Modeling Nuclear Decay

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Grade Level:
High School

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Purpose:
To provide a safe, hands-on, physical model of nuclear decay and half-life.

Objectives:
Students will be able to:

- collect data and create a graph using a spreadsheet.
- utilize a self made graph to determine half-life.
- gain an appreciation of the independence of the mass of a radioactive substance to its half-life.

Time Required:
Two to three periods, depending on how many computers are available.

Materials Required:

- cubes (depending on class size around 500)
- plastic container large enough to hold 200 cubes.
- computer spread-sheet program. Graph paper can be substituted.

Preparation:
The biggest preparation for this lab is initially making enough cubes for the class. For this I took a 1"x 2" x 3' white pine board and spray painted one of the large sides. Then I used a table saw to cut the board into the needed cubes.

Teacher Background:
A difficult concept for students to comprehend is that half-life is a physical quantity that is independent of mass. This lab should be done in such a way where different groups of students are given different quantities of cubes. By giving different quantities to different groups it will allow a class discussion comparing the half-lives found on their individual graphs.

As the teacher you might want to review with your students what an exponential graph should look like and also review for yourself the probability of cubes landing with one particular side up. This probability is 1/6 or in approximately three rolls half the cubes should have rolled painted side up.

Procedure:

1. Have the class divide into groups of three.
2. Each group will need a container and some cubes. Each group should have at least 75 cubes and if possible the other groups should have varying numbers increasing from 75.
3. There should be enough time allowed for the students to go through collecting data at least three times.
4. Once the students have rolled the cubes and removed the ones with the painted side up they should record the number of cubes left to roll.

5. To make the x-y graph the students need to have three columns for the three trials from which they can calculate the average and another column should be designated for number of rolls.

Safety:
The students should be discouraged from throwing the cubes.

Questions to Ask:
1. Does the "half-life" vary from group to group where different numbers of cubes were utilized?
2. If you were told that an eight sided object loses 1/8 of the die each time a group of them are rolled, how many rolls would it take to get to zero for 100 die? Could you produce a graph of this experiment? Could you create an eight sided object and test your expectation?

Where to go From Here:
I utilize this lab as an introduction to a unit on nuclear science. I find using this lab before I talk about types of radiation and half-life particularly useful. After I discuss the forms of radiation and half-life I have the students search the Internet and find sources detailing where nuclear waste comes from, how much is produced and how it is currently being stored.

Another direction to take with this is to ask the students if there are other models that might be used to demonstrate half-life. Many teachers use M&M candies. For further inquiry see if they can come up with shapes having different numbers of sides and determine if the mathematical model of losing 1/n, where n is the number of sides, for each roll holds true.

Suggestions for Assessment:
Once the students create their own graph see if they physically can draw lines on the paper to determine the half-life.

References and Resources:
Modified with permission from Dr. Mark Blachley, PhD

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Student Activity Sheet

Purpose:
To be able to physically witness a model of nuclear decay.

Materials:
- container for holding cubes
- a number of cubes as told by your teacher

Procedure:
1. Divide into groups of three.
2. Have one person from your group get the container and the number of cubes as told by your teacher.
3. Place all the cubes in the container, shake and ***carefully*** spill the contents on to the floor.
4. Remove the cubes that landed with the painted side up and determine how many cubes are remaining to be rolled.
5. Record in a data table the number remaining and the number of roll just performed.
6. Keep rolling and recording the data until all cubes are gone.
7. Repeat steps 3-6 for two more trials.
8. Enter the data into a spreadsheet. The first column should be for number of rolls. The next three columns should be for number remaining from the three trials. The fifth column should be the average for remaining cubes from the three trials.
9. Produce an x-y graph where the x-axis is defined as the number of rolls and the y-axis is defined as the average number of cubes left.
10. Print the graph and plot by hand the half-life of your cubes.

Questions:
1. What is the mathematical relationship for the number of cubes lost in each roll?
2. Can you come up with an object that has more or less than six sides where you can test a mathematical relationship?