pattern [CCC-1]** of motion.

GRADE FOUR INSTRUCTIONAL SEGMENT 4: EARTHQUAKE ENGINEERING

Guiding Questions

- How have earthquakes shaped California's history?
- How can we describe the amount of shaking in earthquakes?
- How can we minimize the damage from earthquakes?

Performance Expectations

Students who demonstrate understanding can do the following:

4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [*Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.*]

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

GRADE FOUR INSTRUCTIONAL SEGMENT 4: EARTHQUAKE ENGINEERING

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [*Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.*]

3–5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3–5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3–5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

**The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.*

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-2] Developing and Using Models [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering)	PS4.A: Wave Properties ESS3.B: Natural Hazards ETS1.A: Defining Engineering Problems ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	[CCC-1] Patterns [CCC-6] Structure and Function

Highlighted California Environmental Principles and Concepts:

Principle III Natural systems proceed through cycles that humans depend upon, benefit from and can alter.

Principle IV The exchange of matter between natural systems and human societies affects the long-term functioning of both.

Principle V Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes.

CA CCSS Math Connections: 3.MD.7b; 4.NF.7, 5.G.1

CA CCSS for ELA/Literacy Connections: SL.4.2; W.4.8

CA ELD Standards Connections: ELD.PI.4.6, 11

Many children in California have never felt an earthquake, though they know about them from family stories, media, and school disaster drills. Teachers can begin by hearing what students already know about earthquakes. They can show maps of recent earthquakes in California, read stories about important earthquakes in the history of California (including the 1857 Southern San Andreas, 1868 Hayward, 1872 Lone Pine, and the Great 1906 earthquake in San Francisco) as well as more modern earthquakes that their parents or grandparents may have felt (1971 San Fernando, 1989 Bay Area, 1994 Northridge).

Opportunities for Mathematics Connections

Where do earthquakes usually strike in California? How about the rest of the world? Students can take a list of the longitude and latitude of earthquake epicenters and plot them on a map (CA History–Social Science Standards 4.1.1; this skill is not part of the CA CCSSM until grade five, 5.G.1). Depending on the skill level of the students, the longitude and latitude should probably be rounded to the nearest whole number and students can plot them on a world map. Students who have greater mastery of decimal numbers (4.NF.7) can use locations rounded to the nearest tenth of a degree, which makes the locations detailed enough to plot on a map of California. To reveal key **patterns [CCC 1]**, students will need to work together to plot a large number of data points (100-200 earthquakes). Students should then **ask questions [SEP-1]** about the patterns they see. Students are likely to discover that earthquakes cluster in certain areas (including California) and there are large areas on the globe where very few earthquakes occur. In the middle grades, students will explain these patterns in terms of plate motions and the internal forces. In grade four, students are only responsible for describing patterns (4-ESS2-2) and asking questions about what might cause these patterns.

Teachers might be surprised to see a large number of earthquakes in Oklahoma, which has experienced more earthquakes per year than California since 2014. US Geological Survey scientists have documented that this increase is due almost entirely to wastewater from the oil and gas industry pumped deep into the ground (Weingarten et al. 2015; Ellsworth et al. 2015). This dramatic change in just a few years is a powerful example of how humans can disrupt natural cycles (EP&C III) and that altering these natural cycles affects human lives (EP&C IV).

CA CCSSM: 4.NF.7; 5.G.1

What does it feel like to be in an earthquake? Students can describe what they see in video clips of major earthquakes. How do objects move when they are attached to the ground? What happens when they are not attached? Students should be able to observe the clear back-and-forth motion during earthquake shaking. The shaking may start off gently, suddenly become severe, and slowly die back down. When students look at videos of the same earthquake from different locations, how does the shaking compare? The strength and duration of shaking a person experiences during an earthquake depend on many factors, including the amount of energy released in the earthquake, the distance the person is from the earthquake source, and the rigidity of the ground underneath the person. Grade four students are not expected to know or be told about these differences. They should focus on describing similarities and differences between different earthquake observations and **asking questions [SEP-1]** about what influences the shaking.

Students must then **develop a model [SEP-2]** of earthquake shaking. They can start with a physical model where they move their hands back and forth, reproducing the intensity of shaking by the distance they move their hands and the timing of the shaking by how quickly they must vibrate them back and forth. They can observe how this shaking forms a visible wave when they hold one end of a wire, string, or toy spring and repeat the motion. The farther up and down they move their hand, the farther up and down the string moves at its peaks (figure 4.11, left side). Students might also notice that the wave becomes longer and broader when they slow down their shaking (figure 4.11, right side). They have discovered two key aspects of describing waves: amplitude and wavelength. In earthquake waves, the amplitude is the intensity of the shaking while the wavelength relates to how quickly the movement repeats (figure 4.12). Teachers can have students practice using pictorial models of seismic waves by asking them to measure the wavelength and amplitude at different points in the recordings of famous California earthquakes, determine where the shaking would be most severe on each recording, and compare the shaking amplitude from different earthquakes.

Figure 4.11. Physical Model of Waves with a String

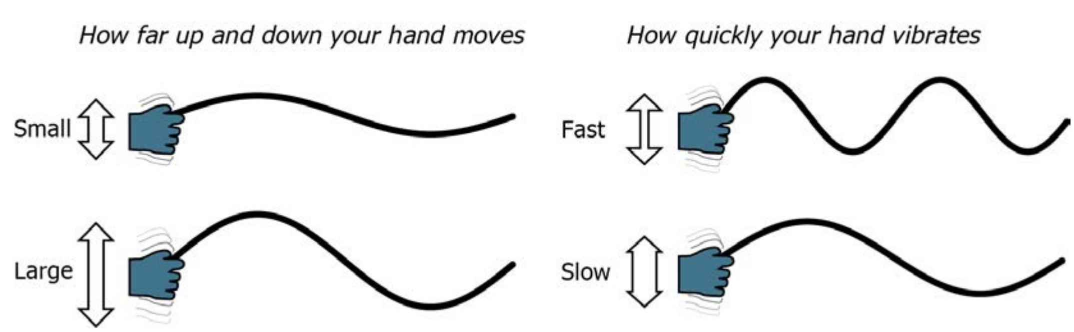

Diagram by M. d'Alessio
Long description of Figure 4.11.

Figure 4.12. Pictorial Model of Simple Waves and Earthquake Shaking

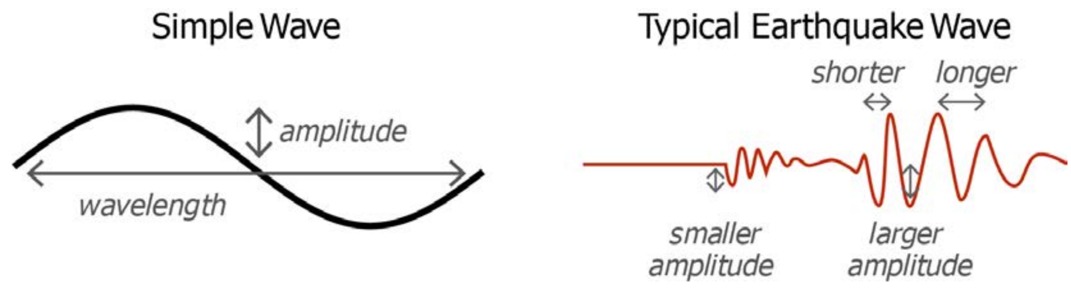

Diagram by M. d'Alessio
Long description of Figure 4.12.

It is not scientifically accurate to describe the width of an earthquake wave from a seismic recording graph as *wavelength* because the horizontal axis on these graphs is time, not length. This distinction is not important for grade four students and students can see how different parts of the earthquake wave have different lengths on the graph just like they can describe different wavelengths in real life.

Lastly, students can view computer visualizations of earthquake waves traveling across the surface (USGS 2016). Students see that earthquake waves appear like ripples on a pond or waves moving across the open ocean. They are in fact all examples of waves whose motion can be described using wavelength and amplitude.

Opportunities for ELA/ELD Connections

Students view two to three different videos on waves and use a note-taking template, such as a T-chart, to capture key information. On the left-hand side of the T, provide students with broad concepts for waves—light waves, sound waves, characteristics of waves, behaviors of waves (reflected, absorbed, transmitted), and examples of movement of energy. On the right-hand side, prompt students to include details gleaned from the videos. Possible sources of videos include Vimeo, YouTube, or recognized science experts (e.g., Bill Nye).

CA CCSS for ELA/Literacy Standards: SL.4.2; W.4.8

CA ELD Standards: ELD.PI.4.6, 11

Engineering Connection: Design a Home to Withstand an Earthquake

While earthquakes are a part of life in California, people can protect themselves from harm. California communities have adopted and enforce strict building codes so that every new building constructed must be designed using earthquake-safe techniques and be inspected by trained engineers prior to being used. These building codes are the difference between life and death. Fewer than 75 people died in each of the last three large earthquakes near cities in California (1971, 1989, 1994). More people die of preventable heart disease in California every day than died from these three earthquakes that took place over a span of more than two decades (CDC 2015). By contrast, a comparable earthquake in Bam, Iran in 2003 killed more than 25,000 people even though it was smaller than any of the California earthquakes. The difference is that homes in Iran were not constructed to the same standards as California buildings. Students will design a structure that can withstand earthquakes so that its occupants stay safe during the next "Big One." (4-ESS3-2).

Teachers should introduce a scenario in which students design a home that is big enough to hold a family and is capable of withstanding a strong earthquake. Teachers can construct a simple shake table where students will test out their designs (Teach Engineering 2010). First, students must **define the problem [SEP-1]** by deciding on criteria for success (3–5-ETS1-1). How long must the structure endure shaking before it can be certified as safe? What will the amplitude of the ground shaking be during the test? What counts as falling down? For example, if the structure tilts to the side during the test, is it still certified as safe? They then must work with the constraints given to them by the teacher. They use only the provided materials (interlocking plastic bricks, toothpicks and gumdrops, spaghetti strands and masking tape, index cards and transparent tape, etc.). Students calculate the area of their home's usable floor space to make sure it meets the minimum size requirements (CA CCSSM 3.MD.7b).

Each group of students generates a possible design that may **solve the problem [SEP-6]** and tests it out on the shake table (3–5-ETS1-3). Students quickly realize that they must be as consistent as possible with the shaking in order for the tests to be fair. Students then compare the different designs to determine which strategies worked best (3–5-ETS1-2). They modify their designs for a second trial and see if their improved structure can withstand stronger shaking. They create a presentation of their design to a future homeowner with diagrams that illustrate the **structural features [CCC-6]** they use to ensure the family's safety.