Introduction to Research Designs

AGSC 4080 – EXPERIMENTAL DESIGN AND ANALYSIS

DEPARTMENT OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

Objectives

- **Introduce Research Designs**: Understand the foundational concepts of research design, including the purpose and importance of systematic study in scientific inquiry.
- **Differentiate Between Research Designs**: Learn the distinctions between experimental, quasi-experimental, and non-experimental research designs, and understand when each is appropriate.
- **Understand Internal and External Validity**: Comprehend the importance of internal validity (causal inference within the study) and external validity (generalizability of findings) and how these concepts are crucial for assessing the quality of research.
- **Identify and Mitigate Threats to Validity**: Recognize common threats to internal validity such as history effects, maturation, and selection bias, and learn techniques for controlling them
- **Explore Common Experimental and Quasi-Experimental Designs**: Study the structure and application of common experimental designs, including post-test only control group design and pretest-posttest control group design, as well as quasi-experimental designs.
- **Examine Non-Experimental Research**: Gain an understanding of non-experimental research methods, such as correlational studies, and when these methods are appropriate.

I- Research Designs

Warm-up Activity: "Magic or Science?" (5 minutes, groups of 3)

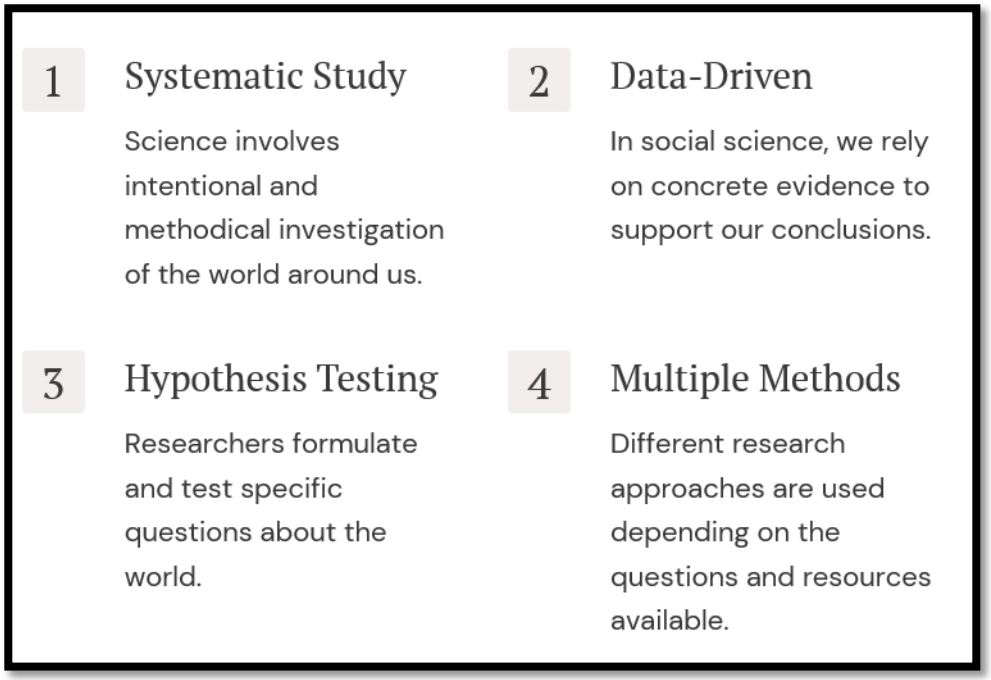
In the following video, David Blaine, the street "magician" takes a bite at a quarter. He then "spits" it back out and "makes" the quarter whole again. Our objective is to figure out how he did the trick.

We will work in groups of 3 for 5 minutes.

- Hypothesis 1: ……
- Hypothesis 2: ……
- Hypothesis 3: ……

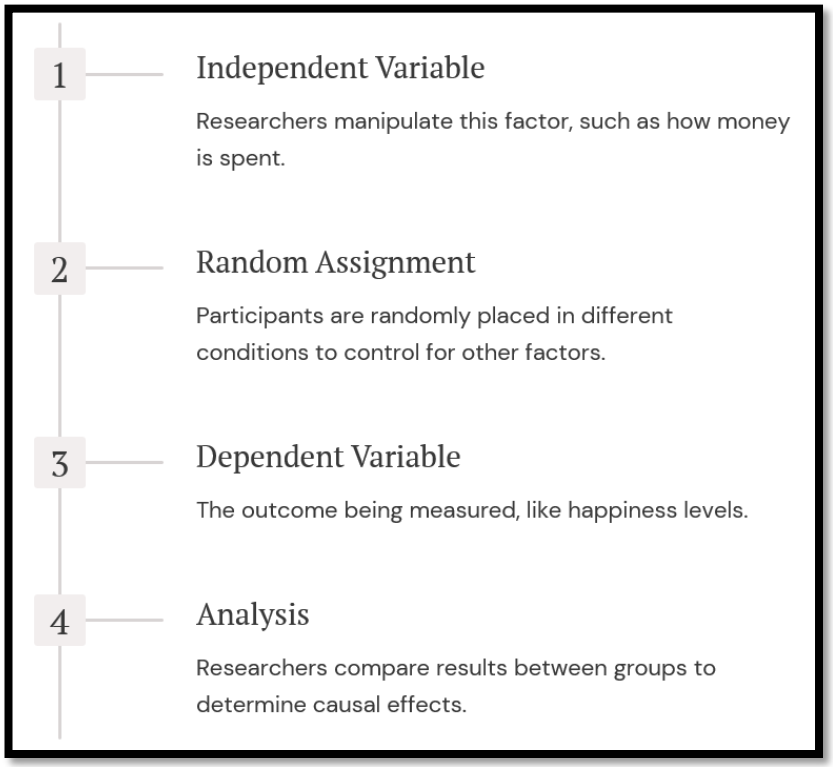
The Scientific Method and Observations

- Science is more than just what we see - it's the **systematic** and **intentional** study of the natural world.
- In social science, we rely on **data** to test our hypotheses.
- **Observations** form the foundation of scientific inquiry, whether we're examining dinosaur bones or studying social phenomena in our communities.



Experimental Research Design

- Experimental research involves manipulating an **independent** variable and observing its effect on a **dependent** variable.
- Example: Professor Elizabeth Dunn's studied spending and happiness. *Participants were randomly assigned to spend $20 on themselves or others, with happiness measured afterward*.
  - What is the independent Variable?.....
  - What is the dependent variable?.....
  - What other factors could explain happiness? .....
- This design allows researchers to establish **causal relationships** by controlling for other factors through **random assignment**.



Importance of Random Assignment

- **Game**: *We want to form a basketball team. We will have two captains. Each will select 4 other team members. We will flip a coin to see who will select his first 5 players.*
- Random assignment is crucial in experimental research as it helps ensure groups are similar on all characteristics except the manipulated variable.
- This allows researchers to infer **causality**.
- Random assignment in experiments creates **equivalent groups**.

Without Random Assignment

- Groups may differ on important factors - Difficult to isolate cause and effect - Results can be biased or misleading

With Random Assignment

- Groups are equivalent on average - Differences can be attributed to manipulation - Allows for causal inferences

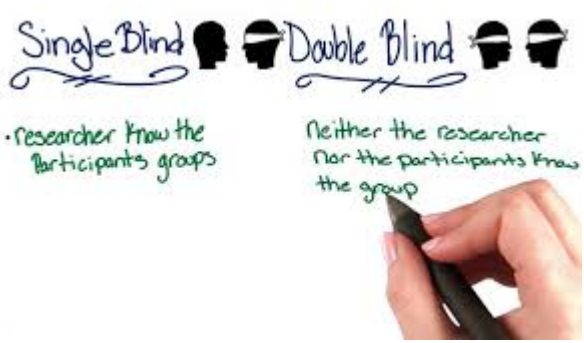
Basketball Team Analogy

- Random selection creates fair teams - Balances height, skill across groups - Illustrates power of randomization

Avoiding Confounding Variables in Experiments

- **Confounding variables** are factors that can undermine the ability to draw causal inferences in an experiment.
  - Example: Suppose you are conducting a study to evaluate the effectiveness of a new after-school tutoring program designed to improve math scores among students. You randomly assign students to either participate in the tutoring program or not and then measure their math scores at the end of the semester.
    - ✓ What is the Independent variable? .....
    - ✓ What is the dependent variable? .....
    - ✓ What other factors could affect the math scores? .....

- **Placebo Effect**: When participants believe they are receiving special treatment, their behavior or perception might change, even if the treatment is ineffective.
- **Experimenter Bias**: The experimenter's knowledge of who is in which group can influence their observations, potentially leading to biased results.
- **Double-Blind Procedure**: A method in which neither the participant nor the experimenter knows who is receiving the treatment.



Importance of Understanding Research Methods

In today's media landscape, research is frequently reported, often with misinterpretations or oversimplifications. Understanding research methods is crucial for critically evaluating scientific claims and becoming informed consumers of information: distinguish between **correlation and causation**.

Critical Thinking

Evaluate claims based on methodology and evidence

Media Literacy

Recognize misrepresentations of scientific findings

Informed Decision-Making

Use research to guide personal and community choices

Scientific Contribution

Prepare for conducting and understanding future research

Quasi-Experimental and Non-Experimental Designs

When random assignment isn't possible, researchers use quasi-experimental or non-experimental designs.

- **Quasi-experimental studies** rely on existing group differences, like comparing married and single individuals.
- **Non-experimental research** involves observing relationships without manipulation, such as correlational studies.

While these methods can't establish causation as clearly as experiments, they're valuable for studying real-world phenomena **that can't be randomly assigned**.

1

Experimental

Random assignment, manipulation of variables, strongest causal inferences

2

Quasi-Experimental

No random assignment, uses existing groups, limited causal inferences

3

Non-Experimental

Observational, no manipulation, identifies relationships but not causation

Practice: Research Design Relay

For each of the following scenarios, identify whether they are experimental, quasi-experimental, or non-experimental designs

1. **Scenario:** A study examining the effects of a new teaching method on student performance where students are randomly assigned to the new method or the traditional method.
2. **Scenario:** Observing the relationship between the number of hours of sleep and academic performance among students without manipulating any variables.
3. **Scenario:** A study where the effect of a new after-school program on student behavior is assessed, but students are not randomly assigned to participate.
4. **Scenario:** A survey conducted to see if there's a relationship between social media usage and self-esteem among high school students.

Particular Case of Non-Experimental Studies: Longitudinal Studies

Longitudinal studies track the same participants over time, providing valuable insights into long-term trends and changes.

- ❑ For example, a 20-year study of over 20,000 Germans revealed patterns in happiness related to marriage.

While these studies offer rich data, they can be **costly** and **time-consuming**, researchers must balance the depth of information gained against practical constraints like time, money, and participant retention when choosing a research design.

Time Investment

Longitudinal studies can span years or decades, requiring long-term commitment.

Financial Resources

Extended studies with large samples can be expensive to maintain.

Participant Retention

Keeping subjects engaged over long periods can be challenging.

Data Richness

Longitudinal designs provide unique insights into changes over time.

Ethical Considerations in Research Design

Ethics play a crucial role in determining appropriate research designs, especially when studying sensitive topics. While certain conditions like brain injuries or long-term isolation could provide valuable insights, it would be unethical to experimentally manipulate these variables.

Research Area	Ethical Approach
Brain Injuries	Study existing cases, not induced
War Experiences	Interview veterans, historical analysis
Long-term Isolation	Voluntary isolation studies, space analogs
Abusive Parenting	Retrospective studies, child welfare data
Drug Use	Observational studies, harm reduction focus

II- Internal Validity

Internal Validity in Research Designs

Internal validity refers to *how well a study supports the conclusion that changes in the independent variable caused observed differences in the dependent variable*.

- Experimental research typically has the highest internal validity due to manipulation of variables and control of extraneous factors.
- Non-experimental research has lower internal validity as it lacks these controls.
- Quasi-experimental research falls in between

Experimental Research
Highest internal validity

Quasi-Experimental Research
Moderate internal validity

Non-Experimental Research
Lowest internal validity

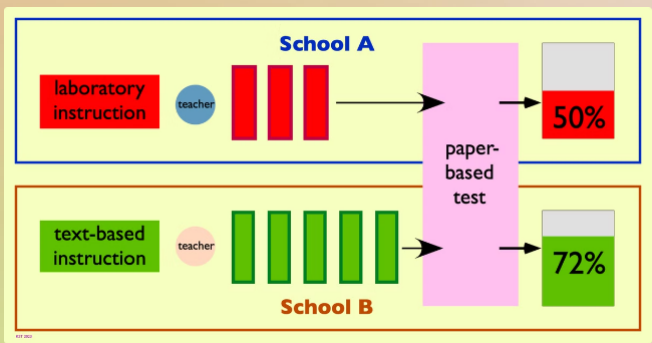
Practice: Validity Maze

On eLearn you have an R code to a Validity Maze.

It illustrates a scenario where you have to conduct a study and as you progress in your research design, you must make decision to maintain high validity in your research study. In your group navigate to the end of the maze. The first to reach the end is the winner!

Here is also a QR code or direct link to the Maze: https://abdelawani.shinyapps.io/Chapter1_Validity_Maze/

Threats to Internal Validity



1 **History**

Events occurring during the experiment that may affect results

2 **Maturation**

Natural changes in participants over time

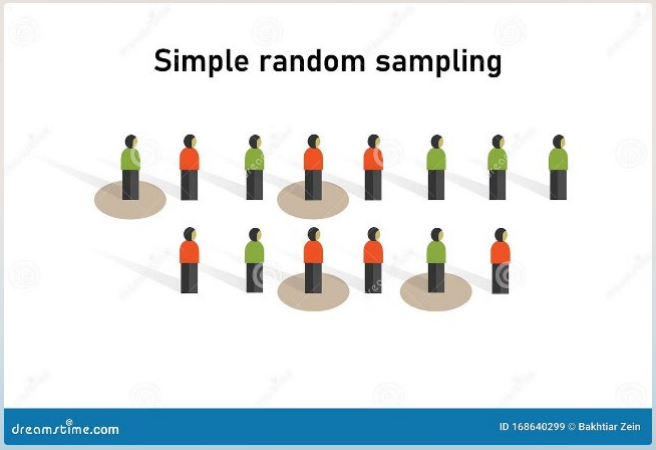
3 **Selection Bias**

Non-random assignment leading to non-equivalent groups

4 **Experimental Mortality**

Loss of participants during the study

Control Techniques in Experimental Design



1. **Random Assignment**

   Most powerful technique to minimize confounding variables by assigning participants randomly to groups

2. **Matching**

   Pairing participants with similar characteristics across groups

3. **Holding Variables Constant**

   Using participants with the same level of an extraneous variable

4. **Building Variables into Design**

   Including potential confounding variables as independent variables in the study

Practice: Confounder Hunt

For each of the following scenarios, identify the confounding variables and propose a control method for that variable

1. **Scenario:** Testing the effectiveness of a study technique where one group studies in the morning and another at night.
2. **Scenario:** A study on the impact of diet on academic performance, but students choose their own diet.
3. **Scenario:** Measuring the impact of a tutoring program where some students receive tutoring and others do not.

Practice: "Design Dash" Game

In this exercise, we will design an experiment for the scenario below under 5 minutes. Once you designed your experiment, you will need to specify the following:

1- Independent Variable,

2- Dependent Variable(s),

3- Control Method

Scenario: Assessing if involvement in community sports reduces delinquency rates among teenagers

III- Common Experimental Designs

Common Experimental Designs

Post-Test Only Control Group Design

Participants randomly assigned to groups, one receives treatment, both measured after

$$\begin{array}{lll} \text{R} & \text{X} & O_1 \\ \text{R} & & O_2 \end{array}$$

Pretest-Posttest Control Group Design

Both groups measured before and after, one receives treatment

$$\begin{array}{llll} \text{R} & O_1 & \text{X} & O_2 \\ \text{R} & O_3 & & O_4 \end{array}$$

- R means there is a random assignment to the group
- X symbolizes exposure to experimental treatment
- O is an observation or measurement

IV- Common Quasi-Experimental Designs

Quasi-Experimental Designs

1

Posttest Only Non-equivalent Comparison Group

Compare treated group to untreated group without random assignment

2

Pretest-Posttest Non-equivalent Comparison Group

Measure both groups before and after, one receives treatment

3

Pretest-Posttest with Switching Replication

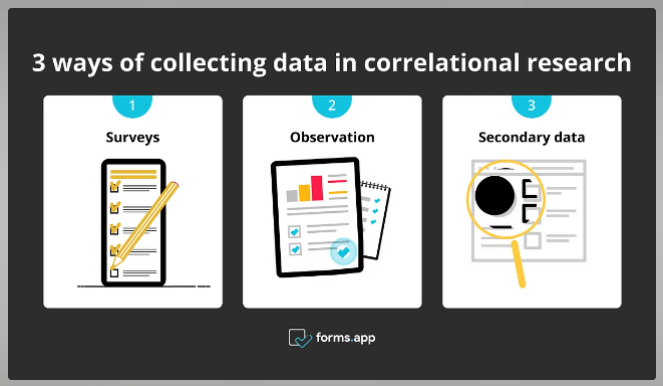
Delayed treatment for control group, multiple measurements

Practice: "Design Match-Up"

Match quasi experimental research designs with appropriate scenarios

1. **Scenario:** A drug trial where participants are randomly assigned to receive either a new medication or a placebo, and their **health outcomes are measured afterward**
2. **Scenario**: A school program where students' reading levels are measured before and after a new curriculum is implemented
3. **Scenario**: Comparing the academic performance of students in two different schools, one that implements a new teaching method and one that does not, without random assignment.

IV- Non-Experimental Designs



Non-Experimental Research

Definition

Research without manipulation of independent variables

When to Use

Single variable studies, non-causal relationships, or when manipulation is impractical/unethical

Common Type

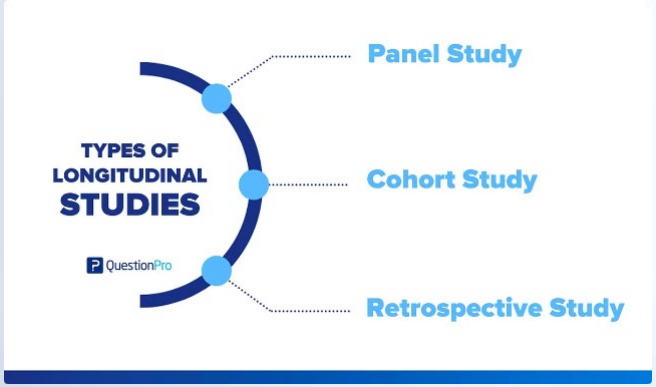
Correlational research, measuring relationship between variables without manipulation

Limitation

Cannot establish causation, only association between variables

Types of Non-Experimental Studies

Cross-Sectional	Compare different age groups at one time point
Longitudinal	Follow same group over time as they age
Cross-Sequential	Combine cross-sectional and longitudinal approaches



Correlational Research

Correlational research is a common type of non-experimental research in social sciences. It involves measuring two variables without manipulating them, then assessing their relationship. For example, a study might look at the correlation between self-esteem and school achievement by collecting data on students' self-esteem scores and GPAs.

1

Measure Variable 1

e.g. Self-esteem scores

2

Measure Variable 2

e.g. GPA

3

Analyze Relationship

Calculate correlation

Cross-Sectional Studies

Cross-sectional studies compare pre-existing groups at a single point in time. For example, researchers might compare memory performance between young adults (18-25 years) and older adults (60-75 years). This approach is efficient but has limitations, as differences between groups may be due to factors other than age, such as generational effects.

1. **Select Groups**
   Choose different age groups
2. **Measure Variables**
   Assess dependent variables
3. **Compare Results**
   Analyze differences between groups

Longitudinal Studies

Longitudinal studies follow the same group of people over time as they age.

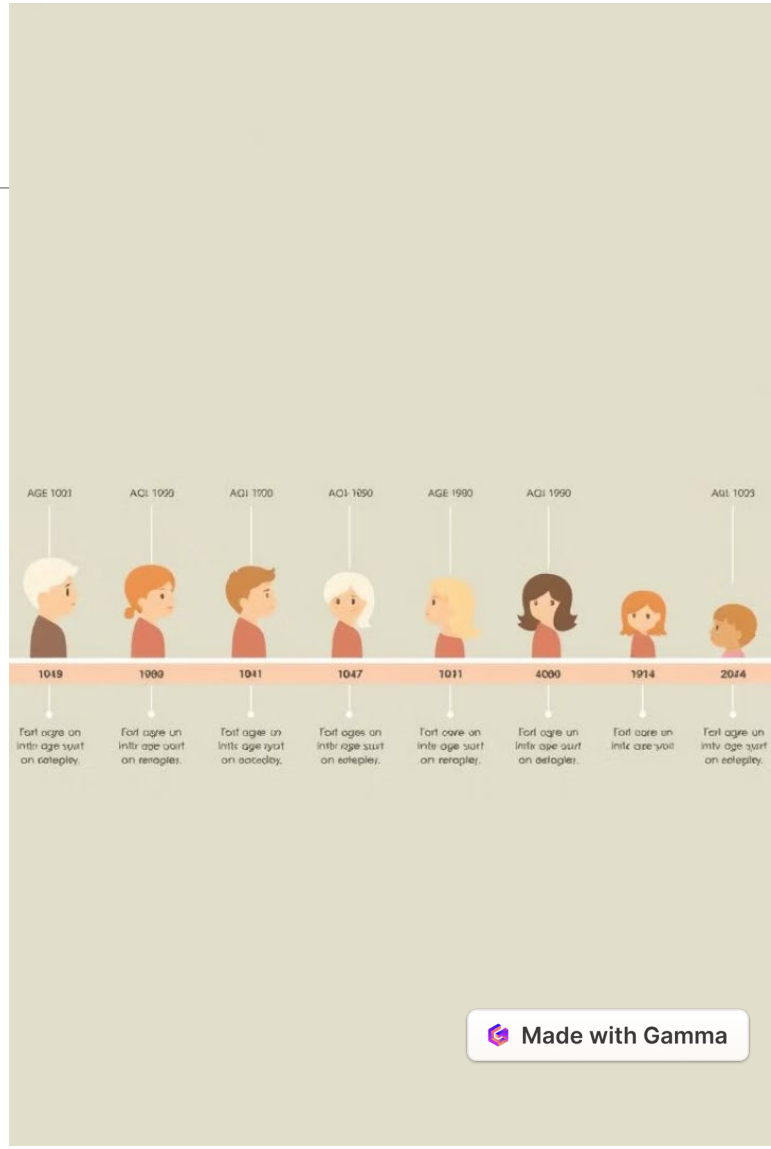
- This approach offers a superior method for studying the effects of aging compared to cross-sectional studies.
- However, they require a much greater time investment from both researchers and participants.

1. **Initial Assessment**
   Measure variables at start of study
2. **Repeated Measurements**
   Assess same variables over time
3. **Analyze Changes**
   Examine how variables change with age

Cross-Sequential Studies

Cross-sequential studies combine elements of both cross-sectional and longitudinal approaches. Researchers follow different age groups over a shorter period of time. For example, they might track changes over 10 years in groups starting at ages 20, 30, 40, 50, and 60. This design allows for immediate comparisons between age groups and helps distinguish between true age effects and cohort effects.

Age Group	Start	After 5 Years	After 10 Years
Group 1	20	25	30
Group 2	30	35	40
Group 3	40	45	50
Group 4	50	55	60
Group 5	60	65	70



Conclusion
Experimental vs Non-Experimental Research

Experimental Research

- Manipulates independent variable
- Randomly assigns participants
- Can establish cause-effect relationships
- High internal validity

Non-Experimental Research

- Measures variables as they occur naturally
- No manipulation of variables
- Cannot establish causation
- Lower internal validity

Practice: "Correlation vs. Causation"

For each of the following statements, determine if each statement represents correlation or causation and suggest possible third variables for correlational examples

1. **Statement:** "People who exercise regularly tend to have lower stress levels."
2. **Statement:** "Increasing study time directly improves test scores."
3. **Statement:** "Higher income is associated with longer life expectancy."
4. **Statement:** "Students who attend more classes get better grades."

Choosing the Right Research Approach

Experimental

Best for establishing causal relationships when manipulation is possible and ethical

Non-Experimental

Necessary for studying naturally occurring phenomena or when manipulation is not feasible

Mixed Methods

Combining approaches can provide comprehensive understanding of complex phenomena