**Topic:** Statistical Studies: Statistical Investigations

**Objective:** Students identify the components of the research cycle and determine whether statistical studies are observational or experimental and consider the strengths and weaknesses in the studies.

**Prerequisite Skills:**

- Applying prior vocabulary

**Resources and Materials:**

- Against All Odds Video
- Potato Chip Bags

**Printouts of the following:**


**Vocabulary**

- alternative hypothesis
- blind study
- control group
- data collection
- double-blind study
- experimental study
- experimental unit
- fact/opinion
- null hypothesis
- observational study
- participant
- placebo
- placebo effect
- population
- population mean
- population parameter
- psychological effect
- questionnaire/survey
- research question
- sample
- sample mean
- sample statistic
- statistical significance
- study limitation
- treatment

**Engage:** Student Activity Sheet 1: Overview of Purpose, Design, and Studies

- Old Ideas: Mean, using data to answer questions or make predictions
- New Ideas: Testing of hypotheses, research cycle, observational and experimental studies, treatments

**Explore:**

**III.A Student Activity Sheet 1: Overview of Purpose, Design, and Studies**

**Opening the Lesson**

Describe for students the following scenario:

- *Music is a large part of many people’s lives. Because of this, it is often the subject of study. For example, doctors want to know how much hearing damage results from loud music.*

Study the following graphic and discuss how it might apply to the above scenario.

**Framing Questions**

What questions would you ask of music enthusiasts? How does the age of the person that you ask matter? For the question(s) you identify, what type of data needs to be collected and analyzed?

**Questions 1 and 2:**

*Students discuss in pairs.*

1. Give students time to write down their thoughts about the Framing Questions. Allow a few minutes for students to share any other ideas they have.
2. Display the research graphic. Have students share a few of their responses.

**Questions 3-5:**

*Students work in pairs.*

1. Assign one person in each pair to read Example 1 *(observational study)* and the other to read Example 2 *(experimental study).* Each then explains the assigned passage to his or her partner. *Whole-class discussion.*
2. After this pairs discussion, conduct a whole-class discussion about the two examples and generally about the two types of studies. Room is available on the activity sheet for students to make additional notes about each of the studies.

**Question 6:**

*Students work in pairs.*

*Whole-class discussion.*

1. Ask students to discuss the graphic with their partner and describe what it represents. After a discussion in pairs, conduct a whole-class discussion about the graphic. Discuss the entire
cycle. Let students know they will focus on this research cycle throughout Unit III.

- Why is there an arrow after Report? (Research studies often lead to new or revised questions to be investigated.)

Reflection Question 7:
Students work independently.
1. Have students consider this question carefully because the ideas they have now will affect their work over the next few weeks. You can use students’ responses to form groups and/or make assignments for the research project that students will work on throughout the unit.

Questions 8 and 9:
Students discuss in pairs.
1. Ask students if they have ever gotten a bag of chips that was not very full. If possible, bring an example to class. Refine this informal question into a research question as illustrated on the activity sheet.
2. Students may be familiar with hypothesis writing from their science classes. They may have heard $H_0$ pronounced as “H-sub-O” or “H-naught” and $H_a$ as “H-sub-A.” Help students write their null hypothesis and then encourage them to write the alternative hypothesis. Ensure that students understand that these hypotheses refer to the population. When researchers select and weigh a sample, they know the sample mean, but they plan to generalize to the population mean. When a numerical representation of a population is computed, it is generally called a population parameter. When a numerical representation of a sample is computed, it is called a sample statistic.
3. Note: In the potato chip case, the null hypothesis states there is “no difference” between the true value and the claimed value. In the case of an experimental study with an applied treatment, the null hypothesis might state that there is “no change” caused by the application of the treatment. In other studies, the null hypothesis might refer to “no relationship,” such as “no relationship between gender and smoking.”
4. Ask the following:
   - What would you think if the potato chip sample showed a mean weight per bag of 26.7 grams? 28 grams? Would you still write a letter of complaint?
   The meat of much statistical analysis lies in determining whether a difference of some kind (for example, weight) is large enough to make it unlikely that the difference is the result of random chance. (Note: This course does not actually proceed to complete a hypothesis test, compute p-values, and so on.
Many college majors, however, require a statistics course that proceeds to that level.)
5. Tell students that they have begun the process of learning to design a study. They began with a question and are designing a plan. Their plan includes collecting and analyzing data and reporting results.
   - Is this an observational study or an experimental study? (It is observational—students will collect data without applying any sort of treatment.)
6. Caution students that this has been a broad overview. The next few weeks will be spent refining the techniques of designing studies, including careful sample selection, data collection and analysis, and reporting of conclusions.

Questions 10 and 11:
Students work in pairs.
1. Give students time in pairs to work on the pizza shop and houseplants examples. (Note: Because these two designs are very briefly described, you must decide how far to go with this discussion. For example, does James’ mother have several different kinds of plants, or just one kind? If she has only one kind, then the results may only lead to conclusions about the type of water best for that type of plant. If his mother has different kinds of plants, does she have two of each plant so that one of each can be given a different type of water? These types of
questions are explored further throughout this unit, but you may wish to foreshadow somewhat here.)

2. Debrief students on the two examples. Then stress the car example—not all research studies involve testing numerical hypotheses such as a population mean.
   • **What kind of data would Giancarlo collect?** (Categorical or qualitative data. The potato chip data are quantitative.)

**Reflection Question 12:**
1. Give students time in pairs to begin the design of the potato chip study.
   *Students work in pairs.*
2. Ask the following facilitation questions, as needed:
   • *Is one bag a sufficient sample?* (No) • *How many bags should you collect?* (Answers may vary.) • *How will you collect them?* (Answers may vary.) • *Then what will you do?* (Weigh the chips and compute average weight.) • *What will you do with this information?* (Report to company owner or the media.) • *What are some strategies for reporting?* (Letter with data, some type of graphical display, and so forth)

**Questions 13-16:**
*Students work in pairs.*
1. Give students time to work in pairs to answer the questions about the advantages and disadvantages of the teachers’ plans.
2. Prompt students to compare and contrast the plans.
3. Ensure that students understand that an observational study does not have to be one person observing others. It can be measuring heights, asking questions, or recording observed characteristics.
4. Ensure that students understand that a treatment is not limited to a medical procedure. A treatment can be any other variable that can be manipulated and its results measured, such as the different types of music in the mouse experiment.
5. Carefully guide students as a class through Questions 15 and 16, since they contain new vocabulary that must be defined. Provide students some examples, but then allow time for them to come up with their own examples to share with the class.
6. Also, when discussing Question 15, refer to Question 4 of this activity sheet where some of the mice in the study described were not exposed to any music. They were the **control group.** A control group may be given a generally accepted treatment, while the experimental group is given the new treatment that is being tested. For example, some Olympic-class swimmers may be randomly assigned to wear the standard swimsuit, while the others wear a suit made of a new synthetic material.

**Example:** Each swimmer is randomly assigned to wear one suit on Monday and the other suit on Tuesday. The two swim times are compared. The swim team is serving as its own control group.
7. With Question 16, discuss **blind** and **double-blind studies.** With a blind study, **participants** do not know whether they are receiving the treatment or the **placebo.** This is crucial for trying to control the **placebo effect.** Using a placebo is worthless if the participants know they are getting it.

There is often a concern that if researchers know who is getting the placebo, it may affect their ability to fairly assess a treatment. For example, researchers may subconsciously check for improvement more carefully. A physical therapist may push the patient who is receiving the treatment to work harder, while not encouraging the control group patient as much. In a double-blind study, only a third person not involved in the assessment knows the participants who are receiving the treatment and those who are in the control group. After all data have been collected, this person then identifies each patient file as **treatment or control.**

**Reflection Question 17:**
*Students work individually or in pairs.*
1. Have students respond to this question as a summary to the activities.

**Reflection Question 18:**
*Students work individually.*
1. Have students respond and solicit those responses as time allows. Feedback regarding the last situation with three or more treatments can provide a very interesting discussion for the class.

**Extension Question 19:**
*Students work in pairs or small groups.*
1. Have students consider one of the three studies and respond to each question. Allow students to self-select pertaining to their own interest or assign one study to each student or group of students.
2. Allow time for student presentations, if possible.

**Additional resources**
The articles “Real Knife, Fake Surgery” and “Are Women Really More Talkative Than Men?” provide interesting examples of observational and experimental studies for discussion:
You may wish to print enough copies of these articles (pages 1-10 for every student and pages 11-13 so that each pair/small group has one page). (These articles will take a significant amount of time to read thoroughly.) The group analyzes the article and then reports to the class. Ask students to consider the following:
• Is the study observational or experimental? How do you know? • Who are the participants? How were they selected? • What do you think of the study? Justify your response. • Is information included in the article about more than one study? Why do you think the author did this?