Exploring the Bell Curve with Pennies

Objectives and Standards: This lesson is intended primarily to address Indiana Science Standard 7.5.4, which says that the larger the sample, the more accurate the measurement. Many other standards are addressed or can be addressed depending on emphasis. Other possible standards include many of those concerning the mathematical world, calculating, or graphing, as well as the nature of science. This lesson also is intended to be an elementary introduction to the ideas of statistics, and why statistics can be important or useful in science. This lesson can be done in 1.5 days, with the students doing all data collection on one day, and then using a half day for discussion and review. We used groups of 4 students, and alternated shaking and recording responsibilities.

Prior Knowledge: Students should be familiar with how to record data, and place the data in a bar chart.

Equipment and Materials:

- Plastic Cups
- Lots of Pennies

Procedure:

- Have the students collect their data by placing 20 pennies in a cup, shaking them, and dumping them (carefully) onto their desk. They then count the number of heads they get, and record it on their worksheet. They should repeat this 'experiment' 40 times.
- When all the data is collected, have students tabulate the data on the worksheet.
- The students then create a bar graph of their data.
- Discuss with the students how their graphs look. Is it what they expected? Can they guess what the 'average' number of heads should be?
- Collect all the data collected into a single bar chart. Show this bar chart to the students. Is this the same shape they had? What difference does a larger sample size make?
- Explain to them that many measurements in science are somewhat random, because of environmental effects, as well as measurement error. Very often, the randomness comes in the shape of the bell curve found in their penny lab. If we take a large sample size, we can obtain very precise results, in spite of random effects and error.

Extensions and Follow-ups:

- In addition to making the bar graph of all the data, overlay the bell curve, appropriately scaled. In this case, if the total number of student experiments is n, the equation of the bell curve is given by:

  $$y = \frac{n}{\sqrt{10\pi}} \cdot e^{-\frac{(x-10.5)^2}{10}}.$$

  The 10.5 is to account for the half unit shift that appears in a typical bar graph. If your bars are centered over their x-coordinates, replace the 10.5 with 10.
- Give a historical sketch of Abraham DeMoivre, the mathematician who produced the earliest work related to the bell curve. He struggled against a significant amount of persecution and bias due to his religious beliefs, and later, his nationality.
- When data is collected for other activities or labs, gather it together into a histogram and show the students how the bell curve naturally arises.

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The Penny Lab

A) Toss 20 pennies and record the number of heads you get in the first box. Repeat this for each box.

B) For each blank below, count how many of each number you got in part A). For example, count how many boxes in A) have the number 13, and record it in the 13 spot below.

# of 0's: ____ # of 6's: ____ # of 12's: ____ # of 18's: ____

# of 1's: ____ # of 7's: ____ # of 13's: ____ # of 19's: ____

# of 2's: ____ # of 8's: ____ # of 14's: ____ # of 20's: ____

# of 3's: ____ # of 9's: ____ # of 15's: ____

# of 4's: ____ # of 10's: ____ # of 16's: ____

# of 5's: ____ # of 11's: ____ # of 17's: ____

C) Using the data organized in part B), make a bar chart on the grid below.