ACTIVITY 7

Improving Experimental Design

COMPUTER SIMULATION


Studying a sample of people is a practical way to learn about a larger population.

7: IMPROVING EXPERIMENTAL DESIGN

GUIDING QUESTION

How do changes in study design affect the results?

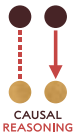
INTRODUCTION

In Activity 6, you learned how observational studies are designed and how they can reveal associations. Now, you'll explore how experimental studies are set up to test cause-and-effect relationships. In an experiment, researchers introduce a treatment—the procedure or situation that is changed only for the experimental group in a scientific study. The experimental group is the group in an experiment that receives the treatment and is compared to the control group. The control group is the group in an experiment that does not receive the treatment and is compared to the experimental group. Using these two groups allows scientists to compare the outcome of an experiment and determine its effects. However, simply having these two groups isn't enough; other parts of the experiment design matter as well. In this activity, you'll use a computer simulation to test different study designs and see how they affect experiment results.

FIGURE 7.1
Experimental vs. Control Groups

The experimental group receives the treatment and is compared to the control group. All other variables are kept the same in both groups.

CONCEPTUAL TOOLS



MATERIALS LIST

FOR EACH PAIR OF STUDENTS

- COMPUTER WITH INTERNET ACCESS

FOR EACH STUDENT

- STUDENT SHEET 7.1 "Comparison of Study Designs"

PROCEDURE

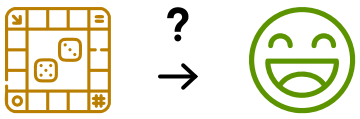
PART A: HOW SURE ARE YOU?

1 With your group, read the following fictional scenario about a new game that has become popular in the city of Salas where Salas High School is located.

RESEARCH QUESTION **Does playing Dapple increase well-being for kids in Salas?**

Some kids in Salas have invented a new game called Dapple, which is played in groups of 2–10 players. The game has become popular in Salas, with Dapple players claiming it makes them less stressed and happier.

Dr. Gilly is a local researcher. She decided to run a series of experiments to see if Dapple really does increase well-being and, if so, by how much. She randomly assigns kids to play Dapple or not to play Dapple.



2 You will use a computer simulation to identify whether playing Dapple affects well-being and, if so, in what direction (positive or negative) and by how much (effect size). Follow your teacher's instructions for accessing the simulation.

3 Begin the simulation by evaluating Part A: Trial 1. Discuss the results with your partner.

4 Explore the missing information in Trial 1 and run additional trials with the same sample size. Discuss with your partner how each new piece of information affects your confidence in the cause-and-effect claim. Each time you run a new trial, new participants are randomly sampled from the population.

5 When you've run at least 8 trials in Part A, look at how much the results vary from trial to trial. Discuss possible explanations for this with your partner. Record your ideas in your science notebook and be ready to discuss them with the class.

PART B: GETTING CONSISTENT RESULTS

6 In Part B, explore how sample size affects the results by running trials with sample sizes from 6 to 120. On the Effect Sizes for Different Sample Sizes graph, each set of 4 arrows represents Trials 1–4 at a different sample size. Compare the lengths (effect sizes) and colors (effect directions) of the 4 arrows at each sample size to see how consistent the results are. You may want to repeat trials to check the reliability of the results. Completing trials for all sample sizes (6–120) is required to move on.

7 After completing the graph up to a sample size of 120, select the Next button to clear the graph. Select the Run 25 Trials At A Time button to generate a new graph showing 25 trials at each sample size instead of just 4. Displaying more trials per sample size will give you a better sense of how consistent the results are at different sample sizes. With a partner, review the graph and identify your best estimate for:

- the smallest sample size where the results become consistent (the arrows are similar enough), and
- the true effect size of playing Dapple. (The true effect size is the actual strength of a relationship or difference in a population, not just what a small number of trials finds.)

Be ready to share your ideas with the class.

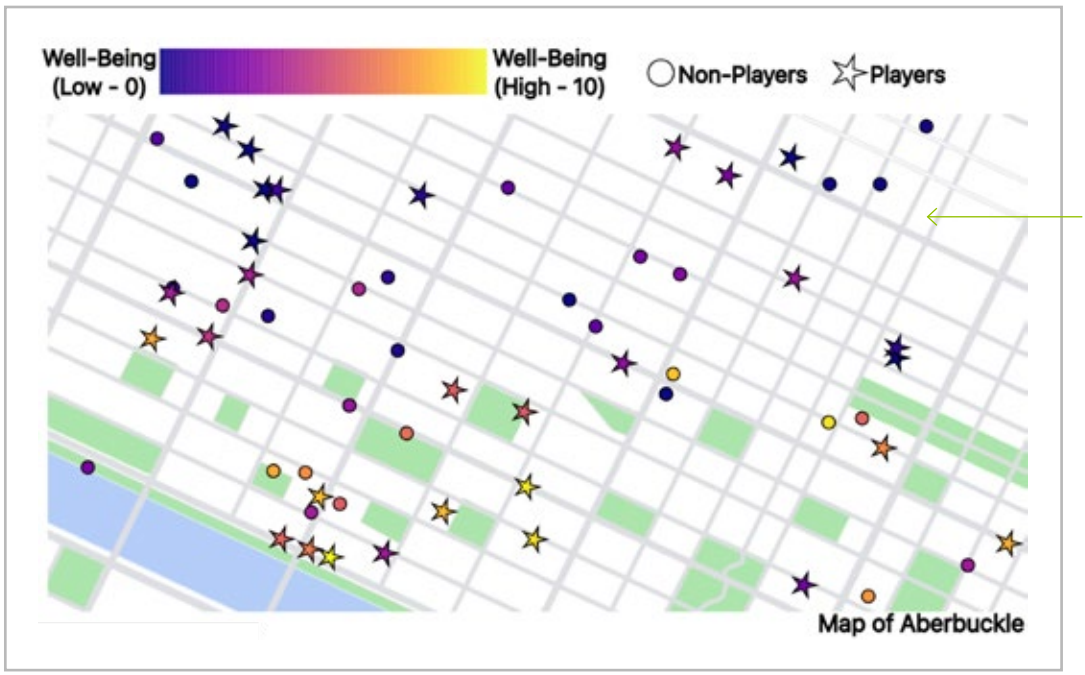
PART C: COMPARING STUDY DESIGNS

8 Your goal is to determine the best experimental design to find out if playing Dapple improves well-being. Besides sample size and effect size, you will want to consider other aspects of studies, such as confounds, that could affect the results. Review Part C in the simulation and look through your options for experimental design.

9 To set up your first study, select the following study design elements:

- an appropriate sample size (6–120) based on your findings in Parts A and B of the simulation.
- a treatment for the experimental group (plays the game once or plays the game once a day for a week).
- a no-treatment condition for the control group (gathering in groups somewhere else or watching from the sidelines).
- a method of assigning participants to the groups (by neighborhood, coin flip, or grade: middle school vs. high school).

FIGURE 7.2
Map Used in Part C of the Simulation



In the simulation, study participants are shown on the Aberbuckle town map as circles or stars.

10 Select the View Assignments button to see which participants were assigned to which group on the simulation map (stars indicate the experimental group, circles indicate the control group). Then, select the Perform the Experiment button to see each participant's rating after receiving the treatment or control.

11 Select the Analyze Results button to see an average for both groups—the players and non-players. On Student Sheet 7.1, "Comparison of Study Designs," record your study design elements from Step 9 in the "Study Design #1" row. Draw a bar graph of the results (from the simulation) and circle whether the experimental group had a lower, equal, or higher value than the control group.

12 Explore additional study designs and record each in a different row of the table on the student sheet. As you experiment, find and record information for at least one study in which:

- **players have higher well-being than the non-players.**
- **results show very little or zero difference between groups**.
- **non-players have higher well-being than the players.**
- **results show the biggest effect you found.**
  Draw a circle around the study design number that has the biggest difference between the players and non-players. If there could be an alternative explanation for this result, record it in your science notebook.

- **there is at least one confound.**
  In the "Control" column and/or the "Assignment to Group By" column, write "confound" and draw an arrow pointing to the confound. If the study you pick has more than one confound, draw an arrow pointing to each confound. Repeat this for at least one other study that has a confound.

13 Use your ideas from Procedure Step 12 to identify which of the studies you investigated has the best experimental design. (Refer to the study design elements in Step 9.) Draw a star next to that study design number on the student sheet. Explain why that study design is the strongest and record your ideas in your science notebook.

14 Share your strongest study design with the class. Compare the strengths and weaknesses of the studies. Discuss which study design helps you feel most confident in answering the research question: *Does playing Dapple increase well-being for kids in Salas?*

BUILD UNDERSTANDING

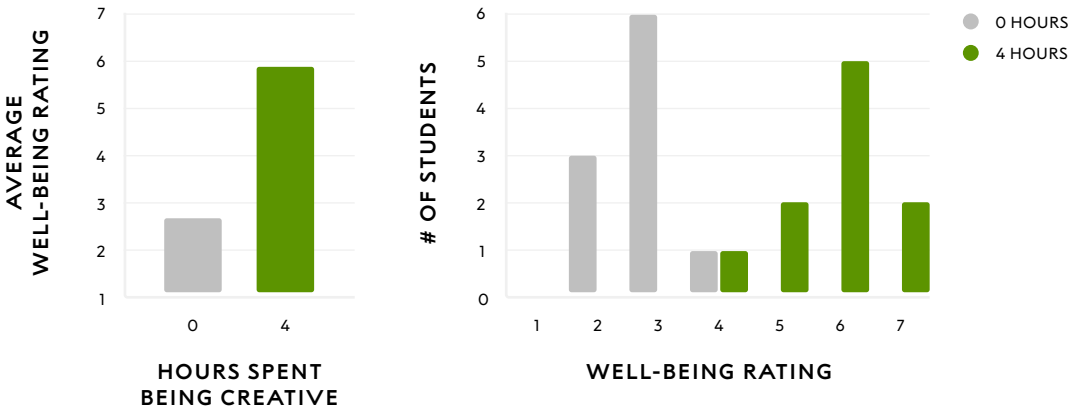
1. Think of a study in which you would want a really large sample size, such as studying a new medicine for asthma.
   - **a** How would a bigger sample size affect your confidence in the results? Explain your answer.
   - **b** Does having a really big sample size guarantee that your results will be accurate? Why or why not?

2. Why do confounding variables make it harder to interpret the results of a study? Use the example of green spaces from the simulation to illustrate your answer.

   HINT: Consider the results in Part C of the simulation when assigning participants by neighborhood.

3. Ms. Lee's class decided to conduct an experiment to test the effect of time spent being creative on a person's well-being. They had 20 students from the class choose to do something creative for 4 hours that week or do nothing creative that week, even if they normally would. Then they asked the participants to rate their well-being. Their results are shown in Figure 7.3.

FIGURE 7.3
Ms. Lee's Class Results Testing Creativity and Well-Being



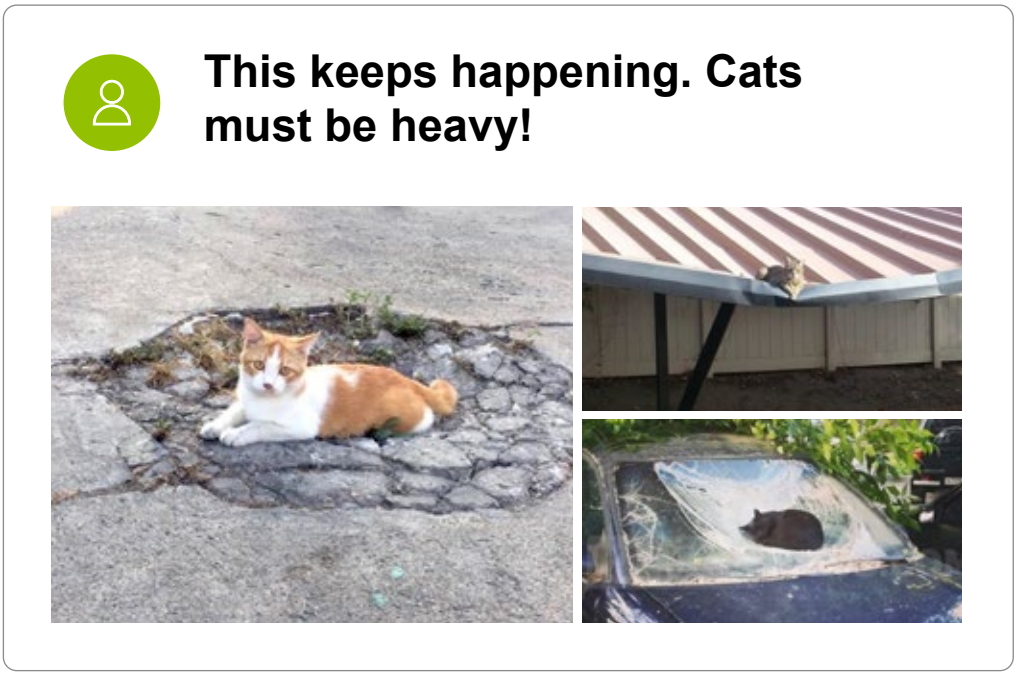
a Does the data support the class's idea that creativity improves well-being? Why or why not?

b What elements of the study design could be improved? Explain how changing these elements would improve your confidence in the study results.

c If you were going to run this experiment in your class, would you change the study design? If yes, how would you change it? If no, why not?

CONNECTIONS TO EVERYDAY LIFE

④ A friend claims, "Those cats are crushing things!" and sends you the following social media post:



Explain why this post does not demonstrate causation. In your response, include sample size and at least two of the four key questions about causation.

5. Why is it sometimes difficult to get a really large sample size for an experiment with people as participants? Provide a few examples.

KEY SCIENTIFIC TERMS

control group
experimental group
treatment