

Fixing Marisol's Hazard Report: Ten Claims, Eight Errors

Learning target: I can find and correct errors about where hazards happen, how magnitude works, and the difference between forecasting and predicting, and explain why each correction matters.

Error analysis

About 40 min

Individual

MS-ESS3-2 · practice

MS-ESS2-3 · supports

writing

independent practice

Standards connections

MS-ESS3-2 (practice): Students correct faulty reasoning about magnitude, frequency, forecasts and early warning, which are the ideas needed to interpret hazard data for this PE. Diagnosing errors practices the reasoning; it does not ask students to analyze a new dataset.

MS-ESS2-3 (supports): Two of the claims are about where volcanoes and earthquakes cluster along plate boundaries and why. Students use plate-boundary knowledge from Lesson 16 as background to correct them; past plate motions are not assessed.

Purpose: practice · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

Rule for magnitude (you will need it) — Each step of one whole number on the magnitude scale means about 32 times more energy released and about 10 times larger ground motion on a seismogram. Two steps means about $32 \times 32 = 1,024$, or about 1,000 times the energy.

Marisol's report: Natural hazards in California

1. Earthquakes and volcanoes are scattered randomly across the planet, so any place is as likely to have one as any other.
2. Under the crust, the mantle is an ocean of melted rock, which is why magma can come up almost anywhere.
3. Mount Shasta and Lassen Peak formed because an ocean plate is sinking beneath North America.
4. The 1906 San Francisco earthquake was magnitude 7.9 and the 1989 Loma Prieta earthquake was magnitude 6.9. Since 7.9 is only about 15 percent bigger than 6.9, the 1906 quake released only about 15 percent more energy.
5. The epicenter is the point deep underground where the rock first breaks.
6. Small earthquakes are good news. Each one lets out some pressure, so lots of small quakes keep a big one from happening.
7. Large earthquakes on one fault have come about 150 years apart on average. The last one was in 1880, so the next one will happen in 2030.

8. Lava flows are the deadliest thing a volcano does, because lava races downhill faster than a car.
9. Earthquake early warning on phones means scientists can now predict earthquakes before they start.
10. The 1989 Loma Prieta earthquake struck without any warning sign that scientists could recognize ahead of time.

Marisol's conclusion — Because nobody can predict earthquakes, hazard maps are just guesses, and there is nothing California can do about earthquakes except wait.

Part A: Sort the claims

1. Decide whether each claim is correct or incorrect. For each incorrect claim, name the word or idea that causes the error. 5 pts

Answer: 1 incorrect: 'randomly' (they cluster along plate boundaries). 2 incorrect: 'ocean of melted rock' (the mantle is mostly solid). 3 correct. 4 incorrect: treats magnitude as a simple percentage (the scale is logarithmic). 5 incorrect: describes the focus, not the epicenter. 6 incorrect: 'small quakes keep a big one from happening' (they release far too little energy). 7 incorrect: treats an average gap as a schedule. 8 incorrect: 'lava races faster than a car' (most lava flows are slow; pyroclastic flows are the deadly fast hazard). 9 incorrect: 'predict' (early warning detects a quake already under way). 10 correct.

Why: Claims 3 and 10 are accurate statements about real California hazards and events; the other eight each contain one central error that Part B asks students to fix.

Also acceptable: Accept short reasons in the second column instead of a single word.

- Claims 3 and 10 marked correct
- The other eight marked incorrect
- A specific wrong word or idea named for at least six of the eight

Part B: Fix the errors

2. Claims 1 and 2: Explain what is wrong with each. Then rewrite them as one or two accurate sentences about where volcanoes and earthquakes happen and why. Include one exception to the pattern. 3 pts

Answer: Claim 1 is wrong because volcanoes and earthquakes cluster in belts, mostly along plate boundaries such as the Pacific Ring of Fire. Claim 2 is wrong because the mantle is mostly solid rock; magma forms only in special places. Rewrite: 'Most volcanoes and earthquakes occur along the edges of tectonic plates, where plates collide, pull apart or slide past each other. The mantle is mostly solid, so magma forms only where something lets rock melt, such as water from a sinking plate or lower pressure where plates spread apart. Hot spots like Hawaii, far from any boundary, are an exception.'

Why: The correction must replace randomness with the boundary pattern and replace the liquid mantle with special melting conditions, and must include an exception.

Also acceptable: Accept the New Madrid zone in the central United States or Long Valley as the exception.

- Says hazards cluster along plate boundaries
- Says the mantle is mostly solid and melts only under special conditions
- Names an exception (hot spot or a fault inside a plate)

3. Claim 4: How many times more energy did the 1906 earthquake release than Loma Prieta? Show how you know, and explain why Marisol's 15 percent is wrong. 3 pts

Answer: $7.9 - 6.9 = 1.0$, exactly one whole step, so the 1906 quake released about 32 times the energy of Loma Prieta (and its seismogram waves were about 10 times larger). Marisol divided the magnitude numbers as if the scale were ordinary counting, but magnitude is logarithmic: each whole step multiplies the energy by about 32, so '15 percent more' should be about 3,100 percent more.

Why: The magnitude difference is what matters, not the ratio of the two magnitude numbers. 32 times the energy is 31 times more, about 3,100 percent more.

Also acceptable: Accept 'about 32 times' or 'about 31 times more'. Accept '10 times larger shaking on the seismogram' as an additional, correct fact, but it does not replace the energy answer.

4. Claims 5 and 9: Each uses a term incorrectly. Rewrite both so that *epicenter*, *focus* and *early warning* are used accurately. 2 pts

Answer: Claim 5: 'The focus is the point underground where the rock first slips; the epicenter is the point on Earth's surface directly above the focus.' Claim 9: 'Earthquake early warning detects an earthquake that has already started and sends alerts that can give people seconds of notice before strong shaking arrives. It does not predict earthquakes.'

Why: Both errors swap one concept for another: focus versus epicenter, and detection after the start versus prediction before it.

Also acceptable: Accept 'the place where the fault slips' for focus.

- Focus is underground and epicenter is on the surface above it
- Early warning detects a quake already under way
- States that early warning is not prediction

5. Claim 6: (a) About how many magnitude 4 quakes would it take to release as much energy as one magnitude 6? (b) If a fault averages 2 magnitude 4 quakes per year, how many years of them would it take to match one magnitude 6? Use your answers to explain why claim 6 is wrong. 3 pts

Answer: (a) Two steps from magnitude 4 to magnitude 6: $32 \times 32 = 1,024$, so about 1,000 magnitude 4 quakes. (b) $1,000 \div 2$ per year = 500 years ($1,024 \div 2 = 512$). A fault that averages 2 magnitude 4 quakes a year would need about 500 years of them to release the energy of one magnitude 6, so small quakes cannot use up enough stored energy to prevent a large quake.

Why: This is the logarithmic energy rule applied in reverse. Small quakes do release a tiny share of stored stress, but nowhere near enough to stop big ones.

Also acceptable: Accept 1,000 or 1,024 for (a) and 500 or 512 years for (b).

6. Claim 7: What is wrong with Marisol's reasoning? Rewrite the claim as an accurate forecast-style statement. 3 pts

Answer: An average is not a timetable. The gaps between large quakes on a fault vary a lot; some are much shorter and some much longer than the average, so nobody can name the year of the next one. Rewrite: 'Large earthquakes on this fault have come about 150 years apart on average, though the gaps vary. Since the last one was in 1880, a large quake in the coming decades is possible, but scientists can only give its chance over a span of years, not a date.'

Why: This targets the 'overdue' and 'schedule' error. The rewrite must express likelihood over a window, not a specific year.

Also acceptable: Accept rewrites that mention a probability percent for a window of years.

- Explains that the gaps vary around the average
- Rewrite states a likelihood or possibility over a span of years
- Rewrite contains no specific predicted year

7. Claim 8: Correct the claim. Name the volcanic hazard that really is fast and deadly, and say what kind of harm lava flows usually cause instead. 2 pts

Answer: Most lava flows move slowly, often at a walking pace or slower, so people can usually get out of the way; they rarely kill anyone but destroy buildings, roads and land in their path. The fast, deadly hazard is the pyroclastic flow, a ground-hugging cloud of hot gas, ash and rock that can race downhill faster than 80 km per hour.

Why: USGS notes that lava-flow deaths are uncommon while property loss is nearly total along the flow; pyroclastic flows travel faster than 80 km/h.

Also acceptable: Accept 'volcanic ash and gas clouds' alongside pyroclastic flows; accept mudflows (lahars) as another deadly hazard if pyroclastic flows are also named.

- Says most lava flows are slow
- Says lava mainly destroys property
- Names pyroclastic flows as the fast, deadly hazard

Part C: Rewrite the conclusion

8. Rewrite Marisol's conclusion so that it is accurate. Explain what hazard maps are based on, what a forecast can tell people, and give two specific ways California reduces earthquake harm. 4 pts

Answer: Example: 'Nobody can predict the day of an earthquake, but scientists can forecast where earthquakes are likely and how likely they are over the coming decades. Hazard maps are based on data: where earthquakes happened in the past, how often they happened and how strong they were, combined with knowledge of active faults and plate motion. California uses these forecasts to reduce harm: the Field Act requires public schools to be built to stronger earthquake standards, older bridges and freeways have been strengthened, and the ShakeAlert system sends warnings once a quake starts so people can take cover before strong shaking arrives.'

Why: The conclusion must separate prediction from forecasting, identify the data behind hazard maps, and give two real mitigation examples.

Also acceptable: Accept other real mitigation examples: building codes, base isolation, keeping homes off fault traces, bolting houses to foundations, earthquake drills.

- Distinguishes prediction (date) from forecasting (likelihood over time)
- Says hazard maps come from data on past locations, frequencies and magnitudes
- Gives two specific mitigation examples
- Removes the claim that nothing can be done

9. Which of Marisol's errors would be most harmful if a whole town believed it? Explain your choice in two or three sentences. 2 pts

Answer: Example: Claim 7 is most harmful, because a town that believed the quake was scheduled for 2030 might put off strengthening buildings until then, or relax after 2030 passes. Earthquakes do not follow a schedule, so the town would be unprepared whenever the quake actually came.

Why: Any choice earns credit if the student explains the harmful decision people would make because of the error.

Also acceptable: Strong answers also choose claim 6 (people ignore small-quake swarms as 'safe') or the conclusion (people stop preparing).

- Chooses a claim
- Describes a specific harmful decision the error would lead to

Teacher notes

Claims 3 and 10 are accurate: the Cascade volcanoes in California formed above the sinking Gorda plate, and no recognized precursor came before Loma Prieta. The 1906 (magnitude 7.9) and 1989 (magnitude 6.9) values are the USGS magnitudes. Claim 7's numbers are invented and describe no particular fault. The claim 8 correction follows USGS: lava flows usually advance slowly and deaths from them are uncommon, though very fluid lava can occasionally move fast on steep slopes. In q3, 'about 32 times the energy' is 10 to the 1.5 power (31.6); seismogram amplitude rises 10 times per step, so both '32 times energy' and '10 times shaking amplitude' are correct facts about different quantities. Students often defend claim 6 because small quakes do release some stress; q5's 500-year answer shows why that release is negligible.

Scaffold offered to students: Hunting for errors

For each claim ask: Is a key word used correctly (focus, epicenter, predict, forecast, magnitude)? Does the claim treat an average as a schedule? Does it ignore the 32-times rule for magnitude? Does it say something is everywhere or always when it is really in some places or sometimes? Claims 3 and 10 are the ones to check twice: they are about real places and events, and they are accurate.

Extension: Where do these ideas come from?

Choose two of Marisol's errors and find a movie, cartoon, news headline or social-media post that spreads the same idea (for example, a film where a fault 'swallows' a city, or a headline that says scientists 'predicted' a quake). Write a short paragraph for each explaining how the source gives the wrong impression and what an accurate version would show.