Designing a Fair Test: Variables and Controls

- Turn any question into evidence you can trust
- Change one thing; keep everything else the same
- Everyday hook: two charging cables or two fertilizers — which really works?
- Roadmap: identify variables, change one, control the rest, measure, check bias, report
- Outcomes: valid comparison, trustworthy evidence, results others can reproduce

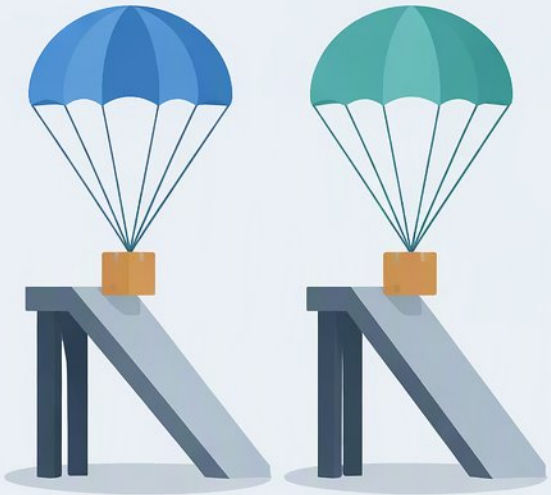




What Makes a Test 'Fair' — And What 'Fair' Does Not Mean

- A fair test changes only one variable and keeps everything else the same
- If more than one thing changes, you cannot tell what caused the result
- Misconception: 'fair' means equal treatment of people, not one-variable control
- Comparative tests can still be fair if all other conditions stay constant
- Quick check: which ramp or parachute run was fair, and why?

One Variable Changed
(Fair Test)



Only one variable is different.

Several Things Changed
(Not a Fair Test)



More than one thing is different.

The Three Variable Roles: Independent, Dependent, Controlled

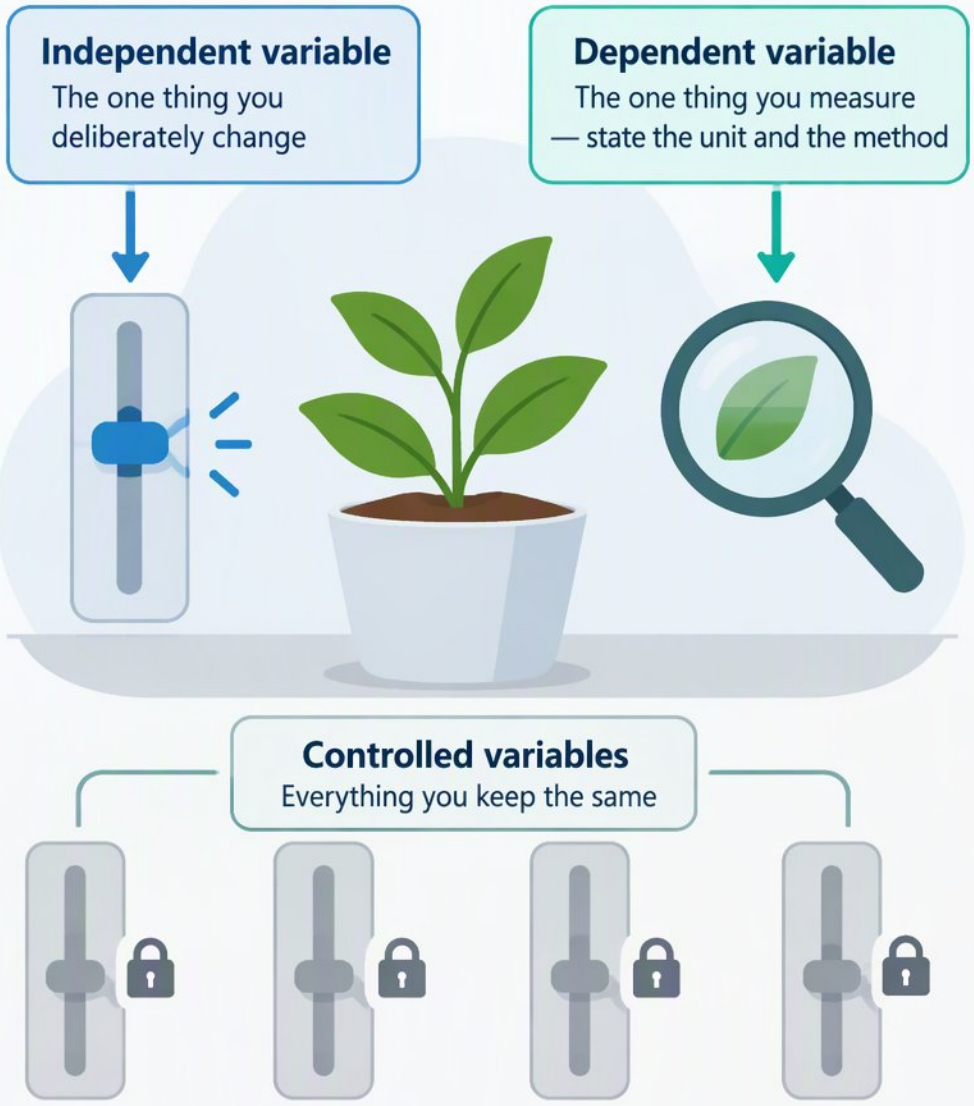
Independent variable:
the factor you deliberately change, at two or more levels

Dependent variable:
the outcome you measure — state the unit and the method

Controlled variables:
everything you keep the same, so the effect can be isolated

Mnemonic: Cows Moo Softly —
Change one thing, Measure what happens, keep the rest the Same

Watch the trap:
science variables are not x and y in equations



Hidden Factors: Confounding Variables, Controls, and Control Groups

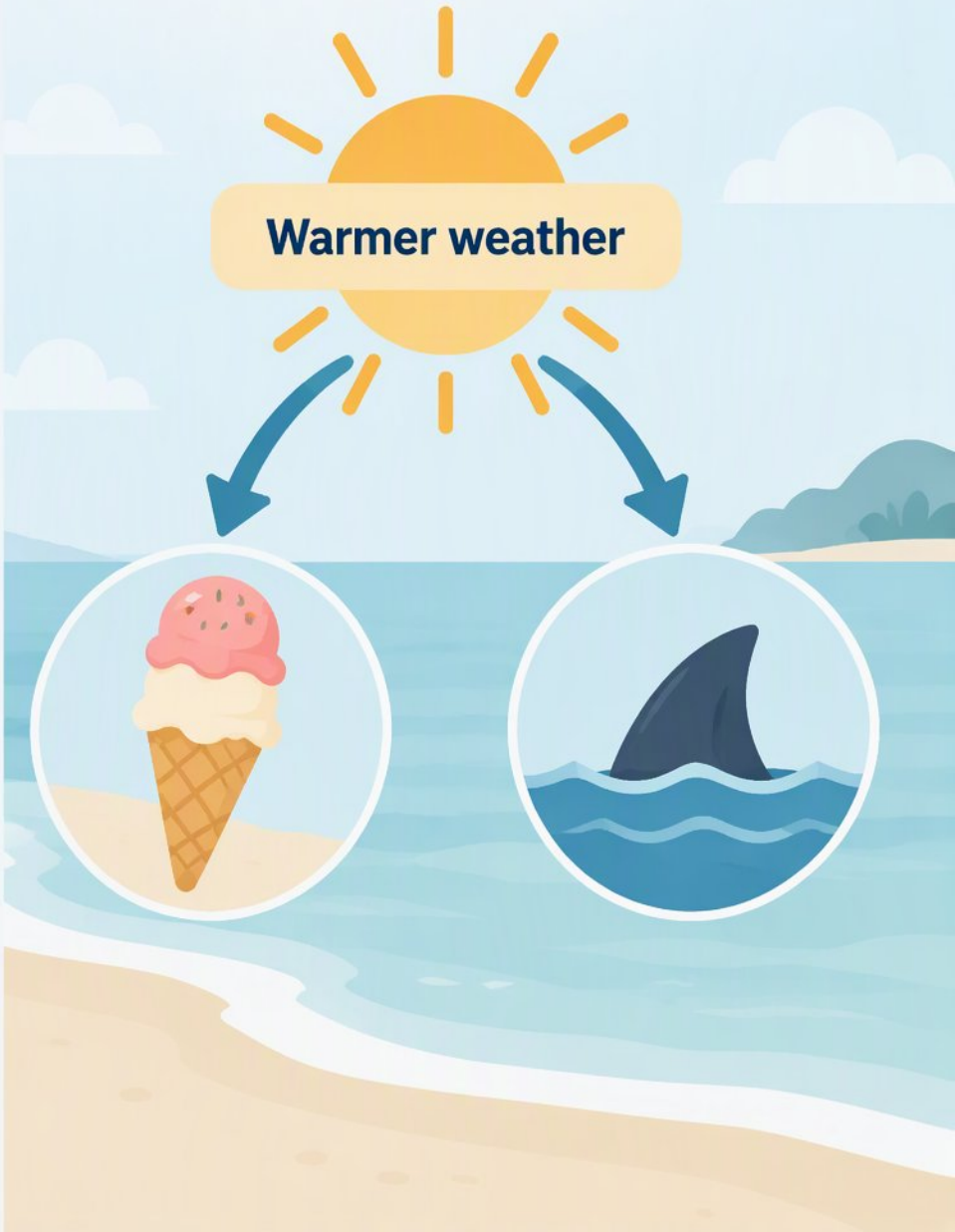
Confounding variable: a third factor that changes systematically across conditions

It offers an alternative explanation for your observed result

Control variables stay constant; a **control group** is the unchanged comparison

You cannot control everything — randomize, match, or use statistical control

Classic trap: ice cream and shark bites — warmer weather drives both



Why Controls Matter: Validity and Bias

- Without controls, other causes can explain results — the design is invalid
- Internal validity: the effect comes from the independent variable, not something else
- Bias enters through human judgment — randomize order, blind testers, hide labels
- Case: plant-growth study where light exposure differed between groups
- “It worked in my class” is not evidence — one run with many differences proves nothing



Same question. Different conditions. Different story.

Setting Up Controls in Practice

SAME CONDITIONS.
CLEAR METHODS.
RELIABLE RESULTS.

- Hold time, temperature, materials, and measurement procedure constant — and state how
- Write a control checklist before running anything, not after odd results appear
- Run a pilot trial to surface uncontrolled factors while changes are still cheap
- Document conditions so another person or group can replicate the test
- Use a variable table: role, value, and how each is monitored

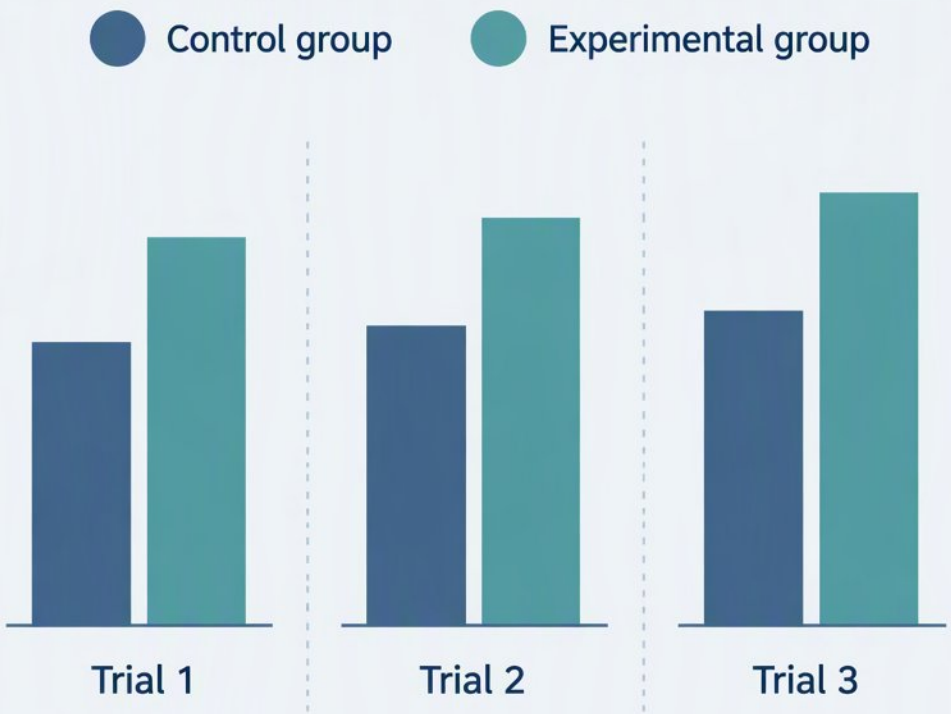
Variable Table (Example)

Role	Value	How Monitored
Temperature	Room temperature	Thermometer
Material	Same type	Visual check
Measurement procedure	Same method	Written steps
Time	Same duration	Timer



CONTROL TODAY FOR A STRONGER TOMORROW

Designing the Comparison: Groups, Trials, and Sample Size



Control group: the reference level; experimental group receives the change

Repeat every condition at least three times — more trials, more valid results

Larger samples detect smaller differences by cancelling out random factors

Random assignment keeps groups similar on factors you forgot to control

No true control group? Compare levels of the independent variable honestly

BETTER QUESTIONS
LEAD TO CLEARER ANSWERS

Measurement and Data Quality

Operational definition: state exactly what you measure, how, and in what unit

Accuracy: closeness to the true value; **precision:** closeness of repeated readings to each other

Random errors scatter readings — average more measurements; **systematic errors** shift all readings — change method or tool

Calibrate instruments, record raw data, flag anomalies as you go

Standardize procedure: same person doing it differently is a hidden variable

Random errors



Readings are scattered around the true value.

Systematic errors



Readings are clustered but shifted from the true value.



Common Pitfalls and How to Fix Them

Spot common issues in test design and follow the right fix to get back on track.



Common Pitfall	How to Fix It
Changing several variables at once	fix: isolate one change, list the rest as controls
Missing or mismatched control group	fix: add a reference condition and check similarity
Treating correlation as proof of causation — or wrongly assuming causation is impossible	
Ceiling, floor, drift, and novelty effects can mask or fake results	



Five-question design review before approving any test

Worked Case 1: Does a New Study Method Improve Quiz Scores?

Question: does the new study method raise quiz scores?

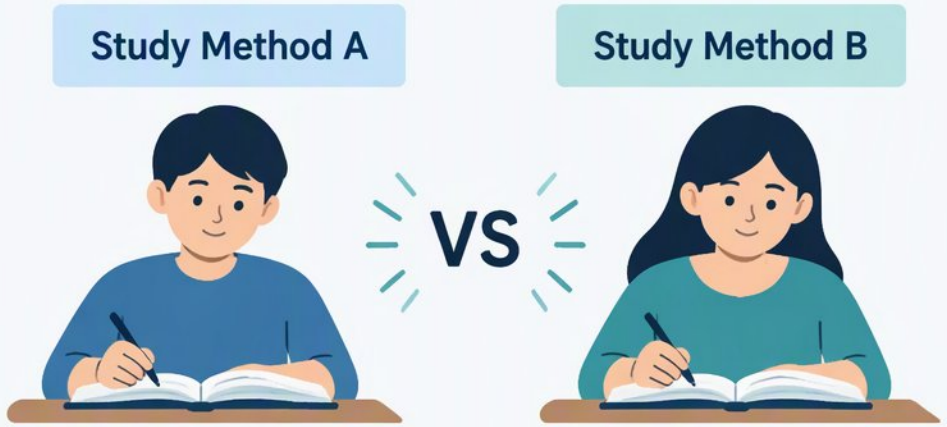
If–then hypothesis naming both variables before data collection

Independent: study method.
Dependent: quiz score, with points and scoring rule

Controls: same quiz, time limit, prior topic coverage, comparable groups

Confounds to watch: motivation, teacher enthusiasm, extra practice time

Design: random assignment, repeated quiz versions, honest reporting of group differences



One variable changes, all others stay the same

- Study method
- Same quiz
- Time limit
- Prior topic coverage
- Comparable groups

Motivation

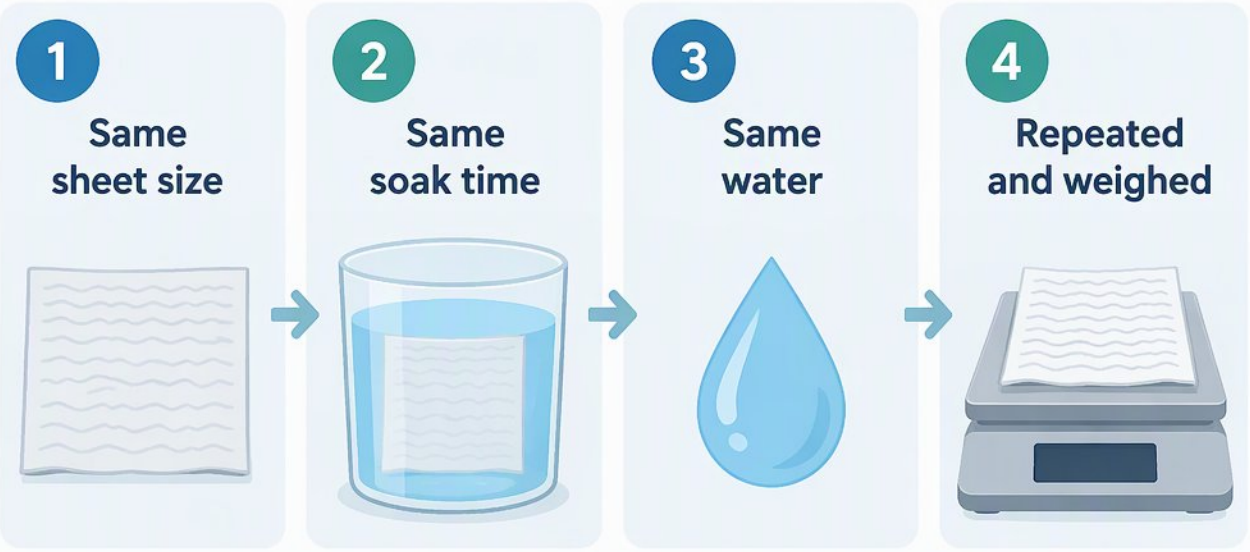
Teacher enthusiasm

Extra practice time

Worked Case 2: Which Paper Towel Absorbs Most Water?

- Tighten the question until “absorbs most” becomes measurable
- Independent variable: towel brand or type; dependent variable: water absorbed by mass or volume
- Controls: same sheet size, soak time, water temperature, drying surface
- Repeated trials per brand with averaging; note outliers rather than deleting them
- Peer review with rubric: one change, rest the same, comparison, repeated trials

Paper Towel Soak Test (Overview)



Key Controls for a Fair Test

✓	Same sheet size
✓	Same soak time
✓	Same water temperature
✓	Same drying surface

Assessing Fairness: Rubric and Self-Check

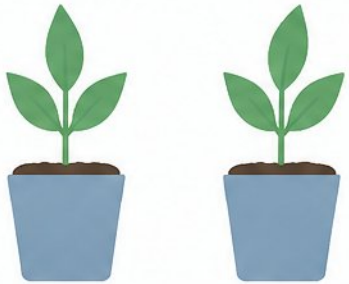
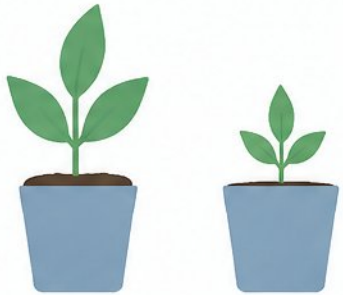
Rubric: variable clarity, control completeness, measurement quality, replication, reporting

Self-check: exactly one change? real comparison? repeated trials?

Scored samples show 'clearly evident' versus 'some evidence'

Claims: must not exceed what the design licenses

Rubric: Sample Design Excerpts

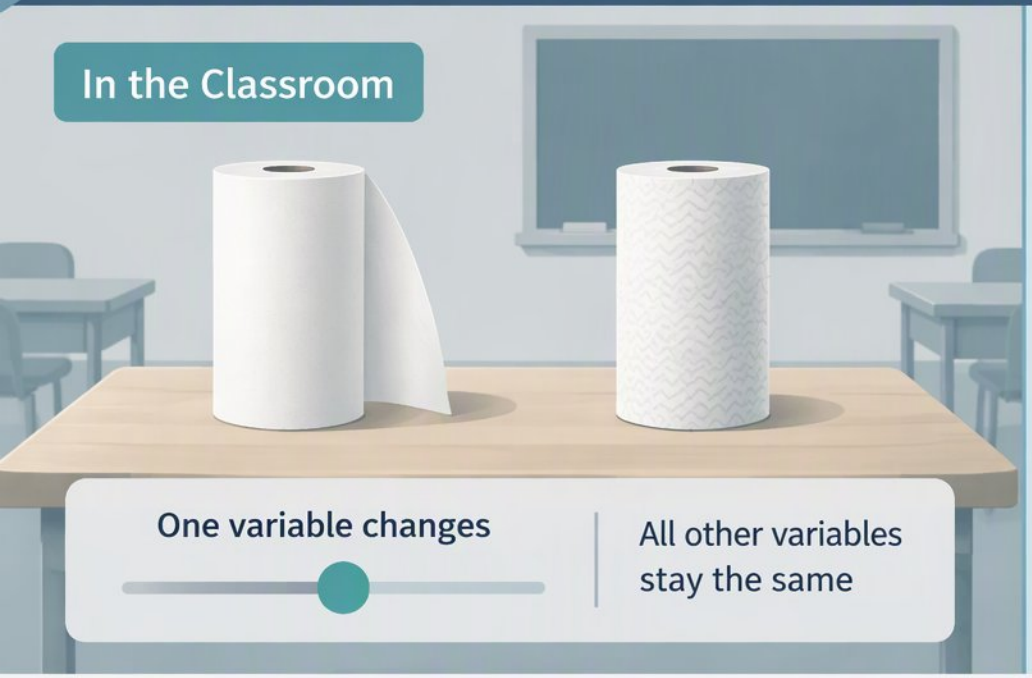
Clearly evident	Some evidence
	
Same plant type, same amount of water and light; only the fertilizer is different.	Different plant types and different amounts of light; more than one change.

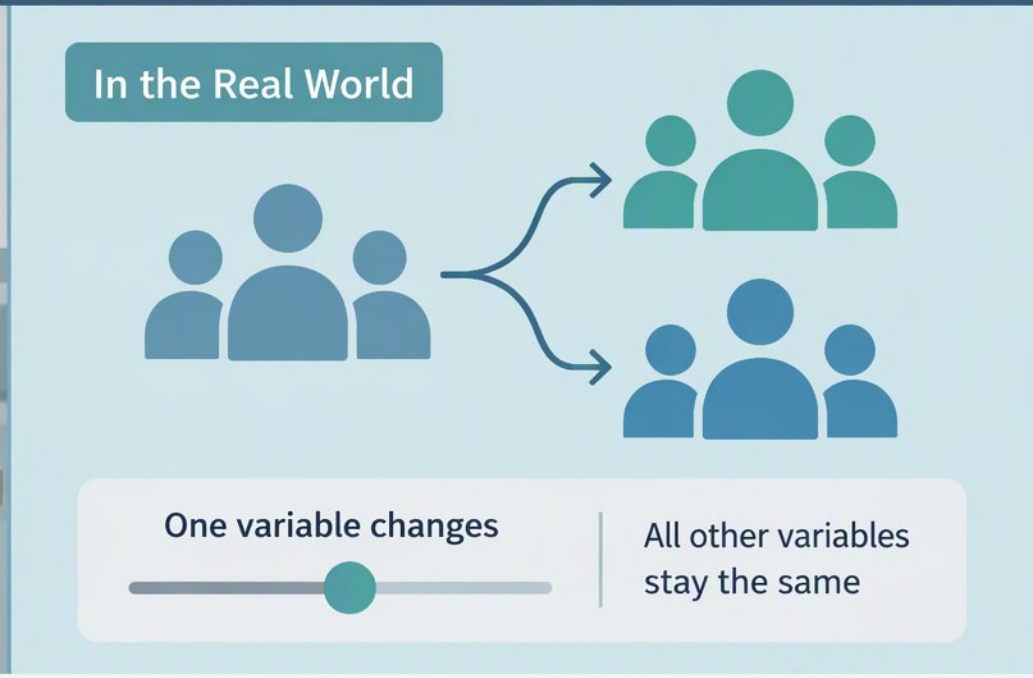


Teachers: score the design, not the result; keep fair-test quality separate from repetition



From Classroom to Real Decisions: A/B Tests and Field Trials





- A/B tests randomly split users between control and treatment variants
- Novelty and primacy effects: run longer, then analyze new users separately
- Underpowered tests exaggerate effects and produce false winners
- Watch interference between users and metrics that take months to emerge
- Controlled tests reveal which variant won, not why — pair with qualitative inquiry

Capstone: Design, Justify, and Present Your Fair Test

Capstone task: in 10 minutes, design a fair test for a question of your choice and justify each design decision.

Presentation frame: question, hypothesis, independent and dependent variables, control list, comparison, trials, measurement plan.

Peer and instructor scoring with the course rubric; one revision based on feedback.

Key takeaways: change one variable, control and document the rest, compare, repeat, measure rigorously, guard against bias.

Next steps: run the test in your classroom or lab; further reading on experimental design, confounding, and controlled experiments.

Presentation Frame

- Question
- Hypothesis
- Independent and dependent variables
- Control list
- Comparison
- Trials
- Measurement plan



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