NSF RET Lesson

Lesson Title: Solar Energy Data Collection	**Grade Level/Subject:** 9th Grade, Physical Science
Maximum # of Students: Students in classroom	**Total Time Required:** 4-5 class periods

Prior Knowledge Needed/Reference:
https://www.teachengineering.org/activities/view/cub_housing_lesson05_activity1

Materials:
Each group needs:

- 32 x 20-inches sheet of 1/8-inch foam core board
- 1 sq ft thin clear plastic
- 4 sq ft aluminum foil
- 2 sq ft thin rubber
- 2 sq ft black fabric
- pencils, erasers and white or graph paper for designing and graphing
- Design Challenge Handout (link)
- Analysis & Results Worksheet (link)
- For the entire class to share: hot glue guns and/or tacky glue, scissors/utility knife, thumbtacks, tape/ masking tape, protractor/ straight edge
- For one testing station: 300-watt light bulb, desk or clamp lamp (that can safely accommodate a 300-watt light bulb), Box fan, Ice, Plastic container for the ice, Thermometer , and a Timer for 30-sec intervals

Performance Objectives/Learning Targets:
The students will make real-world mathematical connections to solar energy as they investigate heat transfer, the impact of our use on the environment, the potential of solar energy and the evaluation of our energy practices. Through demonstrations and inquiry-based learning opportunities, students will acquire and retain mathematical concepts which include writing, solving, and graphing linear equations to discover correlations and rates of change. Students will also analyze the scatter plot and the line of best fit.

Standards:

Students who demonstrate understanding can:

HS-PS3-1 **Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [*Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Create a computational model or simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

PS3.B: Conservation of Energy and Energy Transfer

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.

Crosscutting Concepts

Systems and System Models

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes the universe is a vast single system in which basic laws are consistent.

Lesson Procedure

Day 1:

- Before activity, initiate a class discussion about heat transfer and passive solar heating. Have them explain any questions, comments, or concerns about the topic.
- Next play the YouTube video to generate curiosity (https://www.youtube.com/watch?v=hlRNO8xcrgU)
- After the video, explain the project and learning targets of lesson.
    - Goal: Students will design and build a one-bedroom model house utilizing passive solar heating design to warm up the house a and then sustain that temperature for as long as it can. The specific criteria can be found in the handout below.
- Provide students with materials and the handouts attached below. Gather materials and set up testing stations.
- Describe and discuss with the students what kind of model house they will be

	designing. Students should take into account the materials provided and use critical thinking to select the right materials that will warm up their house. They should collaborate and share their creativity with one another.
Days 2 and 3:	● Over the next two days, students should continue to create their model houses. ● Students should design and sketch out their ideas and share withthe class. ● This will be called a Design Review and serve as a midway assessment. ● Once students have shared their designs, make sure they follow the certain criteria of the model house provided in the handout below. ● To help student switch the build they may watch this video (https://youtu.be/iV-_aTj-bow) ● After time has spent building, it is time to test the houses. ● To test homes: Shine the bright light on the model homes. For each house, start with the same room temperature, and position the light bulb an equal distance and angle away from the light. Place the bulb at a 45-degree angle about 10 inches away from the roof. Then, insert the thermometer through the door and entirely inside the home. Make sure it can be read through a window or door. Next, have students take and record temperature measurements every 30 seconds so they have enough data to graph their results on their handouts. ● For time purposes, only daylight will be tested for this project.
Day 4:	● Students will finish the Analysis & Results Worksheet when they are done testing. Then instruct each group to prepare a short presentation of the house they created. They should discuss the successes and failures of their houses and suggests any improvements made to them. The presentation will count as their post assessment.
5E Model: *(Engage, Explore, Explain, Evaluate, Elaborate)* Engage: Class Discussion with Intro Youtube video Explore: Creation of Design Model Houses Explain: Direct Instruction of heat transfer and passive heating Evaluate: Class Discussion and Short Presentation Elaborate: Students discuss Design Review	

Group name: ____ Date: ________________

Analysis & Results Worksheet

Zero-Energy Housing Project

Testing Part 1: "During the Day"		Testing Part 2: "During Night"	
Time (minutes)	Temperature (degrees)	Time (minutes)	Temperature (degrees)
0		8.5	
		9	
1			
		10	
2			
		11	
3			
		12	
4			
		13	
5			
		14	
6			
		15	
7			
8			

1. Collect your data and record it in the table, above.
2. Plot your data on graph paper (or using Excel software).
   - Calculate the largest slope for your plot during the daytime. Remember, slope = rise/run
   - Next, calculate the largest negative slope for your plot during the nighttime.
3. Compare your results with other groups. A larger slope during the daytime means greater temperature gains, while a larger (less negative) slope during the nighttime means better heat sustainability.

4. How did your group's model home results compare to the other model homes?

5. What worked well in your design? What seemed to work well in other groups?

6. What would you change if you had the time and ability to do so?

7. Draw a sketch of your new and improved model home!

Group name: ____ Date: ________________

Design Challenge Handout

Zero-Energy Housing Project

Your goal

To design and build a one-bedroom model house within the design constraints, utilizing passive solar heating techniques to warm up the house as much as possible and sustain that temperature as long as possible.

Things to keep in mind…

- Insulation
- Thermal mass
- Size of home (the space needed to be heated)
- Orientation of home (from which directions are the sun and wind coming?)
- Color
- Be creative! (house can be of any design you can imagine and build with given materials)

Design constraints

- Floor size >= 70 square inches
- Roof height >= 4 inches
- Door size must be able to accommodate a thermometer that can be placed entirely inside the middle of the model with the door closed, and be able to be read through a window (find out thermometer dimensions from your teacher)

Materials

- 32 x 20-inch sheet 1/8-inch foam core board
- 1 sq ft thin clear plastic
- 4 sq ft aluminum foil
- 2 sq ft thin rubber
- 2 sq ft black fabric
- hot glue and/or tacky glue
- thumbtacks
- scotch tape
- masking tape

Testing

You will place a thermometer in your model house and then blast your model with a large light bulb (representing the sun) for 8 minutes at an angle of 45 degrees. During this time, you will record the temperature inside your model to see how much it warms up. Then, you will simulate nighttime and record the temperature with the light off and the wind blowing (a fan). This part of the test will show how well your model home retains heat.

Tips

- While cutting the board, use a straight edge (metal ruler) to hold the cutting blade in place.
- Glue reinforced by tape usually works best for holding walls together.