

Fixing Dani's Quiz: Eight Statements About Moving Plates

Learning target: I can find the errors in a student's explanations of plate tectonics, explain why each error is tempting, and rewrite each statement so it is scientifically accurate.

Error analysis

About 35 min

Individual

MS-ESS2-3 · practice

writing

independent practice

Standards connections

MS-ESS2-3 (practice): Several of the errors are misreadings of the evidence the PE asks students to interpret (where the youngest seafloor lies, what earthquake belts show, what Wegener's evidence was). Diagnosing and correcting them builds the interpretation skill without producing a full data analysis.

Purpose: practice · **Time:** about 35 minutes · **Format:** individual

Answers with reasoning

Dani's eight statements — **1.** The continents float on an ocean of liquid magma and push through the ocean floor like ships through water. **2.** Scientists ignored Wegener because he did not have any evidence for continental drift. **3.** The youngest rocks on the ocean floor are the ones farthest from the mid-ocean ridge, because the ridge is the oldest mountain chain in the ocean. **4.** The mid-ocean ridge forms where two plates push toward each other and crash, which pushes up the mountains. **5.** A plate moves 5 cm per year, so in 1 million years it moves $5 \text{ cm} \times 1,000,000 = 5,000,000 \text{ km}$. **6.** Plate tectonics is just a theory, which means scientists are not really sure about it. **7.** Earth is not getting bigger, even though new seafloor forms at ridges, because old seafloor sinks into the mantle at trenches. **8.** Earthquakes happen randomly all over the world, so they cannot tell us anything about where the plates are.

Part A: Grade the quiz

- For each statement, write 'correct' or 'incorrect' and copy the single word, phrase or number in the statement that tells you.

Answer: 1 incorrect ('liquid magma', 'push through the ocean floor'); 2 incorrect ('did not have any evidence'); 3 incorrect ('farthest from the ridge'); 4 incorrect ('push toward each other and crash'); 5 incorrect ('5,000,000 km'); 6 incorrect ('just a theory', 'not really sure'); 7 correct ('sinks into the mantle at trenches'); 8 incorrect ('randomly').

Why: Seven incorrect, one correct. Including a correct statement stops students from assuming everything on a misconception sheet is wrong, and the giveaway column makes them locate the error rather than guess.

Also acceptable: Accept any word or number from the statement that actually carries the error.

- All eight marked
- Statement 7 marked correct
- A sensible giveaway for each

Part B: Diagnose and rewrite

For each item below, write three things: (a) what is wrong, (b) why Dani might have thought it, and (c) the corrected statement.

2. **Statement 1** (continents float on liquid magma and push through the ocean floor). Your rewrite must say what the mantle below the plates is actually like and what moves along with a continent.

Answer: (a) The mantle below the plates is solid rock, not liquid magma; it is hot enough to creep slowly, a few centimeters a year, but seismic waves show it is solid. Continents do not push through the ocean floor; a continent and the ocean floor next to it are parts of the same rigid plate and move together. (b) Diagrams color the mantle red or orange, lava is the only mantle-like material people have seen, and the word 'drift' sounds like floating. (c) Rewrite: Tectonic plates, which include both continents and ocean floor, move slowly over a hot, solid mantle that creeps like very stiff putty; a continent rides along with the seafloor attached to its plate.

Why: Two errors are packed into one statement: the liquid mantle and the continent-plows-through-seafloor picture. Full credit addresses both.

Also acceptable: Accept 'the mantle flows like a glacier' for the solid-that-creeps idea.

- Says the mantle is solid and creeps
- Says continent and nearby seafloor move together on one plate
- Gives a plausible reason for the error
- Rewrite is a complete accurate sentence

3. **Statement 2** (Wegener had no evidence). Your rewrite must name at least two kinds of evidence he did have and the real reason his idea was set aside.

Answer: (a) Wegener had strong evidence: the same fossils (Mesosaurus, Glossopteris) on continents now separated by oceans, old rock belts that match across the Atlantic in type, age and order, the fit of the coastlines, and ancient glacial deposits in lands that are warm today. His idea was set aside because he could not name a force strong enough to move continents, and the forces he suggested were shown to be far too weak. (b) People assume a rejected idea must have been a weak one, and the story is often told as one person against everyone. (c) Rewrite: Wegener had good fossil, rock and shape evidence that the continents were once joined, but scientists set his hypothesis aside because he could not explain what moved them; the mechanism came later from the seafloor.

Why: This is the 'no evidence versus no mechanism' distinction from Worksheet 3.

Also acceptable: Accept 'matching mountain ranges' for the rock belts.

- Names at least two kinds of Wegener's evidence
- States the missing mechanism as the real reason
- Rewrite is accurate

4. **Statement 3** (youngest rocks farthest from the ridge). Your rewrite must say where the youngest seafloor actually is and why.

Answer: (a) It is backwards. The youngest seafloor is at the ridge crest, because that is where new seafloor forms; the seafloor gets older with distance from the ridge on both sides. The ridge is not an old mountain chain; it is where the newest rock on the ocean floor is being made right now. (b) Mountains on land are often very old, so a mountain chain 'feels' old; and if you picture the ridge as the starting point, it is easy to think the starting point is oldest. (c) Rewrite: The youngest seafloor is at the mid-ocean ridge, where molten rock hardens into new seafloor, and the seafloor becomes older the farther it has moved from the ridge.

Why: This is the central data pattern of the chapter, and the drill cores of 1968-69 confirmed it.

Also acceptable: A student who adds 'the oldest seafloor is at trenches where there are trenches, or against the continents in the Atlantic' is going beyond the question correctly.

- Youngest at the ridge
- Reason: new seafloor forms there
- Older with distance

5. **Statement 4** (the ridge forms where plates crash together). Your rewrite must name the correct type of plate boundary at a ridge and say what structure **does** form where an ocean plate meets another plate head-on.

Answer: (a) A ridge forms at a divergent boundary, where two plates move **apart** and magma rises to fill the gap. Where an ocean plate meets another plate head-on (a convergent boundary), the denser plate bends down and a trench forms, often with a line of volcanoes on the overriding plate. (b) On land, big mountain ranges like the Himalayas do form where plates collide, so it is natural to assume all mountains are made by collisions. (c) Rewrite: The mid-ocean ridge forms at a divergent boundary where two plates pull apart and rising magma builds new seafloor; where plates converge, a trench forms instead.

Why: The error is a boundary-type confusion; the rewrite should use the words divergent and trench.

Also acceptable: Accept 'volcanic mountains like the Andes' as an additional convergent structure.

- Names the ridge as a divergent boundary (plates apart)
- Names the trench as the convergent structure
- Rewrite accurate

6. **Statement 5** (5 cm per year for 1 million years = 5,000,000 km). Find the exact step where the calculation goes wrong, then redo it correctly with every unit shown. (1 km = 100,000 cm.)

Answer: The multiplication is right but the unit is wrong: $5 \text{ cm/yr} \times 1,000,000 \text{ yr} = 5,000,000 \text{ cm}$, not km. Correct: $5,000,000 \text{ cm} \div 100,000 \text{ cm/km} = 50 \text{ km}$. The plate moves about 50 km in 1 million years.

Why: A centimeter-to-kilometer slip is the most common error in this chapter; students must show the conversion step.

Also acceptable: Accept 50 km, or $0.05 \text{ m/yr} \times 1,000,000 \text{ yr} = 50,000 \text{ m} = 50 \text{ km}$.

7. **Statement 6** ('just a theory'). Your rewrite must explain what the word theory means in science and name at least two independent lines of evidence that support plate tectonics.

Answer: (a) In science, a theory is not a guess; it is an explanation that has passed many tests and ties together many independent lines of evidence. Plate tectonics is supported by matching fossils and rock belts across oceans, the fit of the continental shelves, earthquake and volcano belts that outline the plates, seafloor ages that increase away from ridges, and satellite measurements of plates moving today. (b) In everyday speech 'theory' means a hunch ('I have a theory about who ate the cookies'), and people hear that scientists once rejected drift and conclude science keeps changing its mind. (c) Rewrite: Plate tectonics is a scientific theory, which means it is a well-tested explanation supported by many independent kinds of evidence; scientists still refine details, such as which force moves the plates most, but the core idea is as well supported as any in Earth science.

Why: Full credit needs the science meaning of theory and at least two independent evidence lines.

Also acceptable: Accept any two lines of evidence from the chapter.

- Defines theory as a well-tested explanation
- Names at least two independent lines of evidence
- Rewrite notes it can still be refined without being a guess

8. **Statement 8** (earthquakes are random). Your rewrite must describe the actual pattern of earthquakes and what that pattern told scientists.

Answer: (a) Earthquakes are not random; most happen in long, narrow belts, such as the ring around the Pacific, along mid-ocean ridges and along trenches. Those belts outline the edges of the plates; that pattern was one of the clues that divided the lithosphere into plates. (b) News reports earthquakes from many different countries, so they seem to be everywhere; and without a map it is hard to see the belts. (c) Rewrite: Earthquakes cluster in narrow belts along plate boundaries, and mapping them showed scientists where the edges of the plates are.

Why: The earthquake belt map is a core piece of evidence in the lesson; worldwide seismograph networks revealed the belts.

Also acceptable: Accept 'the Ring of Fire' as the example of a belt.

- Describes narrow belts
- Says the belts mark plate edges

Part C: The one Dani got right

9. Explain why **Statement 7** is correct. Name the process at the trench, and say why 'the seafloor gets destroyed' and 'the seafloor gets made' can both be true at the same time.

Answer: Statement 7 is correct. At trenches, old, cold, dense seafloor bends down and sinks into the mantle; the process is subduction. New seafloor is made at ridges at about the same rate that old seafloor is removed at trenches, so the two balance, and Earth's surface stays the same size while the plates keep moving. Making and destroying happen at different places at the same time, like a conveyor belt that is always both starting and ending.

Why: Students must justify the correct statement, not just label it.

Also acceptable: Accept 'recycled back into the mantle.'

- Names subduction at trenches
- Explains that creation and destruction balance

10. Look back over Dani's seven mistakes. Sort them into two groups: mistakes about **what Earth is like** (structures, materials, directions) and mistakes about **how science works** (evidence, theories, units). Which group would you help Dani with first, and what single idea from this chapter would fix the most statements at once?

Answer: Group 1, what Earth is like: statements 1 (liquid mantle, continents plowing), 3 (youngest seafloor location), 4 (ridge boundary type) and 8 (earthquake pattern). Group 2, how science works: statements 2 (Wegener's evidence), 5 (units) and 6 (meaning of theory). Either group can be chosen first with a reason; a strong answer picks Group 1 and names the single idea 'new seafloor is made at the ridge, moves outward, and sinks at the trench', because that one picture fixes 1, 3 and 4 and explains the belts in 8. A strong answer for Group 2 names 'a theory is an explanation that has survived tests of its predictions', which fixes 2 and 6 together.

Why: The sort is the main product; the choice of group is open as long as the single fixing idea genuinely covers several statements.

Also acceptable: Statement 8 could be argued into Group 2 (reading data for patterns); accept with a reason.

- Correct two-group sort (allow one disagreement about statement 8)
- A chosen group with a reason
- One idea that fixes at least two statements

Teacher notes

Statement 7 is the only correct one; keep that quiet until students have graded. The seven errors map onto misconceptions flagged across the chapter: liquid mantle and plowing continents (1), Wegener had no evidence (2), youngest seafloor far from the ridge (3), ridge as a collision (4), the centimeter-kilometer slip (5), 'just a theory' (6) and random earthquakes (8). In q2, the mantle's solidity is known because seismic waves of the kind that cannot pass through liquids travel through it; students need only 'solid but creeps.' In q7, if students ask what is still debated, say which force moves plates most (the pull of sinking plates is now thought to be the strongest), and note that MS-ESS2-3 does not assess mechanisms. The extension's suggested subtle errors are real: the oldest Atlantic seafloor lies against the continents, not at a trench, because the Atlantic has almost no trenches.

Scaffold offered to students: Three sentence frames

For each diagnosis, use these frames and then smooth them into a paragraph. (a) 'The statement is wrong because it says ____, but actually ____.' (b) 'Dani may have thought this because ____ (a picture, a word that sounds like something else, an everyday meaning).' (c) 'A correct statement is: ____.' For the calculation in q6, write each quantity with its unit on its own line, and check that the unit of the answer is a distance.

Extension: Write the ninth statement

Write a ninth statement for Dani's quiz that is wrong in a **subtle** way: it should sound scientific and use correct vocabulary, but contain one error that a careful reader would catch. Good targets are the location of the oldest seafloor in the Atlantic, the difference between a plate and a continent, or the claim that the oldest seafloor is always at a trench. Then write the diagnosis and the corrected version, and explain why your error is harder to spot than Dani's.