SUSTAINABILITY WORKSHOPS
for Middle School & High School Teachers

Solar Cooker Lesson Plan

Argonne's Sustainability Workshops for Middle School and High School Teachers were conceived, designed and implemented as part of the Laboratory's educational outreach. The goals of these workshops include knowledge and awareness of alternative energy technologies, their advantages and limitations; the key issues and impacts of technologies related to climate change; to extend the resources of sustainability; and to encourage energy literacy. Participating teachers are asked to synthesize their experiences and knowledge gained into a useable lesson plan. The plans presented in this unit are a compilation of those lessons.

Grade Level
Middle School

Time Needed
3-6 class sessions

Activity Description
Most solar cooker design labs are open-ended, allowing students to choose from many types of cookers and materials. This allows for maximum creativity, but not for a controlled comparison of results, as it is difficult to establish and test variables and maintain controls with such a variety of products.

In this lesson, students design and construct a solar cooker based upon their shared results as they test variables the class has identified. By limiting the type of solar cooker and allowing for flexibility in design materials for the preliminary testing phase, the shared data from preliminary testing will lead to better decisions about what factors increase the amount of heat generated by that solar cooker. The students will be constructing the Copenhagen Solar Cooker invented by Sharon Claussen (see *Resources*).

Goals and Objectives
Students will

- Explain how solar ovens can be used to improve the human condition
- Show that solar energy can be easily collected and converted to heat energy
- Apply their knowledge of light, energy conversion and energy transfer to the design challenge
- Use experimental and technological design to construct a working solar cooker
- Integrate their own (and shared) data to drive design decisions and improvements to a solar cooker
- Compare and evaluate the effectiveness of the constructed solar cookers

Copenhagen Model Solar Cooker

Background Information

Solar cookers, also called solar ovens, use the sun's energy to heat food in order to cook it. Although there are many types of solar cookers, they all follow these basic principles:

- Concentrate sunlight to increase heating power
- Convert light energy to heat energy
- Trap heat in a confined space
- Greenhouse effect lets visible light escape, but keeps the thermal radiation from escaping, thereby increasing the trapping effect

Materials

- Reflective placemats (metallic finish or similar)
- Cardboard
- Mylar
- Aluminum foil
- Poster board
- Newspaper
- Insulators (cotton balls, wool fabric, pine needles, grass, straw)
- Twist ties
- Paper clips
- String
- Glue
- Tape
- Hot glue gun
- Cutting tools
- Cups in a variety of colors, materials and sizes (several of each)
- Timer or stopwatch
- Thermometer
- Water
- Marshmallows
- Teacher-made model of a completed solar oven
- NOVA: Saved by the Sun Interactive
- Teacher's Domain Solar Cooker Activity and Interactive
- Copenhagen Model Solar Cooker Instructions

Strategies and Methodology

- Whole group discussion
- Small group discussion and activity
- Computer model testing
- Designing
- Guided inquiry
- Measuring
- Experimental testing
- Data collection and analysis
- Sketching
- Comparing
- Redesigning
- Retesting
- Communication
- Descriptive and scientific writing

PROCEDURE

Introduction

(30 minutes)

1. Establish the purpose of the lesson: Why in the 21st century do we even need solar cookers? Pose and discuss this question after displaying images of technological advances of the modern age (examples: DNA model, satellite, microwave oven, computer).

2. Read and discuss the following quote from the World Health Organization establishing the need for sanitation via the heating of food and water in many countries of the world. *"The World Health Organization reports that in 23 countries 10% of deaths are due to just two environmental risk factors: unsafe water, including poor sanitation and hygiene from indoor air pollution due to solid fuel use for cooking."* Also, Solar Cookers International (a non for profit organization) explains why people use solar cookers and where they are most useful.

3. Share a photo showing refugee camp in Chad in which refugees use wood as fuel, and discuss the ecological and health problems that result. For example, in Somalia, or in Chad.

4. With the students, share a variety of solar cookers - types, and identify similarities and differences in how they work. For example, Solar Cookers International has sample pictures and descriptions of cookers along with an explanation of how each solar cooker works.

5. Distribute the student handout, "*Got Sun? Get Cooking!*", and discuss the student design challenge. Encourage students to explore solar cookers on the web for homework by viewing the solar cooker simulation online.

Construct and Test Solar Cookers

(2 - 5 classes)

Part One: Build and Test Solar ovens with one variable changed

1. Explain the solar panel challenge and show students the materials available. Allow time for the students to discuss the project. Show the teacher- made solar cooker model that the students will be exploring.

2. Brainstorm a list of variables to be investigated by the class and identify the controls. Plan how to best distribute the test variables between groups or even between classes. Examples of variables to test include
   - Size/area of reflective surface
   - Amount (mass or volume) of food being cooked
   - Smoothness of surface
   - Type of cooker material
   - Cooking container color
   - Type of insulation
   - Angle of sunlight
   - Height of solar oven
   - Amount of time
   - Weather conditions
   - Month of year

3. Preliminary Variable Testing: Explain that their first cooker design experiment will be to determine how ***one*** variable affects temperature of solar cooker. Allow the students to figure out how to measure the temperatures reached by the solar cooker. If preferred, provide some instruction on how to collect temperature data. Ask students to make a data table. Each group will share this data and their graphs with the class. You may want to set up a control group of simply a container of water with a thermometer in it (its temperature should increase only a degree or two). Once all teams have had an opportunity to test their cookers, allow students to view all the designs. Have students share the collected data for each cooker and analyze the success of each cooker variable. After this analysis, have the students use the information to improve their designs.

Part Two: Design, draw and build second solar oven with additional modifications

Final Design: For the second design, students may change one or more variables to construct the most effective solar cooker. Have them diagram or sketch out their design. They will complete questions on the student handout and will write a summary describing how data from the first design and their class data guided their second design.

Closure/Sharing/Reflection

Students will discuss and compare each team's final design and results. If allowed, the students may use their solar cookers to roast marshmallows.

Assessment

Use a teacher-created rubric as a summary assessment for students':

- Thoroughness of design
- Involvement in discussions
- Cooperative teamwork
- Safety behavior
- Quality of experimental data
- Graphs
- Re-design improvements
- Written responses to questions

Be sure to include the students' explanations of how they used data to refine their first design and improve on it. Students with special needs may use diagrams with labels and sentences, or oral explanations to support design modifications rather than longer written summaries. The assessment information can inform teacher instruction for the following school year.

To assess student ability to transfer what they have learned, the teacher may want to ask questions such as the following (from *Teacher's Domain*):

- What are the limitations of using a solar cooker? Describe how they may be overcome.
- Using what you learned, what exterior and interior colors and materials would you want in a car if you lived in a hot, sunny climate?
- What colors and materials would you pick if you lived in a cold, sunny climate?
- How might you use the principles of solar radiation in other parts of your life or home?

Extensions

- The lesson may be extended by allowing students to use ***any*** recycled materials found around the house, in addition to materials provided at school.
- Students may also be encouraged to research and build a different type of solar cooker.
- A deeper exploration of the design constraints of cost, durability and portability could be added to the design challenge.
- A good template for thoroughly testing the variables of a box solar cooker can be found at *Teacher's Domain*.

Resources

- NOVA Saved by the Sun Interactive
- Teacher's Domain Solar Cooker Activity and Interactive
- Copenhagen Model Solar Cooker Instructions
- Solar Cooker Design Challenge movie (web link)
- NOVA's Solar Oven Activity, companion to *Saved by the Sun* video
- Teacher's Domain Solar Cooker Simulation
- Teacher's Domain Solar Cooker Handout
- Penn State Public Broadcasting teacher resource page
- Teach Engineering Cooking With the Sun Activity
- Solar Energy Background Info and Readings for Students
- Solar Cooker Plans
- Solar Cooking video by National Geographic
- Not Another Lab Report: making scientific writing more relevant and student-centered

Need more information or help with this lesson?

Contact Argonne National Laboratory by e-mailing SustainabilityEd@anl.gov.

Find out more about Argonne's Sustainability Program at blogs.anl.gov.