Fruit Stick (Rollup) Production

Helen Tyson Middle School Teachers, adapted from Konold & Harradine

Overview

Each student team makes 5 hand-made "fruit sticks" or "fruit rollups." Each stick is 5 cm long and 1.3 cm in diameter. Students weigh each stick with a letter scale, recording their results on a data sheet or whiteboard and eventually merging their collective results into a single TinkerPlots file. Once they have all the class's data, they work individually analyzing the data to answer: "Which team made the most consistent fruit sticks?" and "Which value of mass (weight) should each package be labeled with?" The first question is addressed with statistics of variability and the second with statistics of center. Student teams repeat the process with a play-doh expresser set for a diameter of 1.3 cm. Students propose explanations for the variability observed in the production process.

Materials

- Production kit for each pair of students:
  - two tubs of Play-Doh
  - one letter scale (American Weigh Scale AMWHAND-BLK with 100g capacity, $2.92/scale from Amazon.com)
  - two knives
  - two rulers
  - one data collection sheet
  - Play-Doh Fun Factory (Amazon.com, $8.50/factory, comes with Play-Doh tubs)
- TinkerPlots file for entering data
- TinkerPlots file of previously collected data
- Student Worksheet or Whiteboard to structure the data
- Cardboard trays for transporting/storing product
- Plastic wrap (to prevent Doh from drying out).
- Packages of candy for introduction
- Index Cards
- Timer

Hand Crafted Fruit Stick Production

Introduction: Launching the Activity (15 minutes)

Show (or hand out) packets of some well-known snack, such as M&Ms or nuts. Ask students how much they think a package weighs. After they make predictions, weigh each package and display the weights on the board. It may surprise some students to find that the package weights vary. Ask:

Did you know that all food products like this do not weigh what they say on the label? Why do you think this is?

It's impossible to make something exactly the same every time, even for machines. And it's expensive to get them to be really close.

But by law, manufactures have to put the weight of the product on the package, and there are laws about how far they can be off. For example, here's the law in South Australia:

> It is an offense to pack and sell products where:
>
> - The overall average measure of the sample of goods checked is less than the stated quantity.
> - A single package is more than 5% deficient."

Ask: "What would 5% deficiency look like with the candy? Is it referring to taste, number of candies, or weight?"

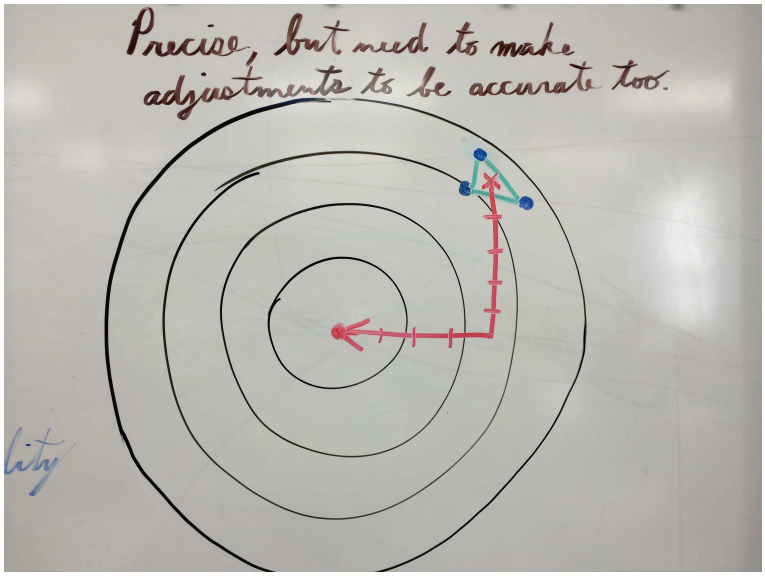
Say: "When they are figuring out how to manufacture a product, companies develop ways of making things that reduce the variability in the taste, weight and size of the product. This is because consumers like things to be the same. If you go somewhere and order pasta and like it, when you order it again you want it to be just like last time. In other words, the products should be consistent."

Say: We're going to be making a new product called a fruit stick. The fruit stick should be 5 cm long and 1.3 cm in diameter. *(Have a drawing on the board that shows a fruit stick along with these dimensions.)* We're going to make them out of Play-Doh. So here's what one of them should look like. *(Some classes may even need to watch a demonstration on rolling out the Play-Doh or samples of cylinders from around the room.)* Because they are handcrafted, we going to charge more for them.

Say: "After we've made them, we're going to weigh them." Demonstrate how to weigh, and discuss the unit of weight, "grams." (There are about 28 g in every ounce.) The letter scale may require the use of a basket (index card) to hold the fruit stick. At this point, discuss calibrating the scale to compensate for the weight of the index card.

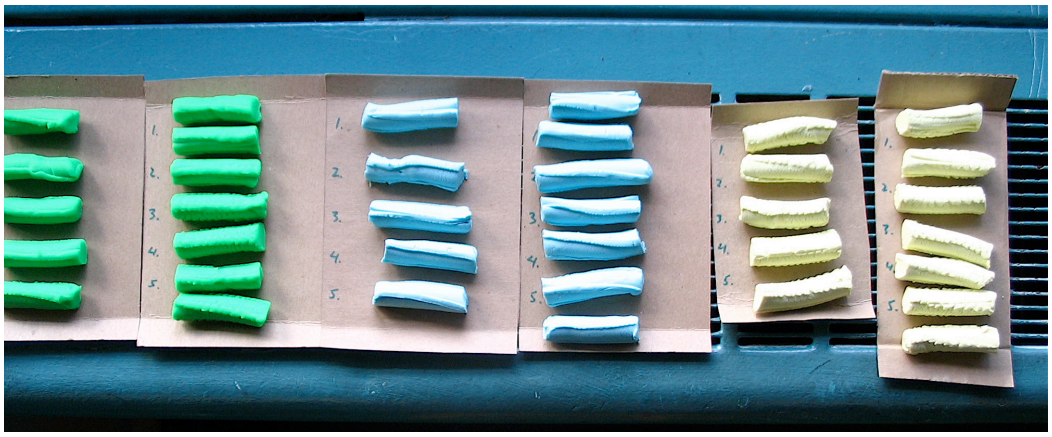
Say: "You will work in teams of two. The team that makes the most consistently weighing bars gets this bag of candy. The team that is most inconsistent will get fired. What do we mean by consistency?"

Some students may relate consistency to our earlier discussions of measurement precision. Remind students that precision is not the same as accuracy. One good example of precision is aiming at a target. When soldiers learn to shoot rifles in the military, they are instructed to shoot at a target three times from a close range (36 yards). They then find the middle of those three shots to adjust their aim according to distance and direction from the center. This soldier's original shots were precise/consistent, but not accurate.



Making and weighing the sticks (30 minutes)

1. Announce pairs and time limit of 6 minutes.
2. Each pair is to make five sticks. Place in order on cardboard tray. The pair works as team to weigh them.
3. Bring data sheet to computer to enter data.
4. Place tray with five sticks on table, labeled with student names.
5. As an extension for those who finish early, give them worksheet and instructions to download data from the website. Name of file: PlaydohFactory.tp



Data analysis (10 minutes)

Using a data sheet (posted on the board), discuss what students notice about the data. An example of a portion of a data sheet is:

Production Method	*Team*	*Trial*	*Mass (grams)*
Hand Made	A	1	11
		2	8
		3	9
		4	7
		5	12
	B	1	6

Another way to organize the data for class inspection is to enter the gram weights for each team by trial, as in trial1, trial2, trial3, trial4, trial5.

Production Method	*Team*	*Trial1(g)*	*Trial2(g)*	*Trial3(g)*	*Trial4(g)*	*Trial5(g)*
Hand Made	A	11	8	9	7	12
	B	6				

Ask: "Which groups were most consistent? Which were least consistent? Which groups had the overall heaviest fruit sticks? Lightest?"
Point out a few interesting data points from the class data (maybe an extreme value or a table with highly consistent data). Then allow the students to walk around and view the other fruit sticks looking for the products corresponding to the highlighted data points.

Before finishing this section of the lesson, have students think about what weight we should put on our package of fruit snacks and what statistic would tell us that (measures of center).

Enter the data into TinkerPlots or other software (CODAP). Be sure to include production method (hand), Team Name, Trial (1-5) and for each trial, the weight.

Data analysis, individuals (20 minutes)

Have students download and analyze the class data file to determine what weight should be put on the package and to measure the consistency of each team, so that we can determine who should receive the bonus.

Class Discussion

Without considering team identity, what statistic will help us determine which weight we should put on the packages of 5 fruit rollups? What is a good measure of consistency that will help us determine which team should receive the bonus? Should we give the bonus to the most consistent team or should we also consider whether or not their rollups tend to weigh an average amount?

Machine-made Fruit Rollups

Introducing the Machine Made Method

Show students the Play-Doh machine. The template that creates cylinders also adds a "wing" spiral around the cylinder. As the fruit snack production manager, inform your employees that we want smooth cylinders when the snacks are completed. There are several methods for making the cylinders smooth, including shaving the "wings" off and rolling the "wings" into the cylinder shape before cutting to length. Let students decide how best to do this.

Remind students of the desired dimensions of fruit sticks (diameter of 1.3 cm and length of 5 cm).

Making and weighing the sticks (30 minutes)

1. Announce pairs, make sure they are consistent with the previous day.
2. Each team to make five sticks. Place in order on cardboard tray. Allow 6 minutes for production.
3. The pair works as team to weigh each stick.
4. Enter the weights with labels of production method (machine) and team name, as with the handcrafted method.

Data analysis group (10 minutes)
Have students look at the class data and identify which team's sticks are the most consistent? Least consistent? Which team produced the heaviest? The lightest? As with the handcrafted method, have students match the data identified to the real products.

Data analysis, individuals (20 minutes)

Using TinkerPlots, compare the consistency and average weight of the fruit sticks across methods of production. Make an inference about which is best. Time permitting, compare the class data with the data from another class that is on the website.

Error Analysis

If time allows, engage students in an analysis of the reasons why the fruit roll ups might not all weigh the same.

Productive questions might include:

What might account for over-average weight?

Teacher Note: Have students add a ½ cm to the length of a stick. What does that do to the weight? How about 1 cm? Have students increase the diameter to about 1.4 cm. What does that do to the weight?

What might account for under-average weight?

Teacher Note: Have students subtract a ½ cm to the length of a stick. What does that do to the weight? How about 1 cm? Have students decrease the diameter to about 1.2 cm. What does that do to the weight? (The effects won't be symmetric because the volume varies with area, but it will be reasonably close.)

Suppose someone just ran out of time. What tends to happen?