OVERVIEW

In this activity, students play the role of a fish farmer trying to determine whether the genetically engineered fish from a new supplier grow to be longer than the fish he usually farms. They begin with a sample of 130 fish, making observations about the differences between the two groups of fish. Then they take more samples of varying sizes to explore variability between samples. They then determine whether their results are valid or just occurred by chance, eventually comparing the conclusions they drew from the sample data with measures from the entire group of fish. This activity could be done as a whole-class demonstration.

If students don't already know how to build a single-variable plot by dragging apart data points and stacking, you'll need to show them that skill for Step 2. (See the movie "TinkerPlots Basics.") They'll also probably need to add a categorical attribute to the vertical axis and drag data points apart to separate them into two plots. Students are asked to find means or medians in Steps 9, 10, and 14. If they haven't done this before, you should show them how. The **Ruler** tool is also useful for measuring the distance between averages. (See the movie "Simulating Group Differences.")

Activity Time: One class period

Objectives

- Use a plot to compare an attribute of two groups in a sample.
- Make inferences based on samples.
- Understand how sample size affects the accuracy of an inference.

Common Core Standards Addressed

Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number.

Grade 6, Statistics and Probability Standard 3

Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.

Grade 7, Statistics and Probability Standard 2

Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations.

Grade 7, Statistics and Probability Standard 3

Prerequisites

- Understanding of the shapes of different kinds of distributions (could be learned by doing the activity "Sketching Distributions")
- Ability to make plots in TinkerPlots and use them to compare two numeric distributions

- Understanding of how to use means and medians to summarize and compare two distributions

Materials

- Fish-Length Distributions worksheet (one copy per student)
- **Fish.tp**
- **Fish Population.tp**

LESSON PLAN

Introduction (10 minutes)

During this activity, students will use **Fish.tp** and **Fish Population.tp** on individual computers. Alternatively, this can be done as a whole-class demonstration.

Introduce students to their task. A fish farmer has stocked a pond with a new type of genetically engineered fish. The company that supplied them claims that these fish will grow to be longer than the fish the farmer has been using. The farmer decided to test this claim by stocking the pond with 625 fish, some normal and some genetically engineered. After they were fully grown, the farmer caught fish from the pond and measured them. Your job is to determine whether the genetically engineered fish are longer than the normal fish.

Ask students what they expect to happen. Will the genetically engineered fish be longer?

Student Work at Computers (10 minutes)

Hand out the Fish-Length Distributions worksheet. Have students compete Steps 1–9. As students work, walk around the room and observe the plots they create; some students will not fully separate the *Length* attribute, which will make comparing centers more difficult. Encourage them to fully separate the values so the shape and center of the distribution are more apparent.

Some students may try to answer the questions by comparing individual fish. Be sure they understand what is meant by the question, "How much longer do the genetically engineered fish tend to be, as a group, than the normal fish, as a group?" By "tend" we do not mean that every genetic fish will be longer than every normal fish. Rather, we mean that as a group, the genetic fish will be longer than the group of normal fish.

Discussion (5 minutes)

Before proceeding to "Looking at the Population," bring students back together to discuss the data as a class. You may also wish to ask them what characteristics of the distribution are important when they answer a question about two groups. As students return to working at their computers, remind them to think about what tools they could use to compare the centers of the two groups of fish.

If students are not familiar with variability of data, you'll need to discuss this in relation to Step 9.

Student Work at Computers (15 minutes)

Explain the task to students, as described in the Fish-Length Distributions worksheet. Then send them back to computers to work in pairs.

Alternatively, you might want to do this part as a whole class discussion, which may be more effective, as some students lose track of what they are exploring. Some students will not understand why they're drawing so many samples.

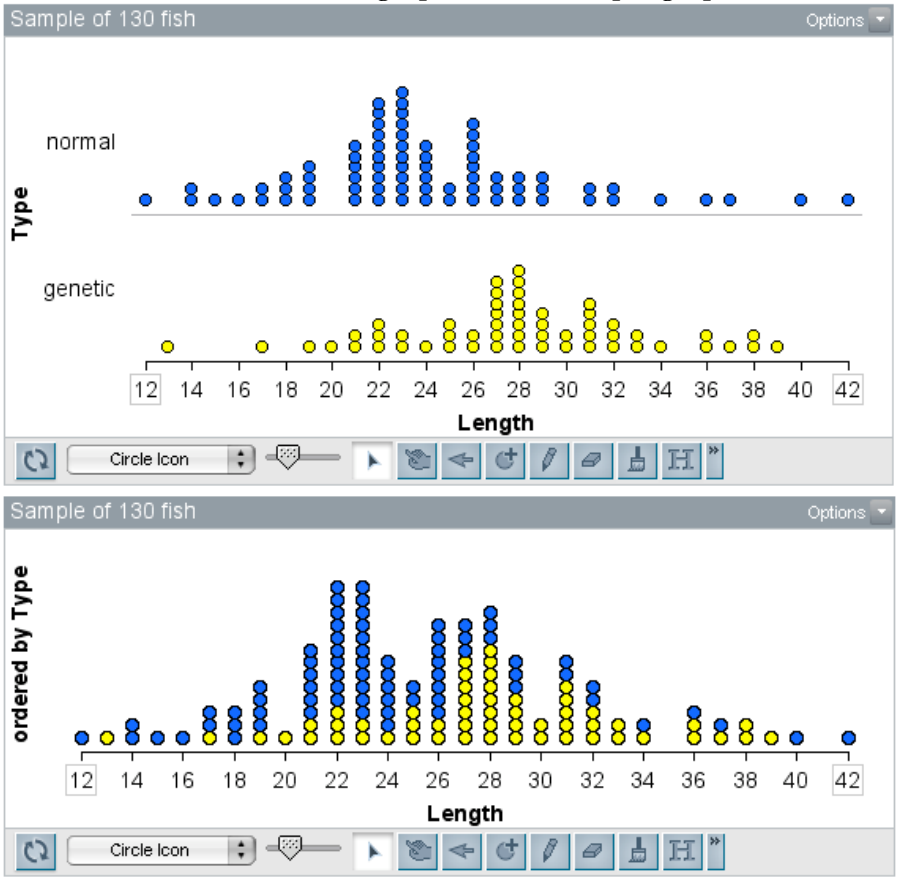
The point of this exploration is to explore how variable the results are from sample to sample, so that students know how much confidence to put in a random sample when they only draw one. Students should recognize that if, for every sample of 130 fish, the group of genetic fish is about the same amount longer than the group of normal fish, then 130 fish is a large enough sample size to make this inference. When looking at samples of 15 fish, students should recognize that the results are much more variable from sample to sample, and thus the sample is not large enough to make an inference.

Wrap-Up (15 minutes)

When students have finished the worksheet, have some of the groups share their findings with the class, demonstrating which tools they used to reach their conclusions. You may wish to ask whether anyone else used different tools to compare the two groups.

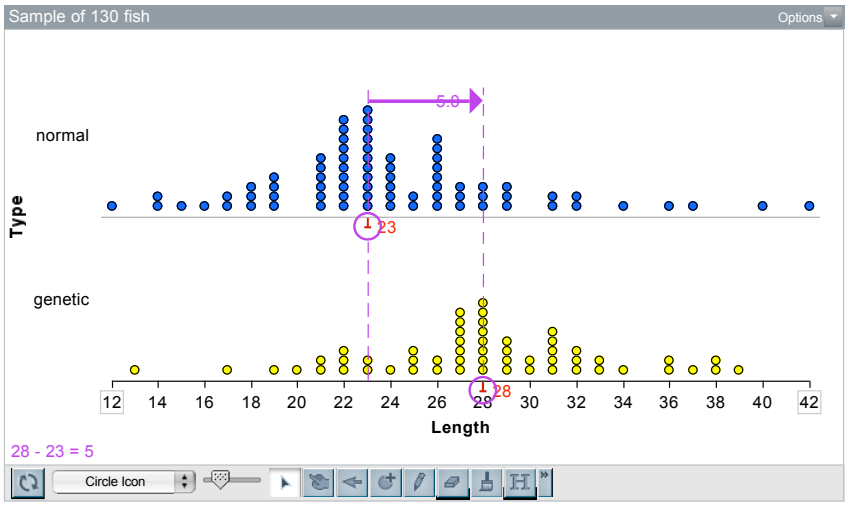
Answers

3. Students will make different graphs. Some sample graphs include:



4. Yes. The center clump of the genetically engineered fish is farther to the right than the center clump of the normal fish, indicating that the genetically engineered fish grew to be longer than the normal fish. Students might also compare the medians or means to answer this question.

5. When you compare the medians and the means of the two groups, the genetically engineered fish appear to grow between 4 and 5 inches longer than normal fish. Here, the **Ruler** tool is used to compute the difference between two medians.



6. By looking at the distributions, you can see that the ranges of the two groups are similar. Students can also use percentile hat plots to see that the widths of the crowns (center sections) are not very different. Because the width is a little wider for the group of genetic fish than the group of normal fish (6 compared to 5), some students may argue that the genetic fish are a little more variable in length than the normal fish. Other students may argue that the normal fish are more variable because they have a wider range. Depending on how much prior experience students have had with measures of variability, you may want to discuss whether any of these measures are better than others, and why that is the case. In this discussion, some students may question whether you can compare two groups of different sizes.

9. The difference between the medians will vary from sample to sample. Most of the differences will be between 4 and 6 (the actual difference is 5), leading to the same basic conclusion as students' initial samples. The difference in the means will likely vary between 3.6 and 5.3. (The actual difference is 4.7.)

10. Answers will vary. See above.

11. There will be considerably more variation in the averages and their differences from sample to sample. Clicking the **RUN** button repeatedly to sample 15 fish will often result in a sample where the genetic fish are longer than the normal fish, but it won't be too many samples before you get a sample where the normal fish are longer. If you have time, you might want to do this as a class to verify that, with this small a sample, it isn't too difficult to get a sample that would seem to support the opposite conclusion.

12. Most of the time, even samples of 15 fish show the difference between the two groups. However, those differences are much more variable from sample to sample, so 15 fish is probably too small a sample from which to draw inferences about the differences in length.

14. The mean length of the normal fish is about 23.4 inches, and the mean length of the genetically modified fish is about 28 inches;--a difference of 4.7 inches. With a sample size of 130 fish, the results were not too far from that. With samples of 15 fish, our differences were much more variable and had differences close to 0 and as high as 10.