

Fixing Mateo's Poster: Nine Claims About How Water Moves

Learning target: I can find the errors in a student's explanation of the water cycle, explain what went wrong in each one, and rewrite the explanation correctly.

Error analysis

About 40 min

Individual

MS-ESS2-4 · practice

writing

independent practice

discussion

Standards connections

MS-ESS2-4 (practice): MS-ESS2-4 is a California Grade 6 PE revisited here. Diagnosing and correcting errors about evaporation, condensation, the sun's role and gravity's role is how students sharpen the model of water cycling the PE asks them to develop.

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

Answers with reasoning

Mateo's poster: 'How Water Travels' — Claim 1. Water vapor is the white mist you see rising from a hot shower or a boiling pot. **Claim 2.** Water can only evaporate when it is heated to 100 °C, so lakes and puddles evaporate only on days hotter than that. **Claim 3.** The sun pulls water up into the sky the same way gravity pulls rain down. **Claim 4.** Clouds form when water vapor rises, cools, and condenses onto tiny particles of dust and salt. **Claim 5.** The water cycle starts at the ocean. Water goes ocean, cloud, rain, river, ocean, in that order, every time. **Claim 6.** Groundwater is an underground river flowing through big open caves. **Claim 7.** Rain falls because gravity pulls on droplets that have grown heavy enough; the air pushing up on a falling drop can flatten it or break a big one apart. **Claim 8.** Plants transpire by drinking water in through their leaves and storing it there. **Claim 9.** Frost on a car window is dew that froze overnight.

Mateo's summary paragraph (for Part C): 'The water cycle begins when the sun pulls water out of the ocean as steam you can see. The steam rises until it warms up and turns into clouds. When clouds get full, the rain falls. Rain runs into underground rivers and flows back to the ocean, where the cycle starts again.'

Part A: Diagnose every claim

1. For each claim, write *correct*, *wrong* or *partly right* in the first column. In the second column, write the idea he mixed up (for correct claims, write 'none').

Answer: Claim 1: wrong; mixes up vapor (invisible gas) with mist (liquid droplets). Claim 2: wrong; mixes up evaporation (surface, any temperature) with boiling. Claim 3: wrong; mixes up supplying energy with pulling. Claim 4: correct; none. Claim 5: wrong; mixes up one example route with the only route, and gives a start to a cycle. Claim 6: wrong; mixes up pore spaces with open rivers or caves. Claim 7: correct; none. Claim 8: wrong; mixes up how water enters (roots) and leaves (leaves, as vapor) a plant. Claim 9: partly right; frost can form straight from vapor (deposition), not only from frozen dew.

Why: Six wrong, two correct, one partly right. The second column is the diagnosis; accept any wording that names the confused pair of ideas.

Also acceptable: A student who marks Claim 6 'partly right' because some caves do carry underground streams is making a defensible point, provided the second column says that most groundwater is in tiny pores.

- Correct verdict on all nine
- A reasonable 'mixed up' idea for each wrong or partly right claim

Part B: Explain what went wrong

2. Claims 1 and 2 are both about evaporation and vapor. Explain what water vapor actually is, what the white mist actually is, and why a puddle can disappear on a 15 °C day. Use the word *molecules* at least once.

Answer: Water vapor is water in the gas state; its molecules are far apart and it is invisible. The white mist over a shower or a pot is not vapor: it is vapor that has already cooled and condensed into tiny liquid droplets, which scatter light so you can see them. A puddle disappears at 15 °C because the molecules in liquid water move at many different speeds; the fastest ones at the surface have enough energy to escape into the air as vapor. No boiling is needed; warming just makes it happen faster.

Why: Three parts: vapor is invisible gas; mist is condensed droplets; evaporation is surface escape by the fastest molecules at any temperature.

Also acceptable: Accept 'the mist is a tiny cloud' as the description of the droplets.

- Vapor is an invisible gas
- Mist is condensed liquid droplets
- Fastest surface molecules escape, so no boiling is needed

3. Claim 3 treats the sun like a force that pulls. Explain what the sun really does to water at the surface, and what actually carries water vapor upward into the sky. Then say why gravity, unlike the sun, really is a pull.

Answer: The sun does not pull on water. It supplies energy: sunlight warms the water surface, the molecules move faster, and the fastest ones escape as vapor. Once vapor is in the air it is carried upward by moving air, for example warm air rising from a heated surface or air pushed up a mountain, not by any pull from the sun. Gravity is different: it is a real force that acts on every drop and every bit of water all the time, pulling it toward Earth's center, which is why rain falls and rivers run downhill.

Why: The distinction between an energy source and a force is the core of this item. Rising air (convection, or air forced up terrain) is the carrier.

Also acceptable: Accept 'the vapor spreads and mixes into the air and rises with warm air' for the carrier.

- Sun supplies energy, molecules escape
- Moving or rising air carries the vapor up
- Gravity is a force that pulls

4. Claim 5 gives the water cycle a starting point and a fixed order. Give two real pathways water can take that break Mateo's order (for example, a route that skips the river, or one that never reaches the ocean), and state what is true about the cycle's starting point.

Answer: Examples of routes that break the order: rain falls straight back into the ocean and never touches land; rain soaks into the ground (infiltration) and becomes groundwater, skipping the river; a lake or river evaporates before reaching the ocean; a plant takes up rain from the soil and transpires it back to the air; snow sits in a glacier for centuries. The cycle has no starting point: water is in every store at once, and a molecule can be followed from anywhere.

Why: Two valid alternative routes plus the no-starting-point statement.

Also acceptable: Any accurate pathway counts, including ones using sublimation.

- Two routes that differ from ocean-cloud-rain-river-ocean
- States the cycle has no start

5. Claims 6 and 8 are both about where water is stored. Describe where groundwater really is and how water really enters and leaves a plant.

Answer: Groundwater is water filling the tiny pore spaces between grains of soil, sand and rock, like water in a sponge; it moves very slowly through connected pores. Underground rivers in caves exist in a few places but hold only a small part of groundwater. Plants take water in through their roots from the soil; it travels up the stem to the leaves, evaporates inside the leaf, and leaves through tiny pores (stomata) as water vapor. Leaves release water; they do not drink it or store it.

Why: Both corrections: pores not rivers; roots in, leaves out as vapor.

Also acceptable: Accept 'most groundwater is in rock that looks solid but is full of tiny holes.'

- Groundwater in pore spaces (sponge idea)
- Water enters by roots and leaves by transpiration from leaves as vapor

6. Claim 9 is partly right. Explain the case where Mateo is right and the case where he is wrong, naming the change of state in each case.

Answer: Mateo is right when dew (liquid droplets that condensed on the window) freezes after the temperature falls below 0 °C: that is liquid to solid, freezing. He is wrong for true frost, which forms when water vapor turns directly into ice crystals on a surface colder than freezing without ever being liquid: that is gas to solid (deposition; the lesson calls both cases crystallization). The feathery crystal patterns on a cold windshield are usually deposition, not frozen dew.

Why: Both cases, each with its change of state. The lesson's umbrella term 'crystallization' covers both; naming freezing and deposition is the accurate version.

Also acceptable: Accept 'crystallization' for both if the student clearly distinguishes 'from liquid' and 'from vapor'.

- Frozen dew case: liquid to solid
- Frost from vapor case: gas to solid
- Identifies which is the usual frost

Part C: Rewrite the summary

7. Rewrite Mateo's summary paragraph so that every sentence is scientifically accurate. Keep it to five or six sentences. It must (a) say what the sun actually does, (b) say what has to happen to vapor for a cloud to form, (c) explain what makes rain fall, (d) describe groundwater correctly, and (e) avoid giving the cycle a starting point.

Answer: Model rewrite: 'Energy from the sun warms the surface of the ocean, lakes and wet land, and the fastest water molecules escape into the air as invisible water vapor; plants add vapor through their leaves too. As air carrying the vapor rises it cools, and the vapor condenses onto tiny particles of dust and salt to form the droplets and ice crystals that make up clouds. When the droplets and crystals grow heavy enough, gravity pulls them down as rain or snow. On the ground, gravity keeps working: some water runs downhill into streams and lakes, and some soaks into the tiny spaces in soil and rock, where it moves slowly as groundwater toward springs, rivers and the sea. Water is in every one of these places at once, so the cycle has no beginning and no end.'

Why: Score against the five requirements: sun supplies energy (not pull, not visible steam); vapor must cool to condense (not warm); gravity makes rain fall (not 'clouds get full'); groundwater is in pores (not rivers); no starting point.

Also acceptable: A paragraph that follows a molecule from a lake instead of the ocean is fine; the requirement is that it does not claim the cycle 'begins' there.

- Sun supplies energy and vapor is invisible
- Cooling causes condensation
- Gravity causes precipitation
- Groundwater described as water in pores
- No starting point stated or implied
- Five or six sentences, each accurate

Part D: The rules that would have saved him

8. Write two short rules Mateo could tape to his desk so he never makes errors like Claims 1, 2 and 3 again. Each rule should be one sentence and should start with *If you can see it...* or *Evaporation happens...* or *The sun supplies....* After comparing with a partner, add one rule your partner wrote that you like.

Answer: Sample rules: 'If you can see it, it is not water vapor; vapor is invisible, and mist or clouds are liquid droplets or ice.' 'Evaporation happens at any temperature, because the fastest surface molecules escape; boiling is not required.' 'The sun supplies energy and gravity pulls; the sun never pulls, and gravity never lifts water into the air.' Plus one rule from the partner.

Why: Any two accurate one-sentence rules with the required openers, plus a third from a partner.

Also acceptable: Accept 'Condensation needs cooling, not warming' as one of the rules.

- Two accurate rules in one sentence each
- A third rule credited to the partner

Teacher notes

The nine claims target the most common water cycle misconceptions, including three the textbook itself invites: the Key Science Concept spread (printed 240-241 / PDF 276-277) draws one loop that reads like a required order (Claim 5); page 235 (PDF 271) says liquid water leaves the stomata and then evaporates, while page 240 correctly says water evaporates inside the plant (Claim 8); and the lesson's single word 'crystallization' covers both freezing and deposition (Claim 9). Claims 4 and 7 are correct and are there so students cannot assume everything is wrong; Claim 7's air-resistance detail matches the lesson's Figure 3A (page 238 / PDF 274). Expect debate on Claim 6; cave streams are real but minor. When reviewing q7, read two or three student paragraphs aloud and have the class check each against the five requirements.

Scaffold offered to students: Three test questions for any claim

When you are not sure whether a claim is right, ask: (1) Can I see it? If yes, it is not water vapor, because vapor is invisible. (2) Does the claim need water to be at a special temperature? Evaporation needs only energy at the surface, not boiling; condensation needs cooling (or air that is full of vapor), not warming. (3) Who is doing the moving? The sun supplies energy; gravity pulls. If a claim has the sun pulling, or gravity lifting water into the air, something is mixed up.

Extension: Write the trap

Write three new claims about the water cycle for a classmate to judge: one correct, one wrong in a way that is tempting (it should sound right at first), and one partly right. Each claim must involve a different process (choose from transpiration, infiltration, crystallization, runoff, melting). Below each claim, write the key: the verdict, the idea it tests, and the corrected version. Trade with a partner and grade each other's reasoning.