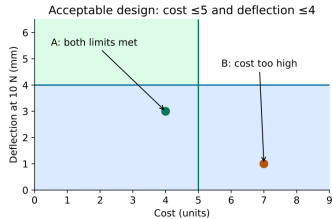


Optional Science: data, investigations and models

Original skill preparation; versioned source scope

Method and conditions



- A controlled comparison changes the proposed cause while holding alternative causes fixed.
- Independent/dependent variables; controls; design constraints.

Worked method 1

Read and reason

A controlled comparison changes the proposed cause while holding alternative causes fixed. An engineering design must satisfy every stated constraint. Repetition estimates variation; it does not undo a change of both material and thickness.

Original context 1

Read and reason

Original hypothetical research summary — A cooling sleeve A laboratory team tests sleeves intended to reduce a small sensor's temperature during operation. All sensors start at 22°C. Temperature is measured after ten minutes of use with the same power setting, room conditions and measuring instrument. Sleeve A costs 4 units, B costs 7 units, and an unsleeved sensor is the control.

Original context 2

Read and reason

The design brief requires a cost no greater than 5 units and a final temperature no greater than 35°C. Lower temperature alone is not the only design criterion. Experiment 1 uses identical sensors and records three independent trials per sleeve. Final temperatures in °C are: control 41,42,43; A 33,34,35; B 30,31,32.

Original context 3

Read and reason

The team resets the starting temperature and checks the sensor charge before each trial. They report the means and the full observed ranges. The ranges describe these trials, not every future result. The team has not yet measured sleeve durability. Experiment 2 investigates thickness for material A. Each sleeve has the same length and fit; thicknesses are 1,2,3 mm.

Original context 4

Read and reason

Mean final temperatures are 38,34,32°C respectively. All other stated conditions match Experiment 1. Changing thickness also changes material quantity, so a future design review must measure costs instead of assuming they stay at 4 units. A student proposes testing a 3-mm sleeve in material B against a 1-mm sleeve in material A to identify thickness's effect.

Original context 5

Read and reason

This comparison would change two factors at once. Two original models explain the observed temperature pattern. Model P says final temperature depends only on thickness, regardless of material. Model Q says both thickness and material matter; at equal thickness it predicts that material B produces a lower final temperature than A under the same conditions.

Original context 6

Read and reason

Both models predict lower final temperatures as thickness rises over the tested 1–3 mm interval. A decreasing trend alone therefore cannot separate them. Experiment 3 tests new A and B sleeves, each 2 mm thick, in matched conditions. Mean final temperatures are A 34°C and B 31°C.

Original context 7

Read and reason

The measuring instrument's stated resolution is 0.1°C , and the team checks its calibration with a reference. Repeated trials would still be needed to characterise variability and rule out other differences in manufacture. The result conflicts with P's material-independence prediction and is consistent with Q's direction; it is not proof that Q is the only possible explanation.

Original context 8

Read and reason

A separate time series for one sensor with sleeve A records temperatures 22,28,32,34°C at 0,2,4,6 minutes. These observations show warming with successively smaller two-minute increases. No measurements beyond six minutes are supplied in this series.

Original context 9

Read and reason

A proposal to continue the first interval's slope to twelve minutes is a model assumption that later measurements may contradict, not a reading from the table.

Attempt 1.1

Read and reason

Find mean and observed range for control, A and B in Experiment 1. Which sleeve satisfies both design constraints in these trials?

Reasoning 1.1

Read and reason

Control mean 42°C, range 41–43°C; A mean 34°C, range 33–35°C; B mean 31°C, range 30–32°C. A costs $4 \leq 5$ and reaches at most 35°C, so it meets both in these trials. B's lower temperatures do not overcome cost $7 > 5$. This does not guarantee future durability or temperatures.

Attempt 2.1

Read and reason

Identify the changed and measured variables in Experiment 2. Why does the student's A-versus-B proposal fail to isolate thickness?

Reasoning 2.1

Read and reason

Thickness is changed and final temperature measured. Material, length, fit, starting temperature and operating conditions are controlled in Experiment 2. The proposal changes material and thickness together, so either could explain a difference; repeats would not remove that confounding.

Attempt 3.1

Read and reason

Propose a follow-up for the 3-mm A design that addresses a previously unmeasured requirement and preserves a fair temperature comparison.

Reasoning 3.1

Read and reason

Measure its actual cost and durability, while repeating matched final-temperature tests with the same material, length, fit, power, starting temperature and duration. The heavier sleeve's cost cannot be assumed unchanged. State acceptance limits before choosing, rather than deciding from cooling alone.

Transfer and limits

Read and reason

Independent/dependent variables; controls; design constraints.

Check yourself

Read and reason

Close the worked reasoning. Explain why the method fits the final transfer task, reconstruct its conclusion, and state a condition that would change your answer. Then check the full reasoning in the reference.