

Heat Does Not Float: Fixing Mateo's Quiz

Learning target: I can find the errors in a classmate's explanations of convection, Earth's layers, energy sources and the biosphere, explain why each idea is wrong, and rewrite it correctly.

Error analysis

About 40 min

Individual

MS-ESS2-1 · practice

MS-LS2-3 · supports

writing

independent practice

Standards connections

MS-ESS2-1 (practice, the flow-of-energy half of the PE): Diagnosing 'heat rises,' 'the mantle is liquid' and 'gravity pushes warm water up' forces students to state the real mechanism of energy flow and matter cycling in the mantle, which strengthens the model they build for this PE.

MS-LS2-3 (supports): One item repairs the idea that energy cycles through a food chain. Correctly stating that matter cycles while energy flows through is background for this PE's ecosystem model.

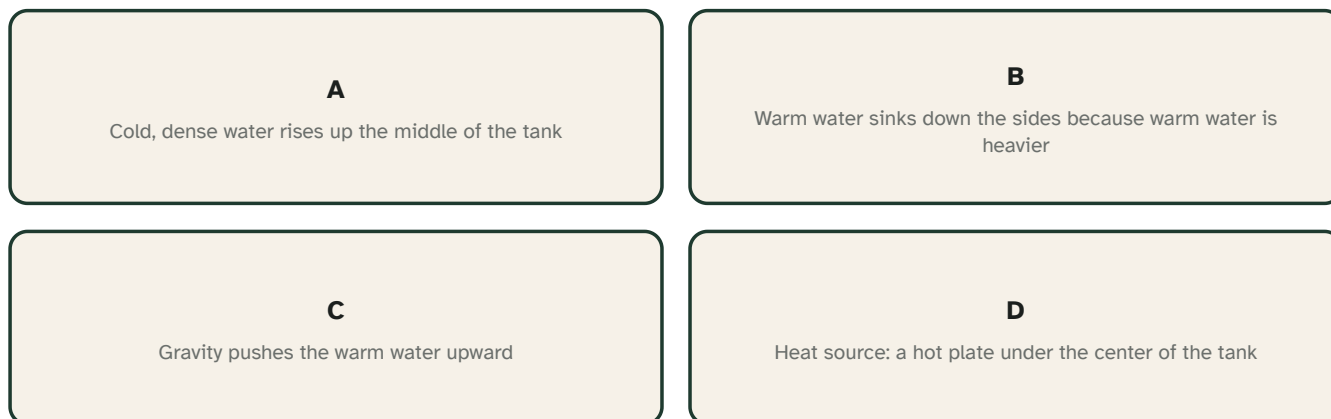
Purpose: practice · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

Mateo's quiz answers

#	Quiz question	Mateo's answer
1	Why does warm water rise in a tank heated from below?	Heat rises. Heat always goes up, so the hot water floats to the top and the cold water just stays where it is.
2	Describe the mantle.	The mantle is a sea of liquid magma under the crust. That is why it flows and why volcanoes have lava.
3	How does the sun's energy reach Earth?	By convection. The hot air from the sun rises and travels through space until it reaches Earth.
4	Why is Earth's core so hot?	Because the layers above squeeze it. Pressure makes heat, like a bike pump getting warm when you use it.
5	What happens to energy in a food chain?	Energy cycles. Decomposers break down dead plants and send the energy back into the soil so new plants can use it, so energy goes around and around.
6	Which Earth system or systems does a rain cloud belong to?	Only the atmosphere, because it is up in the air. Water in the sky is not part of the hydrosphere until it lands.
7	Biosphere 2 was a closed system. What does that mean?	Nothing at all could get in or out, not even sunlight. That is why the oxygen ran low: there was no light for the plants.
8	Why does warm ocean water near the equator stay at the surface?	The sun warms the surface water, which makes it less dense than the colder water below it, so it stays on top instead of sinking.

Mateo's convection tank



Mateo's diagram of a tank heated from below. Four labels, A to D, describe what he thinks is happening. Check each one.

Part A: Diagnose

1. For each of Mateo's eight answers, write 'correct' or 'error' and one sentence naming the exact mistake (or, for the correct one, the idea that makes it right).

Answer: 1: error; heat is energy and does not float; the warm, less dense water is pushed up by denser water sinking. 2: error; the mantle is solid rock that creeps slowly, not a sea of liquid magma. 3: error; there is no air in space and the sun's energy arrives as light (radiation), not convection. 4: error; the core's heat comes mainly from leftover heat of Earth's formation and from radioactive decay; pressure does not keep generating heat. 5: error; energy does not cycle; it flows through a food chain and leaves as heat, while matter cycles. 6: error; a cloud is water, so it belongs to the hydrosphere as well as the atmosphere. 7: error; a closed system is closed to matter, but sunlight entered Biosphere 2 through the glass; the oxygen fell because soil organisms used it. 8: correct; sun-warmed water is less dense than the colder water below, so it stays at the surface.

Why: Seven of the eight contain the lesson's main misconceptions; item 8 is correct so that students must actually judge rather than mark everything wrong.

Also acceptable: For item 4, accept 'pressure keeps the inner core solid; it is not the main heat source' as the error statement.

- Item 8 identified as correct
- Each error named specifically, not just 'wrong'

2. Which of the diagram labels A to D are wrong? For each wrong label, name the mistake in a few words.

Answer: A is wrong: it is the warm, less dense water that rises up the middle over the heat source, not cold water. B is wrong: warm water is less dense, not heavier; it is the cooled, denser water that sinks down the sides. C is wrong: gravity pulls denser water down; it does not push anything up; the warm water is pushed up by the sinking of denser water around it. D is correct.

Why: The diagram reverses the directions and misassigns gravity's role.

Also acceptable: Accept 'A and B are swapped' with the density reasons.

- A, B and C identified as wrong, D as right
- Each mistake named

Part B: Rewrite

3. Rewrite answer 1 correctly. Your version must explain what actually rises, why it rises, and what gravity does. Do not use the phrase 'heat rises.'

Answer: Model response: The water touching the hot plate gains energy by conduction and expands, so the same mass takes up more space and its density drops. Gravity pulls more strongly on the cooler, denser water around it, so that denser water sinks and squeezes the less dense warm water upward. What rises is the warm water (matter) carrying energy with it; the energy itself does not float. At the top the water loses energy, becomes denser again, and sinks, so the cold water does not stay put either: it moves down to replace the water that rose.

Why: Full credit needs: warm water (not heat) rises, because it is less dense, because gravity pulls the denser water down, and the cold water moves too.

Also acceptable: Accept an answer that starts with the density change and leaves conduction implicit.

- Says warm water, not heat, rises
- Links rising to lower density
- Gravity pulls denser water down, which pushes the warm water up
- Cold water also moves

4. Rewrite answer 2 correctly. Include what state the mantle rock is in, how it can still move, and where the liquid rock in a volcano comes from.

Answer: The mantle is hot, solid rock. Over millions of years solid rock under heat and pressure can slowly creep and change shape, a few centimeters per year, so the mantle circulates without being liquid. The lava in a volcano is magma, rock that melted in particular places near the top of the mantle or in the crust, which rises because it is less dense than the solid rock around it; it is not evidence that the whole mantle is liquid.

Why: This corrects the most common geosphere misconception and uses the accurate version of the textbook's batter comparison.

Also acceptable: Accept 'solid but flows like a glacier' with the local-melting point.

- Mantle is solid
- Moves by very slow creep
- Magma forms locally and rises because it is less dense

5. Rewrite answer 3 correctly. Name the right transfer method and explain why Mateo's method is impossible between the sun and Earth.

Answer: The sun's energy reaches Earth by radiation: it travels as light, including infrared, which can cross empty space. Convection is impossible there because convection needs matter (a fluid) that moves and carries energy, and the space between the sun and Earth is almost empty; there is no 'hot air from the sun' to rise or travel.

Why: Students must name radiation and explain the missing-matter problem.

Also acceptable: Accept 'light' for radiation.

- Radiation named
- Convection needs matter, and space has almost none

6. Rewrite answer 4 correctly, naming the two main sources of the interior's heat. (The textbook also mentions pressure; say what pressure actually does to the inner core.)

Answer: The core is hot mainly because of heat left over from Earth's formation (collisions and the sinking of iron to the center released a huge amount of energy that a planet this large loses very slowly) and because radioactive elements such as uranium, thorium and potassium inside Earth release energy as they decay. Pressure does not keep making heat; squeezing warms something once, like the bike pump, but then stops. What the enormous pressure does is keep the inner core solid even though it is hot enough to melt.

Why: The textbook says the core is hottest because of pressure from above; the accurate statement is that formation heat and radioactive decay supply the heat and pressure keeps the inner core solid. Credit students who note the textbook disagrees.

Also acceptable: Accept 'heat from when Earth formed plus radioactive elements' without the pressure detail if the student says pressure is not the source.

- Leftover formation heat
- Radioactive decay
- Pressure's real role (keeps the inner core solid) or a clear statement that pressure is not a continuing heat source

7. Rewrite answer 5 correctly. Your version must say what cycles and what does not, what decomposers really return to the soil, and where the energy ends up.

Answer: Model response: Matter cycles, but energy flows through. Plants capture the sun's energy and store it in food; herbivores, carnivores and decomposers get that energy by eating, and at every step some of it leaves the living things as heat, which eventually radiates away into space. Decomposers return matter, the nutrients from dead plants and animals, to the soil so that new plants can build their bodies, but they cannot send energy back; new plants need fresh sunlight. So the arrow from decomposers to plants should say 'matter (nutrients),' not 'energy.'

Why: This is the correction of the textbook's figure that labels the decomposer-to-producer arrow 'energy and matter.' Full credit requires both halves (matter cycles, energy flows and leaves as heat) and the nutrient role of decomposers.

Also acceptable: Accept 'energy is used up as heat along the way' for the exit.

- Matter cycles
- Energy flows one way and leaves as heat
- Decomposers return nutrients, not energy
- Plants need new sunlight

8. Rewrite answers 6 and 7 correctly, in one or two sentences each.

Answer: 6: A rain cloud is made of water droplets (and ice), so it is part of the hydrosphere, which includes water in every form and place; because it floats in the air it is also part of the atmosphere, so it belongs to both. 7: A closed system is one that matter cannot enter or leave; energy can still cross. Biosphere 2 kept its air, water and soil inside, but sunlight poured in through the glass and heat escaped. Its oxygen fell because organisms in the rich soil used oxygen faster than the plants replaced it, not because of missing light.

Why: Item 6 tests overlap of the spheres; item 7 tests the accurate meaning of closed and the actual Biosphere 2 cause.

Also acceptable: Accept 'bacteria in the soil' for the oxygen cause.

- Cloud in both hydrosphere and atmosphere
- Closed means closed to matter; energy crosses
- Oxygen drop attributed to soil organisms

9. Rewrite the wrong labels on the diagram (A, B and C) so that the diagram is correct. Keep label D.

Answer: A: Warm, less dense water rises up the middle of the tank above the hot plate. B: Cooled, denser water sinks down the sides because it has lost energy and become denser. C: Gravity pulls the denser water downward, and that sinking pushes the less dense warm water up. D: Heat source: a hot plate under the center of the tank (unchanged).

Why: Each corrected label must state the right direction and the right density word; C must give gravity its real job.

Also acceptable: Accept 'cold water sinks on the sides' for B if 'denser' or 'heavier per cup' appears.

- A: warm, less dense water rises
- B: cooled, denser water sinks
- C: gravity pulls denser water down

10. Mateo's errors in answers 1, 3 and 5 and in label C share one underlying confusion. Name it in one sentence, and suggest one habit that would help him avoid it.

Answer: Mateo treats energy (heat) as if it were a thing that can float, travel on its own or be passed around in a loop, and he gives gravity a pushing job. The underlying confusion is mixing up energy with matter: in this lesson matter is what rises, sinks and cycles, while energy is carried by matter or by light and flows through. A helpful habit: in every sentence, name the matter that is moving and the energy it carries separately, and never let 'heat' be the subject of a verb like rises.

Why: Naming the pattern helps students transfer the correction to new situations rather than memorizing fixed answers.

Also acceptable: Accept 'he thinks heat is a substance' as the confusion.

- Names the energy-versus-matter confusion
- Suggests a concrete habit

Teacher notes

Items 1, 3 and 5 and diagram label C are the lesson's central misconceptions and all stem from treating heat as a substance. Item 4 deserves a gentle note: the textbook itself attributes the core's heat to pressure from the layers above, so students who repeat it are quoting the book; the accurate statement (formation heat plus radioactive decay as sources, pressure keeping the inner core solid) is the one in the key, and chapter.json records this in accuracyNotes. Item 5 corrects the textbook figure that labels the decomposer-to-producer arrow 'energy and matter.' Item 8 is correct on purpose; students who mark it wrong usually believe 'the sun's water should sink because it is on top,' which is worth a brief class discussion. Collect q3 and q7 as evidence of whether 'heat rises' and 'energy cycles' have been replaced.

Scaffold offered to students: Two test questions for every answer

For each of Mateo's answers, ask: (1) Is he talking about energy or about matter? Energy is carried, matter moves; if a sentence has heat doing the moving on its own, something is off. (2) What is the force? In this lesson the only force that makes things rise or sink is gravity acting on denser and less dense material, so any answer that gives gravity a different job needs rewriting. Check the word bank from W2 for the exact meaning of each term before you rewrite.

Extension: Write the next quiz

Write three new quiz questions about this lesson that would catch a student who still believes 'heat rises,' 'the mantle is liquid' or 'energy cycles.' For each question, write a wrong answer such a student would give, the correct answer, and one sentence explaining why the wrong answer is tempting. The best questions describe a new situation (a swimming pool, a greenhouse, a volcano on another planet) rather than repeating the textbook's examples.