

Fixing Mateo's Field Trip Poster: Six Mistakes About Changing Landscapes

Learning target: I can find the errors in another student's statements about weathering, erosion, scales of change and uniformitarianism, explain the mistaken idea behind each one, and rewrite it correctly.

Error analysis

About 40 min

Individual

MS-ESS2-2 · practice

writing

independent practice

Standards connections

MS-ESS2-2 (practice): Students who believe that unchanging-looking landforms are not changing, that big landforms need big causes, or that uniformitarianism means constant speed will build faulty explanations of surface change. Diagnosing and rewriting these statements practices the accurate reasoning the PE requires.

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

Answers with reasoning

Mateo's poster (copied exactly) — **1.** The hoodoos look exactly the same as they do in a photo from 1990, so weathering has stopped here. **2.** Weathering carried the broken rock from the cliff down to the stream. **3.** A canyon this deep must have been cut by one giant flood, because big changes need big causes. **4.** Uniformitarianism means Earth's processes always run at exactly the same speed, so there were never sudden events in the past. **5.** Continents move about 2 cm per year, so in a million years a continent moves about 2 km. **6.** The eruption that made the lava flow happened in one afternoon, so nothing about it took a long time. **7.** Raindrops moving a few sand grains at a time can, over thousands of years, help wear down a whole hill. **8.** Dust from a large asteroid impact can cool the whole planet within days, so a global change can also be a fast one.

Part A: Diagnose

- Complete the table. For each incorrect statement, name in a few words the idea Mateo got wrong. For the two correct statements, write 'correct.'

Answer: 1 incorrect (too slow to see is not the same as stopped). 2 incorrect (weathering confused with erosion). 3 incorrect (big change does not require a big single cause). 4 incorrect (uniformitarianism confused with constant speed; sudden events are real). 5 incorrect (unit conversion error; the answer is 20 km). 6 incorrect (the event's duration confused with the build-up time). 7 correct. 8 correct.

Why: Six errors and two correct statements, matching the directions. The 'few words' column is a diagnosis, not an explanation; the full explanation comes in Part B.

Also acceptable: Accept any short phrase that points at the right idea (for example, 'can't see slow change' for 1, 'wrong by 1,000' for 5).

Part B: Explain and rewrite

For each incorrect statement, write two things: (a) **What went wrong**: the mistaken idea behind the statement, and (b) **Rewrite**: the statement corrected so that it is true. Keep Mateo's topic; change only what is wrong.

2. Statement 1 (the hoodoos have not changed). (a) What went wrong? (b) Rewrite it, and include what kind of evidence would show that the hoodoos are still changing.

Answer: (a) Mateo assumed that a change too small to see in a photo is no change at all. Hoodoos weather and erode continuously, but the amount lost in 35 years is far too small to show in a photo. (b) Rewrite: 'The hoodoos look the same as in a 1990 photo because weathering and erosion here are too slow to notice in a few decades, but they are still happening; fresh rock chips at the base of the pillars, thinner pillars measured over many years, or a fallen cap would show the change.'

Why: The explanation must recognize that the rate, not the existence, of change is what the photo tests, and the rewrite must name some evidence of continuing change.

Also acceptable: Accept 'measure the pillar width every year' or 'look for caps that have fallen since 1990' as evidence.

- Explains that slow change is invisible in a short time
- Rewrite says the hoodoos are still changing
- Names at least one kind of evidence of continuing change

3. Statement 2 (weathering carried the rock). (a) What went wrong? (b) Rewrite it so that weathering and erosion are each used correctly, and name the agent that moved the rock.

Answer: (a) Mateo used weathering to mean moving. Weathering breaks rock where it sits; erosion is the carrying away. (b) Rewrite: 'Weathering broke the cliff rock into loose pieces, and erosion by gravity (and by running water) carried the pieces down to the stream.'

Why: The two terms must each be used correctly and an agent named; gravity is the most direct answer for rock moving from a cliff to a stream, with water also acceptable.

Also acceptable: Accept 'rockfall' or 'a landslide' as the way gravity moved the rock.

- Identifies the weathering/erosion confusion
- Rewrite uses weathering for breaking and erosion for moving
- Names gravity or water as the agent

4. Statement 3 (a deep canyon needs one giant flood). (a) What went wrong? (b) Rewrite it. Your rewrite must explain how a small, slow process can produce a very large change, and must also admit that giant floods have really carved some landscapes.

Answer: (a) Mateo assumed a big result needs a big single cause. Most canyons are cut by a river removing a small amount of rock every year for a very long time; the total adds up. (b) Rewrite: 'A canyon this deep can be cut by a river wearing away a few millimeters of rock each year over millions of years, because small changes add up over long times. Some landscapes really were carved by giant floods in days, so the way to tell is to look at the evidence: rounded, sorted river deposits and a river that still cuts rock today point to slow change, while enormous boulders, giant ripple marks and no river big enough to make them today point to a flood.'

Why: Both halves are required: the adding-up explanation and the admission that catastrophic floods exist, with evidence that distinguishes the two.

Also acceptable: A rewrite using a rate (for example, 1 mm per year $\times$ 1,000,000 years = 1 km) is excellent.

- Identifies the big-cause assumption
- Rewrite explains small changes adding up over long times
- Rewrite admits giant floods have carved some landscapes and names evidence that would tell the two apart

5. Statement 4 (uniformitarianism means constant speed). (a) What went wrong? (b) Rewrite it so that it says what the principle actually claims and what it does not claim.

Answer: (a) Mateo confused 'same processes' with 'same speed.' Uniformitarianism says the same kinds of processes, obeying the same natural laws, acted in the past as today; it says nothing about rates being constant, and sudden events are part of Earth's history. (b) Rewrite: 'Uniformitarianism means the processes we can watch today, such as weathering, erosion, eruptions and landslides, also worked in the past, so the present helps us read the past. It does not mean processes always ran at the same speed, and sudden events like floods and impacts happened in the past too.'

Why: This is the chapter's most important correction to the textbook's 'in the same way' wording.

Also acceptable: Accept 'the present is the key to the past' as a summary if the rate point is also made.

- Identifies the same-speed confusion
- Rewrite states the principle as same processes and laws
- Rewrite says rates vary and sudden events are included

6. Statement 5 (2 cm per year gives 2 km in a million years). (a) What went wrong? (b) Rewrite it with the correct distance, showing the calculation step by step with units.

Answer: (a) Mateo slipped by a factor of 1,000 in the unit conversion (he treated 2,000,000 cm as 2 km). (b) Rewrite with calculation: 2 cm per year $\times$ 1,000,000 years = 2,000,000 cm. 2,000,000 cm $\div$ 100 = 20,000 m. 20,000 m $\div$ 1,000 = 20 km. 'Continents move about 2 cm per year, so in a million years a continent moves about 20 km.'

Why: The correct answer is 20 km. The common slip is dividing by 1,000 only once, or confusing cm-to-km ($\div$ 100,000) with m-to-km.

Also acceptable: Accept 20 km with any correct conversion path (for example, 2 cm = 0.02 m; 0.02 $\times$ 1,000,000 = 20,000 m = 20 km).

7. Statement 6 (the eruption took one afternoon, so nothing about it took long). (a) What went wrong? (b) Rewrite it so that it separates the time the event took from the time its conditions took to build up.

Answer: (a) Mateo confused how long the event lasted with how long its conditions took to develop. The eruption was fast, but the magma collected and pressure built underground over a long time before it broke through. (b) Rewrite: 'The eruption that made the lava flow lasted only an afternoon, but the conditions that caused it, magma collecting and pressure building beneath the volcano, took a long time to develop. The sudden event was the end of a slow one.'

Why: The lesson states that catastrophic events are the result of slow changes beneath the surface; the rewrite must separate event duration from build-up time.

Also acceptable: Accept 'the volcano itself took thousands of years to build' as part of the slow story.

- Identifies the duration/build-up confusion
- Rewrite keeps the eruption fast
- Rewrite names a slow build-up (magma collecting, pressure rising)

Part C: Step back

8. Statements 1, 3 and 6 share one habit of thinking: judging a process by what can be seen in a short time or by its size alone. Write one sentence Mateo could put at the top of his poster that would protect him from all three mistakes.

Answer: Examples: 'Every change has two rulers, size and time, and you cannot judge one from the other or from what you can see in a single visit.' Or: 'Slow is not stopped, big is not sudden, and fast events have slow beginnings.'

Why: One sentence that covers invisible slow change (1), size not implying cause (3), and sudden events having slow set-ups (6).

Also acceptable: Accept any sentence that would genuinely block all three errors.

- A single sentence
- Addresses time scale and size (or sudden versus gradual) together

9. Statements 7 and 8 are correct. Pick one and explain why it is correct, as if Mateo had asked you to check it.

Answer: Statement 7: each raindrop moves only a few grains (a tiny change), but rain falls countless times over thousands of years, and the moved grains are carried downhill and never return, so the small losses add up to a lower hill; this is weathering and erosion acting at the human scale over a long time scale. Statement 8: the dust thrown up by a large impact spreads around the planet in days and blocks sunlight, cooling the whole surface within days to months; it is a global (large spatial scale) change that is also fast, which shows that size and speed are independent.

Why: Either explanation earns credit if it gives the actual reason the statement is right, using the two-rulers idea.

Also acceptable: Extra examples (dunes built grain by grain; impact cooling lasting years) are welcome.

- Picks one correct statement
- Gives the scientific reason it is right

Teacher notes

Statement 4 is deliberately the subtle one: the textbook says processes happened 'in the same way' in the past, which students read as 'at the same speed.' The accurate version keeps the same processes and laws

and lets rates vary; the extension's 1920s flood geologist is J Harlen Bretz and the Channeled Scablands (see Worksheet 3). Statement 5 is the chapter's unit-conversion trap: $2 \text{ cm} \times 1,000,000 = 2,000,000 \text{ cm} = 20 \text{ km}$, not 2 km; have students write units at every step. Statement 6 reflects the lesson's point that eruptions are the result of slow changes underground; eruption durations vary from hours to years, so 'one afternoon' is Mateo's observation, not a rule. For statement 1, a 1990 photo versus today is 35 years; hoodoos lose rock at rates that would not show in a photo at that scale, though a fallen cap would.

Scaffold offered to students: The 'so' test

Most of Mateo's mistakes happen at the word 'so' or 'must.' Underline that word in each statement and ask: does the first half really force the second half? For example, 'it looks the same, so it has stopped changing' assumes that every change is big enough to see in a photo. For the calculation in statement 5, write the units at every step: $\text{cm per year} \times \text{years} = \text{cm}$, then $\text{cm} \div 100 = \text{m}$, then $\text{m} \div 1,000 = \text{km}$.

Extension: Write the tricky ninth statement

Statement 4 hides a real history. For about a century after uniformitarianism became popular, many geologists did reject sudden events, and a geologist who proposed a giant ice-age flood in the 1920s was rejected for decades before the evidence proved him right. Write a ninth statement for Mateo's poster that is true, that mentions this history, and that explains the modern version of the principle in one or two sentences. Then write a tenth statement that is wrong in a subtle way and challenge a partner to find the error.