Topic 3.5: Introduction to Experimental Design

How do we design studies that can establish causation?

Video Follow-Along Worksheet (Videos 1–3)

Learning Objectives:

- **VAR-3.A:** Identify the components of an experiment.
- **VAR-3.B:** Describe the elements of a well-designed experiment.
- **VAR-3.C:** Compare experimental designs and methods.

Essential Knowledge: Well-designed experiments can establish evidence of causal relationships through comparisons, random assignment, replication, and control of confounding variables.

Key Vocabulary

Experiment	A study where treatments are intentionally imposed on experimental units to observe a response.
Experimental units	The individuals (people, animals, objects) to which treatments are applied.
Confounding variable	A variable related to the explanatory variable that also influences the response, creating a false perception of association.
Random assignment	Using chance to determine which treatment each experimental unit receives.
Placebo	A "fake" treatment similar in appearance to the real treatment.
Blinding	When subjects and/or researchers do not know which treatment is being administered.

Video 1: Confounding & Components of an Experiment [6:20]

Part A: The Problem with Observational Studies [0:00–3:12]

1. **Research question:** Do students who take notes during AP Stats earn _____ than students who just listen?

2. One way to study this is through an _____: observe student grades after the midterm and record which students regularly took notes.

3. If the group who took notes earned higher grades, can we conclude taking notes *caused* the higher scores?

   Circle one: Yes / No

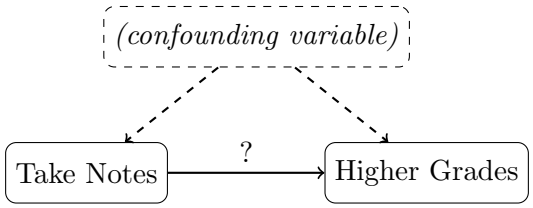
4. Just because there's a _____ does not automatically mean there's _____.

5. A **confounding variable** is another variable that is related to the _____ variable and influences the _____ variable.

Name: _____ Period: _____

6. In this example, _____ is a confounding variable because:
   - Students who are academically motivated are more likely to _____.
   - Students who are academically motivated are more likely to _____.

Confounding: Visualized



Fill in the confounding variable: _____

Part B: What Is an Experiment? [3:32–5:43]

7. An **experiment** is where a treatment or treatments are intentionally _____ on the experimental units.

8. **Experimental units** are the _____ to which we apply the treatments. When experimental units are humans, we call them _____ or subjects.

9. The **explanatory variable** (or _____) may help to predict a change in the response variable.

10. The **response variable** is what we use to _____ the outcome of a study.

11. **Proposed experiment:** Let students *decide* whether or not to take notes.
    - Explanatory variable: Does the student take notes? (Levels: _____)
    - Response variable: _____

12. Is this a well-designed experiment? **Circle one:** Yes / No

13. Why or why not? Confounding is still possible because _____.

Part C: Key Takeaways [5:59–6:20]

14. Observational studies cannot determine _____ due to possible _____.

15. An experiment intentionally imposes _____ on the participants in order to observe a _____.

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Video 2: Elements of a Well-Designed Experiment [6:58]

Part A: Four Principles of Experimental Design [0:00–1:42]

15. A well-designed experiment must include:

Principle	Description
1. _____	Compare at least _____ treatment groups (one could be a control group).
2. _____	Randomly assign treatments to experimental units to balance out confounding factors.
3. _____	Use _____ experimental units in each treatment group.
4. _____	Control potential _____ where appropriate.

Part B: Bulls-Eye! Example [1:43–4:17]

16. **Research question:** Does painting eyes on cattle's rears reduce _____?

17. A study in _____ randomly assigned cattle to receive one of three treatments:
    - Treatment 1: _____ (683 cattle)
    - Treatment 2: _____ (543 cattle)
    - Treatment 3: _____ (835 cattle)

18. Results: Of the 683 cattle with eyespots, _____ were attacked. _____ cross-marked and _____ unmarked cattle were killed.

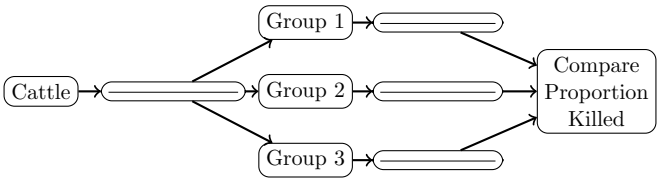
19. This is an _____ (not observational) because cattle were _____ to treatments.

20. How was **control** achieved in this study? The experiment was conducted in the same general _____ during the same general _____.

Part C: Experimental Design Diagram [4:18–6:27]

21. Complete the experimental design diagram:

Name: _____ Period: _____



22. **Important note:** On the AP Exam, simply providing a diagram may *not* give full credit. You must also explain _____ the random assignment is performed.

23. **One method:** Number all cattle from 1 to N. Use a _____ to select which cattle go to each group. Continue until the desired number are assigned to each treatment group.

Part D: Key Takeaways [6:38–6:58]

24. A well-designed experiment should include:
    - _____ between at least two groups
    - Random _____ of treatments to experimental units
    - _____ of treatments to multiple experimental units
    - _____ of possible confounding factors

Video 3: Experimental Designs & Methods [10:11]

Part A: Completely Randomized Design [0:00–3:12]

27. **Example:** A melanoma treatment study compared standard care to a combination treatment. The _____ was measured in both groups.

28. The study is described as: "randomized, _____, _____"

29. In a **completely randomized design**, treatments are assigned to experimental units completely at _____.

30. **Benefit:** Random assignment tends to _____ the effects of confounding variables so that differences in responses can be attributed to _____.

31. **Limitation:** Can *all* differences in survival rate be attributed to the treatment? There may still be something about the _____ that affects results.

Part B: Randomized Block Design [3:13–5:26]

32. **Randomized Block Design** ensures that experimental units within each _____ are similar with respect to a blocking variable.

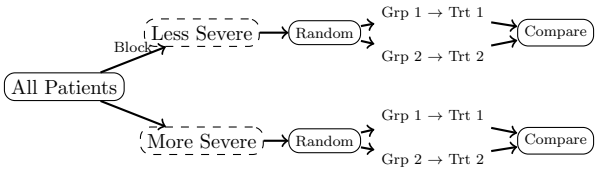
33. Blocking helps to separate _____ from differences due to the blocking variable.

Name: _____ Period: _____

34. In the melanoma study, _____ could be a blocking variable because the treatment may work differently for more severe vs. less severe cases.

35. **Key distinction:** Blocking is **NOT** random. It's done by the _____. Then, **within** each block, we _____.

Randomized Block Design Diagram



Part C: Placebo and the Placebo Effect [5:27–7:38]

36. A **placebo** is a "_____" treatment that is similar to the treatment being tested.

37. **Why use a placebo?** So that all patients behave the same way (e.g., come in at the same _____) regardless of which group they're in.

38. The **placebo effect** occurs when experimental units have a _____ to a placebo. This is a naturally occurring phenomenon.

39. Using a placebo helps determine if an effect is truly due to the _____ or just from receiving *some* treatment.

Part D: Blinding [7:39–8:13]

40. **Single-blind experiment:** The _____ do not know which treatment they're receiving, but the researchers do (or vice versa).

41. **Double-blind experiment:** Neither the _____ nor the _____ who interact with them know which treatment is being administered.

Part E: Matched Pairs Design [8:14–9:28]

42. **Matched Pairs Design** is a special type of block design where each block has size _____.

43. Pairs are arranged such that the two units are very closely _____ on relevant factors (like twins!).

44. Within each pair, _____ is used to determine which unit receives which treatment.

45. **Alternate form:** Each subject may receive _____, with randomization to determine the _____ of treatments.

Name: _____ Period: _____

Part F: Key Takeaways [9:29–10:11]

46. A completely randomized design helps to _____ potential confounding variables.
47. Block design ensures _____ within blocks *before* randomization of treatments.
48. The use of a _____ helps determine if an effect is truly due to the treatment.
49. _____ occurs when subjects and/or researchers are unaware of the treatment.

Post-Video Reflection

49. **Identifying Components:** A pharmaceutical company wants to test whether a new pain medication is more effective than a current medication. They randomly assign 200 patients with chronic back pain to receive either the new medication or the current medication for 4 weeks, then measure pain levels.

    - Experimental units: _____
    - Explanatory variable (factor): _____
    - Treatments: _____
    - Response variable: _____

50. **Design Improvement:** The company is concerned that the severity of back pain (mild vs. severe) might affect how well the medication works. What type of experimental design would address this concern, and how would it be implemented?

51. **Critical Distinction:** Explain the difference between **random selection** and **random assignment**. Which one allows us to generalize results? Which one allows us to establish causation?

52. **Confounding Check:** A researcher wants to determine if drinking coffee improves test scores. She surveys students about their coffee habits and compares their exam grades. Identify one potential confounding variable and explain why it creates a problem.

Name: _____ Period: _____

Exit Ticket

In 2–3 sentences, explain why random assignment of treatments is essential for establishing a cause-and-effect relationship.

Name: _____ Period: _____