

Statistical Half-Life Math Activity

Introduction: This math activity uses the theory of radioactive decay to demonstrate statistical analysis of a data set to support a scientific hypothesis.

Target Age Range: High School Sophomores and Juniors (10th & 11th grade)

Duration: 0.5 hours

Supply List:	\$15 - \$20 in pennies	Pencils or pens
	A few available calculators	Computer and projector
	Containers or paper bags	Data collection spreadsheet (attached)
	Student worksheet (attached) or scratch paper	Hand sanitizer (to clean hands)

No. of Facilitators: 2 (ideally, can be done with 1 facilitator for smaller groups)

Purpose: This is a math activity. This activity is geared toward 10th and 11th graders and is meant to exercise (relatively) advanced knowledge and skills that high school students with an aptitude for math and science should master.

This activity reinforces the concepts of mean, standard deviation, exponential curves, collecting data to test a hypothesis, using a spreadsheet, fitting an expression to a data set, and radioactive decay.

Event Preparation: Split the available coins into separate paper bags or containers. Each bag should contain between 90 and 250 coins (no need to count). One bag per 2-3 person student group will be needed.

Prior to beginning, decide which facilitator will enter data in the spreadsheet and who will communicate data from the students. (If the group is small, 1 facilitator could fill both roles.) The students will produce data FAST once they understand the procedure.

The spreadsheet should be displayed for students to see. The worksheets align with the discussion that follows. The raw data and mean data charts use data from the "Data" worksheet.

Procedure:

Facilitator(s): Distribute coin containers and data sheets (optional) around the room. Ensure that each team has a calculator available (smart phone calculator is fine).

Initiate a conversation with the students:

- Before showing Half-Life Explained worksheet:
 - What is an "isotope?"
 - What is a "half-life" of a radioisotope?
 - Fun fact: Biological half-life determines medication doses.
- Before showing Standard Deviation Explained! Worksheet:
 - What is a "mean?"
 - What does "standard deviation" tell you?
- Introduce your hypothesis: "Regardless of how much we started with, after 10 half-lives a radioactive isotope will have decayed away enough that it can be considered gone."
 - The students will use coins in an experiment to help the Facilitators test this hypothesis.

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Pair students up. (Teams with larger numbers of coins might want 3 students.)

Explain the experiment procedure.

Show students the spreadsheet formulas for the mean and standard deviation (2σ in this spreadsheet) and explain what they are calculating. Encourage students to observe how the standard deviation changes as more data is collected.

Student Teams: Perform the following procedure:

1. Count the initial number of coins. This is "Trial #0."
2. Return the coins to the container and shake them up. (NOTE: If a paper bag is used, hold the bottom of the bag so it won't break!)
3. Pick which side of the coin (heads or tails) will be the "decayed" side and which will be the "radioactive" side.
4. Spill the coins onto the table.
5. Remove the decayed coins. DO NOT return them to the container.
6. Count the number of radioactive coins.
7. Using your calculator, divide the number of radioactive coins by the initial number of coins. Record this fraction as the next "Trial."
8. Return the radioactive coins to the container.
9. Repeat steps 7 and 8 until no radioactive coins are left.
10. Return all coins to the bag when the experiment is complete and review the trends.

Facilitator(s) As the Student Teams collect experimental data, record each Student Team's trial data in the "Data" worksheet. Encourage the students to observe how the standard deviation changes.

- The Communications Facilitator can relay Student Teams' data to the Data Entry Facilitator.
- Data will automatically populate to the "Raw Data – Chart" and "Mean Data – Chart."
- When a Student Team reports all their coins have "decayed," do not enter their fraction as 0.00 because it will impede the data fit. Rather, enter a very small fraction close to zero (like "0.1/Trial #0").
 - See if any student can tell you why you did not enter zero for the last entry. (This is consistent with an exponential curve, which is the type of curve associated with radiation decay.)
- Discuss the curve fit with students.
 - Discuss the meaning of the coefficient of determination (R^2). (See Definitions! worksheet.)
 - A student may also understand the concept of an asymptote. (See Definitions! worksheet.)
- When all coins have "decayed," discuss with students whether the data supports the hypothesis.
 - Discuss standard deviation behavior that would indicate when hypothesis is not supported by the data or the test conditions are inadequate.