OVERVIEW

In this activity, students take on the roles of quality-control officers in a candy factory. They model the candy factory, using TinkerPlots, to investigate how likely it is that a bag of candy the company president received occurred by chance. The other possibility is that the company's equipment is faulty. By taking additional samples and analyzing the results, students are able to observe that actual results often deviate from their expectations. They also deepen their understanding of how probability is measured.

Activity Time: One class period

Objectives

- Model a simple probability experiment.

- Collect data over multiple samples and analyze the distribution.

- Develop the understanding that probability can be estimated by looking at the results of a large number of samples.

Common Core Standards Addressed

Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of discrepancy.

Grade 7, Statistics and Probability Standard 7

Develop a probability model (which may not be uniform) by observing frequencies in data generated from a chance process.

Grade 7, Statistics and Probability Standard 7b

Prerequisites

None

Materials

- Modeling a Candy Factory worksheet (one copy per student)

- **Candy Factory.tp**

- Transparency of "1000 Bags of TEN Candy" (blackline master at the end of these Notes)

- Letter from the Company President (blackline master at the end of these Notes)

LESSON PLAN

Introduction (10 minutes)

Introduce students to their new positions in the quality-control department at the TEN Candy Company, and describe how the company produces its candy.

The company makes candy called TEN that comes in a bag with exactly ten candies in it. It fills the bags from a huge container that is stocked in only two colors that are mixed together: red and green.

Of the candies in the container, 70% are red and 30% are green. Ten candies are dropped into a small container, which is emptied into a bag. Ask students how many candies of each color they might expect to find in each bag. Once they understand how the factory works, introduce them to their next task.

Read or display the letter from the company president. A blackline master is available at the end of this document. Be sure students understand the difference between what he expected and what he got.

Hand out the Modeling a Candy Factory worksheet, and have students answer Step 1. You may wish to save the page asking them to write a letter to the president (Step 9) until later.

Modeling (10 minutes)

To answer the president, students will study what happens when many bags of candy are filled randomly with ten candies. They'll then write a short letter back to the company president.

Display **Candy Factory.tp**, which shows a model partially built. The spinner shows red and green with equal probability, and Repeat set at 5 rather than 10.

Explain to students that they will use this sampler to investigate what happens when the bags are randomly filled from the candy container. Have students help you finish setting up the sampler to accurately model the factory. Students should suggest that the green portion be 30% and the red portion be 70%. Consider having them estimate, as a group, where the spinner divider should be set to be 30%, and then check how accurate their estimate is. (You can check by clicking the arrow in the bottom left corner of the device and selecting **Show Percent.**)

If no one suggests changing Repeat to 10, run the sampler and ask students if this correctly models the factory. After seeing only five candies, a student will likely suggest changing Repeat to 10. (You could also model this by setting Draw to 10. Then each case would be a bag of ten candies. But setting Repeat to 10 often allows students to better understand the final distribution.)

After the model is set up and you have run the sampler a couple of times at slow or medium speed, ask students to answer this question:

If we draw ten candies from this spinner, could we ever get a bag of ten that had four red candies? Why?

Run the sampler a few more times as a class, saying out loud the number of red candies in each bag.

Show students how to drag a plot from the object shelf into a document and make a plot of the data (by fully separating the data and stacking; see the movie "TinkerPlots Basics"). Click the **Case Count (N)** button to see the number of red candies. Run the sampler to make a few more bags of candy, and record the number of red candies in each bag by entering the count in the Bag Results table.

Student Work at Computers (15 minutes)

Have students open the document **Candy Factory.tp** and work in pairs to set up the factory like the one that was worked on in class. Hand out the student worksheet and have them complete Steps 2–8.

Discussion (10 minutes)

Have each group share their results with the class. Record on the board or using TinkerPlots the number of times each group got four, three, two, and one red candies. Ask students how likely they are to get four or fewer red candies in a bag by chance.

Explain that to answer this question, you need to look at a lot of data. Displaying your screen for the class, show students how to use TinkerPlots to automatically keep track of the number of red candies. Click the **RUN** button to collect another sample. If you haven't already done so, separate the red and green candies in the Results of Filling One Bag plot and, with this plot selected, turn on the count by clicking the **Count** (**N**) button in the upper plot toolbar. Click the **History** button in the plot window's tool shelf, pointing out the grey boxes that appear around the number of red candies and the number of green candies. Click on the count of red candies. A history results table will appear, automatically recording the number of red candies.
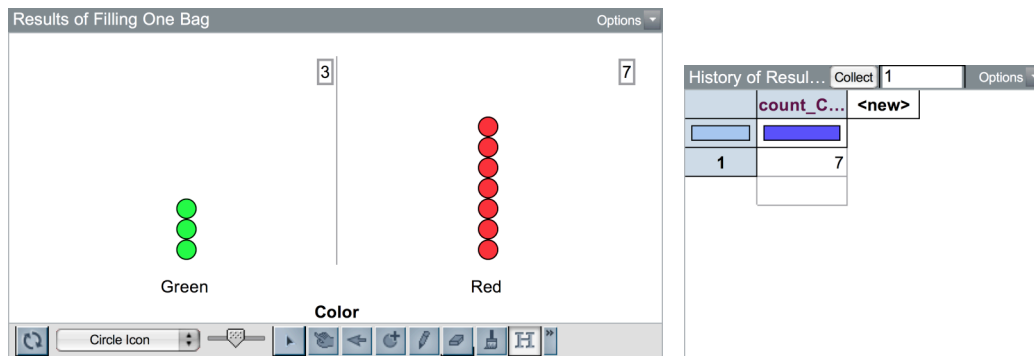
Click the **RUN** button again, showing students that each time you collect another sample, the number of red candies is automatically recorded in the history results table. Click the **RUN** button about three more times. Then drag a plot from the object shelf into your document and plot *count_Color_Red* on the horizontal axis, fully separating and stacking the values.

Run the sampler three more times to show students how the points are added to the plot of the *count_Color_Red* (as shown below). Changing the **Icon Type** to **Square Icon** will help students remember that each case in this plot represents a bag of candy, not a single candy.
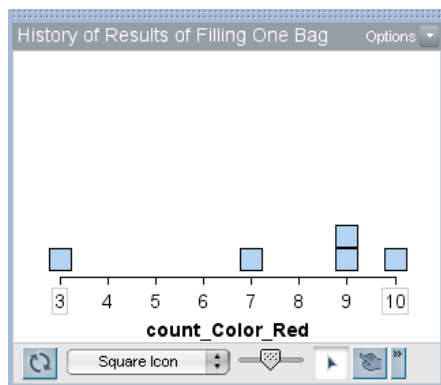
Collect 40 more cases and plot the results—the quickest way to do this is to enter "40" in the top bar of the History of Results of Filling One Bag results table, and click the **Collect** button to the left. Watch the plot as data are added.

Be sure to check students' understanding of each square in the plot. For example, point to a square over six and ask, "What does this square represent?" (A bag of candy with six reds.)

Then collect another 60 cases, instructing students to focus on the plot as data are being added.
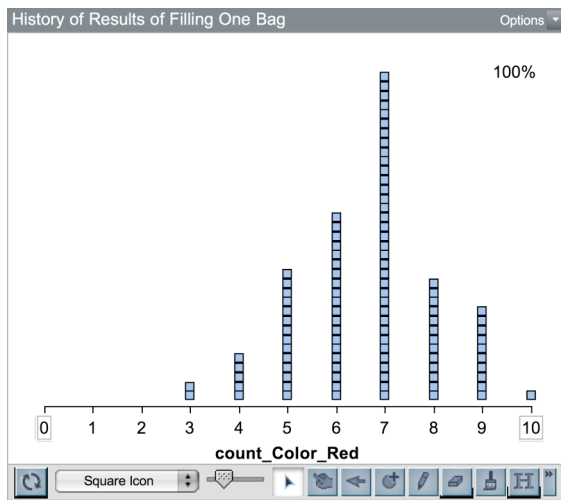
Ask these questions to help the class summarize their findings:

How many reds candies do the majority of the bags contain? (Use dividers to show their suggestions.)
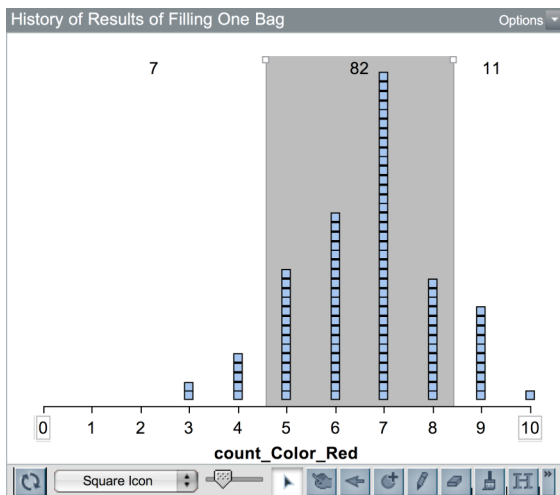
About how often can you expect to get four or fewer red candies in a bag? (After students give their responses, use dividers and click the **Percents** button to calculate this for your sample of 100 bags.)
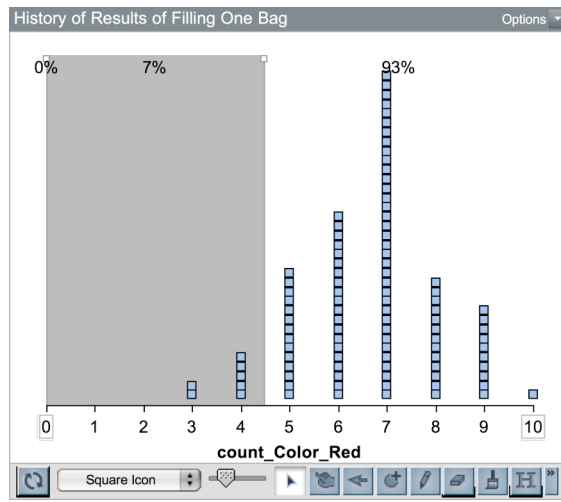
How do you explain why this sometimes happens? (This will happen about 5% of the time if there is nothing wrong with the equipment.)

You may also wish to display a plot of the results of 1000 bags of candy (included as a blackline master at the end of this document) and compare this to the results the class got. Students may want to reference this in their letters to the president.

Wrap-Up (10 minutes)

If you haven't already done so, hand out the page of the worksheet containing Step 9, asking students to write a letter to the company president. Allow about 10 minutes for students to write.

ANSWERS

1. Many students will agree with the company president. There should be seven red candies and three green candies, so the results in the president's bag seems nearly impossible. Students often think this must mean something is wrong with the machinery at the factory. If some students argue that this could happen by chance, ask them, "In a sample of 100 bags of candy, about how many of them would you expect to have four or fewer red candies?"

5. About half of the groups likely got one or more bags of candy with four or fewer red candies. If students had a large number of bags of candy with four or fewer red candies, suggest they check their spinner. They may have forgotten to change to probabilities to 70% for red and 30% for green.

7. Students should recognize that the president's bag could have occurred by chance, and that it doesn't necessarily mean there is something wrong with the factory.

9. Student letters should note that the factory is likely working properly, and that when they used the computer, which they know works properly, to model the factory, they got bags with four or fewer red candies about 5% of the time.

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TEN Candy Company

December 3, 2011

Ivan Halman
TEN Candy Company, President
1000 Pretzel Lane
Hull, IA   20202

Quality Control:

Yesterday I bought a bag of our holiday candies. As you know, we say on each bag that it contains exactly ten candies, and that about seven of them are red and about three of them are green. Imagine my surprise when I opened my bag and found that it contained four red candies and six green candies!

Our loyal customers expect the truth from us, and they expect quality. Thank goodness I was the one who bought this bag. Please explain how I got a bag with four red candies instead of seven. Is our equipment working properly? Did someone fill the candy container with fewer than 70% red candies?

This is a matter of great importance. I expect an answer by the end of the week.

Ivan Halman
TEN Candy Company, President

1000 Bags of TEN Candy