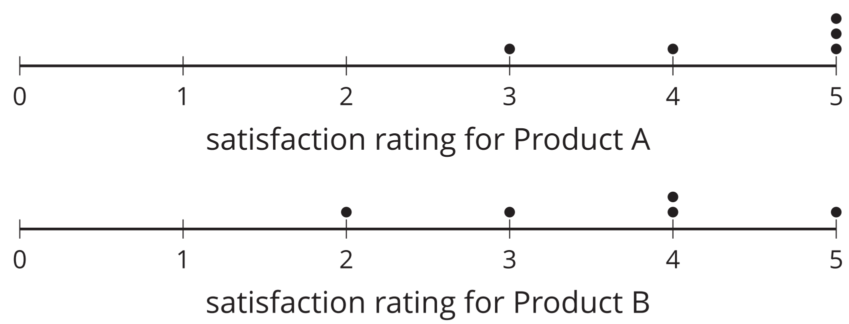
Experimenting

Let’s do an experiment.

12.1 Satisfaction Test

Ten people are selected at random to be given either Product A or Product B to test. After using the product, they rate the product on a scale from 1 to 5, with 1 being the worst and 5 the best.

The dot plots represent their ratings.



1. Which product has a higher overall satisfaction rating? Explain your reasoning.

2. Do you think that 2 different random samples of 5 people would lead you to the same conclusion?

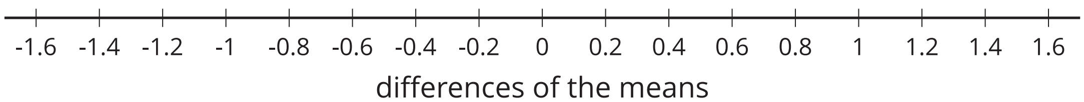
12.2 Randomizing Satisfaction

Your teacher will select 10 of your classmates to create a **randomization distribution**.

1. Complete the table using the data from the activity.

trial	group 1's mean	group 2's mean	(group 1's mean) minus (group 2's mean)
actual	4.4	3.6	0.8
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

2. Complete the dot plot to display the distribution of the differences of the means from the last column of the table.



3. What information is represented in the dot plot?

4. The actual data had a difference in means of 0.8. What percentage of the trials have a difference in means either greater than or equal to 0.8 or less than or equal to -0.8?

Are you ready for more?

Here are 2 lists of 5 students' scores on a memory test. List A contains the scores of the 5 students from taking the test after listening to pop music. List B contains the scores of the same 5 students (in the same order) from taking the test after listening to classical music.

- List A: 59, 28, 73, 58, 44
- List B: 75, 93, 13, 21, 70

1. Find the mean of List A, the mean of List B, and the difference: mean of List A minus mean of List B.
2. What does this difference of means represent in our context?
3. Create a third list, List C, that has 5 numbers, each of which is the difference of a number in List A and its corresponding number in List B. So, for example, the first element of List C is -16 because $-16 = 59 - 75$. Find the mean of List C.
4. What does the mean of differences represent in this situation?
5. What is the connection between the difference of means and the mean of differences? Explain why this is true.

12.3 Get Ready to Experiment

Does counting while moving affect your heart rate? Let’s think about how to design an experiment to find out.

1. In another lesson, the class will be divided into 2 groups. One group will move around silently. The other group will count out loud while they move. Which of these methods would be good for dividing the class so the results are based only on the counting and heart rate rather than on other factors? Explain your reasoning for each method suggested.
   a. The athletes in the class are assigned to the counting group, and the non-athletes are assigned to the silent group.
   b. The teacher puts everyone’s name in a bag and draws half of the names. The names that are drawn are in the group that counts, and the others remain silent for the movement.
   c. The tallest half of the students are put in the counting group, and the shortest half of the students are assigned to the silent group.
2. Do you think counting out loud will have an effect on heart rate? Explain your reasoning.
3. A **treatment** is the value of the variable that is changed between the two groups in an experiment. What is the treatment in this experiment?
4. How would you design an experiment to answer the question, “Does counting while exercising affect your heart rate?”

Lesson 12 Summary

Experiments provide a way to test how a variable affects a situation. It is important to design the experiment carefully so that other variables that might have an effect on the response are accounted for.

One important aspect in experimental design is the use of randomness to assign groups for the experiment. Random assignments are used so that there is less of a chance that other variables will affect the data.

For example, a researcher wants to study the question, “Does the size of the aquarium in which frogs are kept affect the sizes of the frogs?”

The researcher selects 20 young frogs to be used in the experiment. The frogs are then numbered, and a random number generator is used to separate the frogs into two groups of 10. One group will be put in a 10-gallon aquarium to grow, while the other group is placed in a 100-gallon aquarium to grow. The researcher will measure the sizes of the frogs, using their weight, at the end of a year.

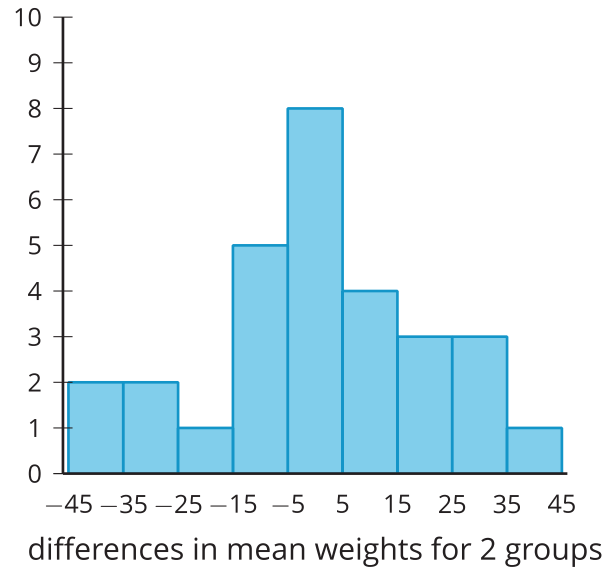
The size of the aquarium is one of the variables, and a **treatment** is the value of the variable that is changed between the two groups in an experiment. In this experiment, there are two treatments—a smaller aquarium and a larger aquarium.

The researcher finds that the frogs in the smaller aquarium have a mean weight of 111.2 grams and the frogs in the larger aquarium have a mean weight of 169.3 grams. The difference of 58.1 grams seems large, but is it enough to say the aquarium size is the cause of the difference? Even if all the frogs were in the same aquarium, we expect there to be some variability in the weight of the frogs. If some of the frogs were switched at the beginning of the experiment, would there still be a large difference? A simulation can be used to see if differences we see in our groupings are also consistent with groupings that did not depend on our treatment.

In this kind of simulation, all the data is grouped together, then data is randomly redistributed among two groups, and the difference between the means of these new groups is computed. This process is repeated several times to create a **randomization distribution**: a distribution of the differences between the means for the treatment groups containing randomly redistributed data. The mean difference from the experiment is then compared to this distribution to determine whether such differences are also consistent with groupings that did not depend on the treatment. To investigate whether the aquarium size is the important factor in the difference or whether the difference could be due to the chance ways the frogs were separated into treatment groups, we can use a simulation to examine what results we might expect from chance. For the moment, we assume the aquarium does not play a part in the size of the frogs, and we put all 20 frog weights into one group. We can separate the weights into two groups in a random way and determine the difference in mean weights between the groups.

Doing this many times will produce a distribution of weight differences that could be the result of how the frogs happened to be divided into groups. We can then compare the actual difference in mean weights from the treatment groups to the randomization distribution to determine if the 58.1-gram difference is unusual (which would suggest the aquarium size played an important role) or whether this difference is also typical of what we might see from random assignment to groups.

Randomly breaking the data into two groups 30 times produces the histogram here.



Notice that, based on this distribution, a difference of either 58.1 grams or greater or -58.1 or less is unusual. This suggests that the original difference of 58.1 grams is highly unlikely to occur if the aquarium size played no role. The researcher has evidence to support the hypothesis that aquarium size has an impact on the weight of frogs growing in it.

If the original difference had been about 15 grams, there would have been reason to believe that the weight difference observed might be due to random chance because 11 out of the 30 differences in the randomization distribution are at least 15 grams away from 0.