Math Modeling Project - Modeling Radioactive Decay

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Math Connections in the STEM Classroom - Summer 2020

Engaging Concept:
The following videos will be shown to students to introduce the topic of radioactive waste and storage and to build interest.

- **Yucca Mountain Video Clip:** Video from the United States Department of Energy details the construction of and purpose for the Yucca Mountain Nuclear Waste Repository
  https://www.youtube.com/watch?time_continue=139&v=tbq9a2oyMAo&feature=emb_logo

- **Radioactive Waste Video Clip:** Video from Verge Science that covers nuclear power, radioactive waste, half-life, storage etc
  https://www.youtube.com/watch?v=YgVyPwhkoJs

Modeling Activity: Radioactive Pennies

- **Summary:** Students use pennies to model the concept of half-life and graphically explore exponential decay.

  Materials: Cup 100 pennies Graphing calculator or graph paper

  Directions:
  1. Put 100 pennies in a cup, shake cup and pour pennies out on the table
  2. Place pennies that landed heads up back in the cup
  3. Count the number of pennies that landed with tails facing up and record the data table. These represent atoms that have decayed into a daughter atom. Stack these pennies in a single column.
  4. Repeat steps 2 and 3 until you have no more pennies to return to the cup – after each shake, place pennies that landed with tails up in a new stack.
  5. Use graphing calculator, Desmos or Excel to graph data.

- **Full Activity Link from Exploratorium:**
  https://www.exploratorium.edu/snacks/radioactive-decay-model

Measurable Objective:
Students will be able to create an exponential model of data and relate this to the exponential decay of radioactive elements.

Standards:

NGSS

HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay

PS1.C: Nuclear Processes: Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.

(Standards Continued:)

CCSS

MP.4 Model with Mathematics

HS Interpreting Functions: Analyze functions using different representations

HS Building Functions: Build a function that models a relationship between two quantities

HS Linear, Quadratic, & Exponential Models: Construct and compare linear, quadratic, and exponential models and solve problems

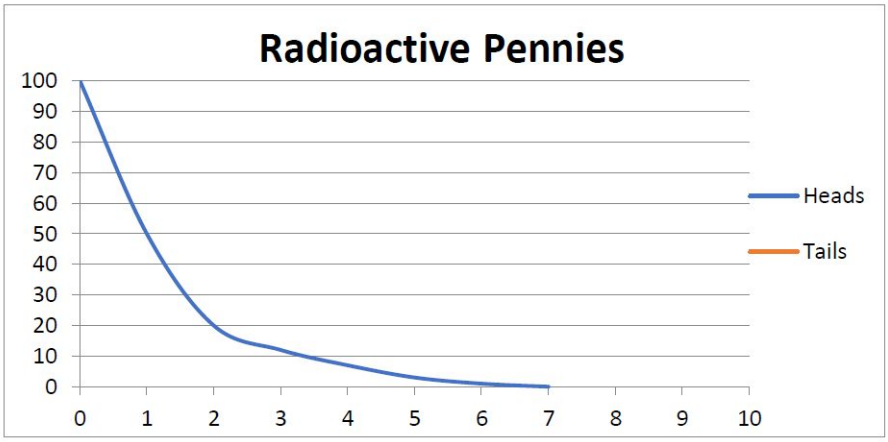
HS Quantities: Reason quantitatively and use units to solve problems

HS Creating Equations: Create equations that describe numbers or relationships

Evidence:

Students will create a table of values of the pennies that land with tails facing up each round. They will then graph this table using a graphing calculator, Desmos, or graph paper. If the graph is created on graph paper, the graph should have correct data on the x and y axis (y = number of pennies with tails facing up), and the axis should be labeled. The numbering on the x and y axis should be appropriate. If the graph is created on a graphing paper or Desmos, the data for the x and y axis should be correct (y = number of pennies with tails facing up). Students will determine the function that best fits their data. Students will then use this model to describe exponential decay as well as describe how they came up with the model in paragraph/sentence form. The graph and written explanation will serve as a formative assessment.

At the end of the lesson, students will complete this Lesson Reflection. Additionally, students will complete the following exit ticket:



Use the graph above to answer the following questions:

1. The half-life of a radioactive element is defined as the amount of time it takes for half of the original atom, called the parent atom, to decay into daughter atoms. If each “shake and pour” of the cup represents 15,000 years of time, what is the half-life of the radioactive pennies?

2. Assuming that each shake still represents 15,000 years, about how many years will it take for 90% of the parent atoms to decay into daughter atoms?

3. On the graph above, draw what the graph would look like for the daughter atoms that were generated by the decay of the parent atoms using a red pen.

4. The fuel rods in a nuclear reactor are mainly composed of uranium-235. Used fuel rods still contain many radioactive by-products, such as plutonium, which has a half life of 24,000 years. Explain why this is a concern for countries that employ nuclear energy. How do you think nuclear waste should be managed?

Reflection on Team Collaboration

Our team of Claire, Karan, Tera and Kristina worked very well together. We utilized collaborative tools including Zoom and Google Docs to share ideas and information. We began by brainstorming ideas that fit into all of our subject areas of math and science, particularly chemistry. After narrowing down to a few ideas, we did some independent research. We then reviewed our independent research together and decided on a single lesson. All members of the group contributed greatly and equally to the project.

References

Department of Energy, United States of America. *"Yucca Mountain: The Making of an Underground Laboratory"* [Video]. (Uploaded December 20,2010 by tmk8118). YouTube. https://www.youtube.com/watch?v=LKkQL0cjF0Y

"Radioactive-Decay Model." Exploratorium. Retrieved June 16, 2020, from https://www.exploratorium.edu/snacks/radioactive-decay-model

Verge Science. (2018, August 28). *"88,000 tons of radioactive waste - and nowhere to put it"* [Video]. YouTube. https://www.youtube.com/watch?v=YgVyPwhkoJs