Science: research summaries, controls and engineering tests

Original skill preparation; versioned source scope

ACT Science: Research Summaries, Controls and Engineering Tests

- Identify the **independent variable** 自变量, the **dependent variable** 因变量 and the controls.
- Judge whether a **controlled comparison** 控制比较 is fair.
- Evaluate an **engineering design** 工程设计 against each **constraint** 约束条件.
- Propose or evaluate a **proposal** 提案 for a follow-up test.

Variables and controls

- The **independent variable** is what the researchers change on purpose. The **dependent variable** is what they measure.
- Controlled variables are kept the same so that only one factor differs.
- A control (such as an unsleeved sensor) shows what happens with no treatment.

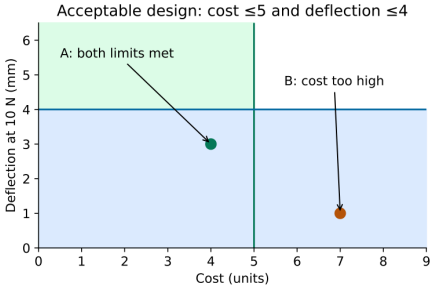
Repeats and ranges

- Repeated trials show how much results vary. Report the mean and the range.
- A range describes these trials, not every future result.
- If two ranges overlap a lot, a small difference in means may not be meaningful.

Engineering tests

- A design brief lists constraints, such as maximum cost and maximum temperature.
- A design is acceptable only if it meets every **constraint**. The best performance on one measure is not enough.
- Requirements not yet measured, such as durability, still need testing.

Figure: Engineering tests



- A design is acceptable only inside both limits: cost at most 5 and deflection at most 4
- Read the axes and units first.

Planning a follow-up

- Change only the factor you want to study; hold the others.
- Measure any requirement that a change might affect, for example the cost of a thicker sleeve.
- State acceptance limits before testing, not after.

Practice research summary

- 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.

Worked example: checking the brief

- Control: mean 42 °C (41–43). A: mean 34 °C (33–35). B: mean 31 °C (30–32).
- The ranges of A and B do not overlap, so B was cooler in every trial.
- A meets both constraints: cost $4 \leq 5$ and temperature ≤ 35 °C in all trials. B fails on cost: $7 > 5$.
- Durability has not been measured, so A is the only candidate so far, not a final choice.

Worked example: a fair follow-up

- Experiment 2: thickness is the **independent variable**; final temperature is the **dependent variable**; material, length, fit, start temperature and conditions are controlled.
- The student's **proposal** (3 mm of B against 1 mm of A) changes two factors at once, so it cannot isolate thickness.
- A better follow-up for the 3 mm A sleeve: measure its actual cost and durability, and repeat matched temperature tests with the same material, length, fit, power, start temperature and duration. Thicker sleeves use more material, so the cost cannot be assumed to stay at 4 units.

Common errors

- Swapping the independent and dependent variables.
- Choosing the best-performing design while it breaks a **constraint**.
- Accepting a comparison that changes two factors.

Common errors (2)

- Treating a range from three trials as a guarantee.
- Ignoring a requirement that has not been measured.

Key terms

- **independent variable**: The factor changed on purpose.
- **dependent variable**: The quantity measured.
- **controlled comparison**: A comparison in which only one factor differs.
- **engineering design**: Developing a solution that meets stated requirements.

Check yourself

- In Experiment 1, what is the purpose of the unsleeved sensor?
- Why can't a 3 mm A sleeve be assumed to cost 4 units?
- A design is cheap and cool but breaks after one day. Does it meet a brief that includes durability?