AAAS ScienceNetLinks

Bell Curve

MATERIALS

- Objects to be measured: 2 types of Hershey's Kisses (plain and almond) or 2 types of dried beans (kidney and lima)
- Balances that will measure to 0.1 gram (if measuring Hershey's Kisses)
- Centimeter rulers (if measuring beans)
- Graph paper
- Tracing paper
- Overhead projector

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PURPOSE

To understand normal distribution of a measurable characteristic within a group of objects; to realize that differences in a characteristic between groups with overlapping distribution curves cannot be used to describe individuals.

CONTEXT

In this lesson, students will construct two bell curves using two different yet related objects. For example, two kinds of Hershey's Kisses (plain and almond) or two kinds of dried beans (kidney and lima).

The data will be compiled into a separate chart for each group and overlapped. The observation of the overlapping curves will reveal a difference in the middle value (curve peak) of the measured characteristic (weight or length) for each group. However, most values will be in the overlapping section. When individual objects are measured, you can't tell which group it is in by that measurement alone.

It's important to keep the concept of "middle" values simple at this grade level. According to research, "students should be introduced first to location measures that connect with their emerging concept of the 'middle,' such as the median, and later in the middle-school grades, to the mean. Premature introduction of the algorithm for computing the mean divorced from a meaningful context may block students from understanding what averages are for. (*Benchmarks for Science Literacy*, **p. 354 (http://www.project2061.org/tools/benchol/ch15/findings.htm#9d)** .)

Or put this way: "The important thing to emphasize at this level is the kind of questions that can be posed and answered by a data distribution: 'Where is the middle?' is a useful question; 'What is the average?' probably is not. Because there is a persistent misconception, even in adults, that means are good representations of whole groups, it is especially important to draw students' attention to the additional questions, 'What are the largest and smallest values?' and 'How much do the data spread on both sides of the middle?'" (*Benchmarks for Science Literacy*, **page 227 (http://www.project2061.org/tools/benchol/ch9/ch9.htm#Uncertainty_3_5)** .)

Note: This lesson is most appropriate for students at the upper end of the 3-5 grade band.

MOTIVATION

Ask students to talk about what sorts of toys they played with when they were younger. Then pose the following question:

- If boys typically like to play with trucks rather than dolls, does that mean that *no girls* like to play with trucks (rather than dolls)?

Help students understand (using language appropriate for your students) that in this lesson, they'll learn about normal distribution of characteristics within groups. Tell them that they will be able to better answer the question by understanding how normal distribution graphs, sometimes called bell curves, can overlap.

DEVELOPMENT

In this part of the lesson, students will construct two bell curves using two different yet related objects. For example, two kinds of Hershey's Kisses (plain and almond) or two kinds of dried beans (kidney and lima).

Distribute the materials and have students (either working alone or in pairs) follow this procedure:

Measure 5-10 Hershey's Kisses (or beans) of each type (plain and almond, or lima and kidney). If measuring kisses, use a balance to measure to the nearest 0.1 gram. If measuring beans, use a centimeter ruler to measure to the nearest millimeter. (Note: There should be about 100 measurements total for each group of objects.)

Next, before having students graph their results, review the basics of graphs with them, as necessary. For example, show them an already created graph and ask questions like:

- What is graphed along the X-axis (horizontal line) of this graph?
- What is graphed along the Y-axis (vertical line)?

Then facilitate a discussion about how they will create graphs for this lesson. Ask questions such as:

- What will be graphed along the X-axis? (The weight of Hershey's Kisses, or length of beans.)
- What will be graphed along the Y-axis? (The number of kisses/beans of a particular weight/length.)
- How will you record your measurements? (Students could use X's; stack the X's on top of each other for the same measurements.)

When you feel the students are ready, have them create two graphs (one for each type of Hershey's Kiss, for example) with increments of measurement on the X-axes and number of measurements on the Y-axes. You could have students graph their individual measurements for practice or you could move right into a class graph.

As a class, combine all of the students' measurements onto two graphs and follow these steps:

- Draw a bell curve over each set of data (using an overhead projector or tracing paper).
- Overlap the two bell curves to show the slightly different peaks (middle values) and the large overlap.
- Measure one object without letting the students see it. Mark its value on the overlapped curves.

- Ask students if they know to which group the unidentified object belongs. (They won't be able to know this for sure; however, if the value falls outside of the overlap they can make a good guess.)

ASSESSMENT

By creating normal distribution curves (bell curves) for two groups of objects for which the measured characteristic overlaps, and then analyzing the position of individual measurements within the curves, students should recognize that middle (median) values for a measured group characteristic do not indicate that one individual in one group is greater or lesser than a particular individual in the other group.

The students should be able to apply concepts in this lesson to other situations, such as the scenario posed in the Motivation about the toys with which boys and girls play. Ask students to revisit their answers to that question: If boys typically like to play with trucks rather than dolls, does that mean that *no girls* like to play with trucks (rather than dolls)? Ask them: "Have your answers changed? If so, in what way?"

In an effort to assess understanding, you could ask students to respond to this scenario based on ideas learned in this lesson:

- Some electronics manufacturers hire only women to assemble tiny parts. They say women are better at using their hands to work with small things, that is, they have better manual dexterity. Do you think that's right? Do you think it's fair for these companies to hire only women?

Students should understand that it isn't fair to hire only women for electronics assembly, and they should be able to explain why. After the graphing exercise, they should be able to explain that the difference in manual dexterity between men and women is only a difference in the middle point in normal distribution curves of ability. The curves overlap so that many men will be more dexterous than many women.

The way to select workers who are dexterous enough to do the work is to test the dexterity of each job applicant. In decisions based only on gender, some women may be hired who can't do the work and men who can will be unfairly excluded.

EXTENSIONS

For related Science NetLinks lessons see:

- **Bag the Beans**
- **Bias Sampling**

You may wish to see what happens to the bell curve shape when there is a broader range of values in the groups, keeping the median point the same. Be careful not to make this part of the lesson complicated. You may wish to use it only with your advanced students.

Ask students what the normal distribution curves would look like if some of the objects measured were "lower" than what was actually measured in the lesson and some were higher. Keeping the median value the same, the shape of the curve will be shorter and flatter. For an illustration of this, see **The Normal Distribution (http://www-stat.stanford.edu/~naras/jsm/NormalDensity/NormalDensity.html)** .

Have students trace some of these different shaped graphs and overlap them at the same median values that they obtained from their measurements of Hershey's Kisses or beans. In some cases, use a different shaped curve for one of the groups.

Ask questions such as the following:

- Does the shape of the curve make it more likely that an individual will be in one group or the other? (If the overlap area in one graph is different than in another, then the likelihood will be greater or less depending on if the area is greater or smaller.)
- Does it make any difference how much the manual dexterity curves overlap between men and women in your decision about hiring individuals to assemble electronic equipment? (No. The important factor is still the actual ability of the individual to do the job.)