

The Three-Cup Mystery: Rank the Temperatures by Watching Dye

Investigation question: Three cups of still water look identical, but each is at a different temperature. Can you rank them from coldest to warmest using only how fast a drop of dye spreads, and what does your ranking tell you about the particles in each cup?

Evidence-based mystery

Groups of 4

1 session

Setup 8 · Activity 37 · Cleanup 5 min

MS-PS1-4 · practice

MS-PS3-4 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Dropper captain:** Leads the '3, 2, 1, drop' countdown and, with two teammates, makes sure each cup gets exactly one drop from the same height at the same moment.
- ☐ **Timekeeper:** Runs the stopwatch, calls each check time aloud, and makes sure nobody touches the cups, the tray or the table during the run.
- ☐ **Scorer:** Compares each cup with the spread-score card at every check time and calls a score; the team agrees before it is written down.
- ☐ **Recorder and thermometer reader:** Writes every score, leads the sketch at the 2:00 check, and after the ranking is committed reads each cup's temperature at eye level.

Safety

- The warm water is no hotter than 50 °C and is prepared and poured only by the teacher; students do not use hot-water taps, kettles or the warm pitcher.
- Use digital or alcohol-filled thermometers, never mercury. If a glass thermometer breaks, step back and tell the teacher; do not pick up the pieces.
- Spilled water is a slip hazard. Keep the cups on the tray and wipe up spills at once.
- Food coloring stains skin, clothing and paper. Roll up sleeves and keep recording sheets off the tray.
- Nothing in this lab is for drinking, not even the plain water.

Procedure

1. Read the spread-score card together. Before any dye goes in, write any clues you notice about the three cups in q1 (for example, fogging on the outside). Your final ranking must rest on the dye evidence, not on these clues.
2. From now until the thermometer step, do not touch the cups, the tray or the table. Wait one minute so the water stops swirling from being poured.
3. Three teammates each hold one pre-filled pipette straight up, about 1 cm above the center of one cup. On the dropper captain's '3, 2, 1, drop', each squeezes out exactly one drop. The timekeeper starts the

stopwatch on 'drop'.

4. At 0:30, 1:00, 2:00, 3:00, 4:00, 6:00, 8:00, 10:00 and 12:00, the timekeeper calls the time and the scorer gives each cup a spread score from 0 to 4, looking from the side against the white backdrop. The team agrees on each score before the recorder writes it.
5. At the 2:00 check, every student sketches a side view of all three cups in the sketch box.
6. When a cup first reaches score 4, write that time in the summary table. If a cup has not reached 4 by 12:00, write 'more than 12 min'.
7. At 12:00, stop watching. As a team, rank the cups from coldest to warmest, write the ranking and your strongest evidence in q2, and show it to the teacher, who initials it. The ranking cannot change after this.
8. Reveal: the thermometer reader places the thermometer in each cup in turn, waits 30 seconds, and reads it at eye level. Record each end temperature. The teacher then reads the starting temperatures from the key card; record those too, and answer q3.
9. Plot all three cups on the spread-score graph, score against time, one line per cup, each labeled with its end temperature.
10. Add your group's results to the class table on the board (end temperature and score at 4:00 for each cup), copy the class table onto your sheet, and answer the analysis questions individually.

Record your observations

Lab 1 recording sheet: The three-cup mystery

Spread-score card. **0:** a tight blob or thread of color. **1:** color in less than a quarter of the water. **2:** color in about half of the water. **3:** color in most of the water, but streaky. **4:** evenly tinted, no streaks. Score each cup from the side, against the white backdrop.

1. Clues before the drop: write anything you notice about the three cups before any dye goes in.

Spread scores (0 to 4)

Time (min:s)	Cup X	Cup Y	Cup Z
0:30			
1:00			
2:00			
3:00			
4:00			
6:00			
8:00			
10:00			
12:00			

 Sketch a side view of cups X, Y and Z at the 2:00 check. Shade where the color is, and label each cup.

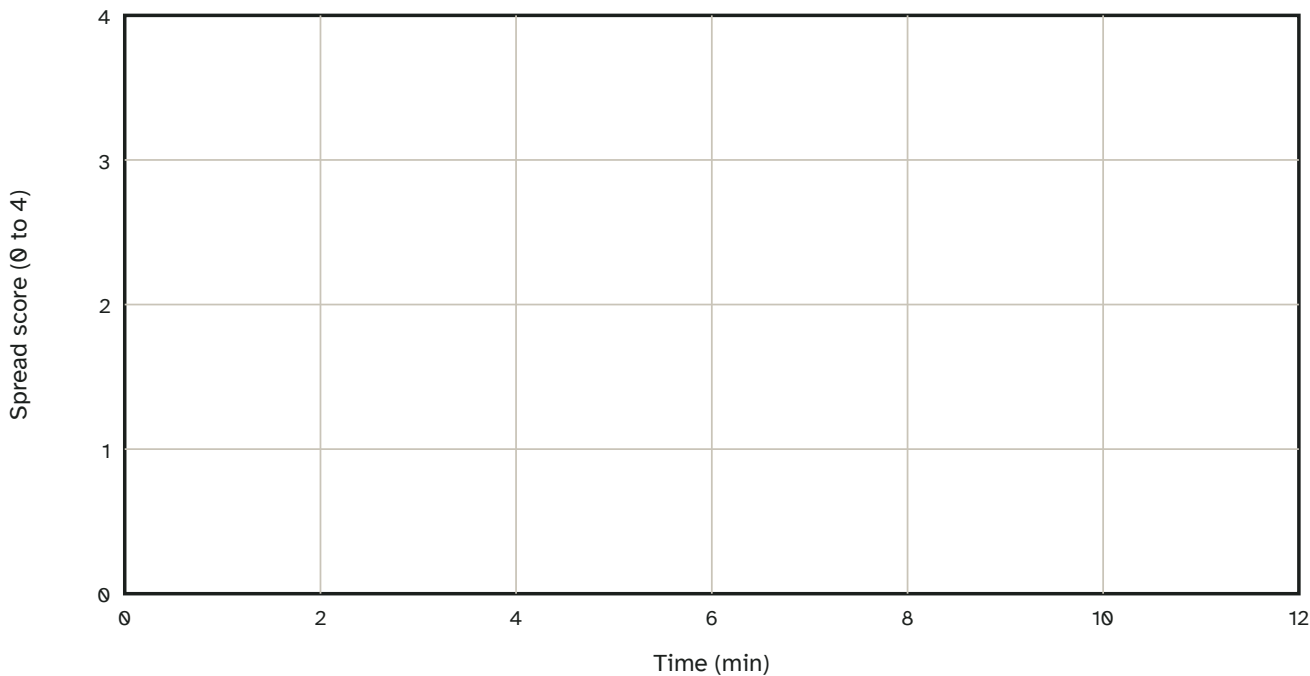
2. Before the reveal: our ranking from coldest to warmest is ____, ____, ____. Our strongest piece of evidence is: (Teacher initials: ____)

Summary

Cup	Time to first reach score 4	End temperature (°C)	Start temperature from the key card (°C)
X			
Y			
Z			

3. After the reveal: was your ranking correct? If not, what misled you?

Spread score against time



Class results

Group	Cold cup: end °C	Cold cup: score at 4:00	Room cup: end °C	Room cup: score at 4:00	Warm cup: end °C	Warm cup: score at 4:00
1						
2						
3						
4						
5						
6						
7						
8						

Analysis questions

4. Use your graph to describe how the three cups differed. Which cup changed fastest in the first two minutes, and which was slowest to become even?

5. Explain your ranking in terms of particles. What moves the dye when nobody stirs, and why does that happen faster in some cups than in others?

6. A classmate says the cold water 'has no motion in it, so the dye can only sink'. Use your data to argue against this claim.

7. A fourth cup of water is at 30 °C. At the 4:00 check, where would its spread score most likely fall?

- ☐ A. Lower than the cold cup's score
- ☐ B. From the room cup's score up to the warm cup's score
- ☐ C. Higher than the warm cup's score
- ☐ D. Exactly zero, because 30 °C is close to room temperature

8. The spreading you watched was not caused by particle motion alone. Name one other thing that could move the color around in a cup, and describe how you could change the test so that particle motion is the only cause.

- 9.** Look at the class table. Did every group's warm cup have the same score at 4:00? Give two reasons groups could differ, and explain why pooling the class's data makes the conclusion stronger.

- 10.** A bathtub of water is at 45 °C, the same as a warm cup. Which holds more thermal energy? Do the particles in the bathtub move faster than those in the cup? Explain both answers.
