Optional Science: data, investigations and models

Original skill preparation; versioned source scope

ACT Science: Data, Investigations and Models

- Read data from tables and graphs, with units.
- Identify the changed, measured and controlled **variable** 变量 of an experiment, and the **control group** 对照组.
- Judge whether a **controlled comparison** 控制比较 isolates one factor.

ACT Science: Data, Investigations and Models (2)

- Compare models and decide what **evidence** 证据 could separate them.
- Apply **engineering design** 工程设计 criteria and evaluate a **proposal** 提案.

Reading data

- Read the title, axes, units and key before any number.
- Describe a trend in words: increases, decreases, levels off.
- Interpolate between measured values with care; extrapolate beyond them only with a stated assumption.

Experimental design

- The independent **variable** is changed on purpose; the dependent variable is measured; controlled variables are kept the same.
- A **control group** receives no treatment, for comparison.
- A fair test changes one factor at a time. Repeated trials show how much results vary.

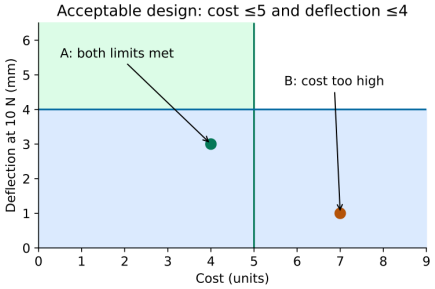
Models and viewpoints

- Two models can both explain the same trend. To separate them, find a situation where they predict different results.
- A result can be consistent with a model without proving it.

Design criteria

- An **engineering design** must meet every stated requirement, such as cost and performance, not just the most impressive one.
- A design inside all limits is acceptable; one outside any limit is not.

Figure: Design criteria



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

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: meeting the design brief

- Means: control $(41 + 42 + 43)/3 = 42$ °C; A $= 34$ °C; B $= 31$ °C. Ranges: 41–43, 33–35, 30–32 °C.
- A costs 4 units (at most 5) and reached at most 35 °C: it meets both limits in these trials.
- B is coolest but costs 7 units, more than 5, so it fails the brief.
- Durability has not been measured, so even A is not yet fully approved.

Worked example: a fair comparison

- In Experiment 2, thickness is changed and final temperature is measured; material, length, fit, start temperature and conditions are controlled.
- The student's **proposal** (3 mm of B against 1 mm of A) changes material and thickness together, so a difference could come from either. Repeating it would not fix this.
- Models P and Q both predict cooler results with thicker sleeves, so Experiment 2 cannot separate them. Experiment 3 holds thickness at 2 mm and changes only material: A 34 °C, B 31 °C. This conflicts with P and is consistent with Q, without proving Q.

Common errors

- Reading numbers before units and labels.
- Choosing the best-performing design while ignoring a cost limit.
- Accepting a comparison that changes two factors at once.

Common errors (2)

- Treating "consistent with a model" as "proves the model".
- Extending a trend far beyond the data without saying so.

Key terms

- **variable**: A quantity that can change in an experiment.
- **control group**: A group that receives no treatment, used for comparison.
- **controlled comparison**: A comparison in which only one factor differs.
- **evidence**: Data that support or weaken a claim.

Check yourself

- In Experiment 2, which **variable** is independent and which is dependent?
- Which result could tell Models P and Q apart?
- The time series reaches 34 °C at 6 minutes. Can the table tell you the temperature at 12 minutes?