Engineering Design Challenge – Our Solar Cooker Company

Student Objective
The student:
- will design and construct an original solar cooker
- will research, analyze, and critique solar cooker designs and assimilate these ideas into a new cooker design
- will work with a group to develop a plan, material list, and delegate tasks
- will demonstrate originality and inventiveness using low cost and recycled materials.

Key Words:
Fresnel lens
hybrid
parabolic

Time:
1 class period for research (could be homework)
1 class period for brainstorming and planning
2 - 3 class periods for construction & testing
½ class periods for presentations

Materials:
- photos of various cookers including lens cookers and hybrid cookers
- internet access
- materials (purchased or recycled) for construction – i.e. glass, plexiglass, mirror, corrugated plastic, mylar camp"space" blankets, sheet cardboard, fresnel lens from overhead projector, etc.
- hand tools and cutters
- glue in various forms
- tape - aluminum and clear
- black high temperature "grill" paint
- ruler and tape measures
- protractor, T-square
- table protection
- cutting boards
- thermometers, oven thermometers, digital or infrared thermometers

Background Information

Solar cookers come in various sizes and shapes. The three most common types of solar cookers are box cookers, parabolics and panel cookers. Many variations on these basic types exist. Additional types of solar cookers are lens cookers and hybrid designs that combine two or

more types of cookers. Lens cookers use a lens (commonly a fresnel lens) to concentrate the light from above the cooking surface. This is differentiated from a parabolic cooker which concentrates the heat from below the cooking surface. Hybrid designs could be a combination lens and another design–box, panel or parabolic (although the latter is very difficult to align in the sunlight), or something more unique like a box oven with a hot air convection component.

Solar cookers can be made from a wide variety of materials–both purchased (wood, sheet aluminum, flexible sheet plastic, glass, mirror, plexiglass, etc) and recycled (cardboard, mirror, umbrellas, coolers, cds, car windshield shades, etc.). Garages and garage sales are great sources of materials for solar cooker construction. A cooker can easily be made for under $10. in materials.

Procedure – Cooker Research & Design Planning

1. **Engage:** Lead a classroom discussion on what they have learned so far about solar cookers.
2. Show the students some cooker photos. Include lens and hybrid cookers in the presentation. Let the students make comments and discuss the designs.
3. **Explore:** Tell the students they will be researching solar cookers–both commercially available designs and those that can be handmade, and then making a cooker of their own design and testing it. During their research into different cookers they will be evaluating the materials, shape and size, ability to reflect, cost and portability of each design. They can then use this information to help in constructing their own cooker.
4. Divide the students into groups. Within the groups, each member should research at least one cooker design.
5. Inform students to use caution and ethics when accessing and viewing web sites to use as research sources. Their searches should conform to the standards of scientific investigations.
6. Students should complete the Research section of their Laboratory Manuals. Research can be conducted during class hours or assigned as homework.
7. On the following day, instruct the students to discuss their findings within their group, specifically the advantages and disadvantages of the different cookers and different building materials they researched.
8. Based on their research and brainstorming the students will determine a solar cooker design that they can construct using low cost and/or available (recycled) materials. You may provide some materials or have students create a class-wide list of available items they can purchase, recycle, or donate from home.
9. Observe the groups during the planning stage. Remind the students that their goal is to maintain high standards and produce a quality product. Additionally, remind students that the cookers they construct are to be an original creation. They may take ***ideas*** from their research, but may not take actual measurements and construction plans from another source. Pass out (or post) the rubric to show the students the criteria you desire.
10. Encourage students to work out a rough draft before completing the drawing of their final plan in their Laboratory Manuals. Students need to develop a scale for their drawing and label all measurements. This should not be a trial and error activity. Students need to have a plan. Assist the students as needed in completing their Laboratory Manuals.

11. Students must generate a list of all construction materials including amounts and cost. Partial product cost must also be calculated. For example, 2.5 rolls of aluminum foil at $3.99, recycled packing styrofoam peanuts at $0.
12. Students must generate the instructions for constructing their cooker based on the specifications of their design and materials needed.
13. Have students develop a company name and logo to complete this planning phase of the activity. Note: Assigning a company cover page for the activity packet will integrate an "art-in-science" concept and showcase your artistically talented students.

Procedure - Construction & Testing Days

1. Have an outside area available for students to use for painting, gluing and testing of their cookers.
2. Assist students as needed during construction of their cookers.
3. If students vary their designs during the construction (or testing) process (and they probably will) have them note their changes in their Laboratory Manuals.
4. As the groups finish their cookers, have them clean up their area then take their cooker outside to test and modify slightly, if necessary.
5. There are several methods that can be used to test cookers. At your discretion, testing can be done by the groups individually as they finish their cooker construction, or a class wide criterium can be set up to be done during the following class period. Some tests that can be done are:
    - Put a small container with 100 ml of water and a thermometer inside the cooker and measure the temperature increase in the water during a set amount of time.
    - Test the ability of the cooker to boil water. Place a specific amount of water in a container prepared according to cooker type and place in the cooker.
    - Test the speed of heating in their cookers by taking temperature readings at intervals and graphing the results.
    - Cook a specific item (i.e. boil/steam an egg to a hard-boil stage).
6. **Explain and Elaborate:** After completing the activity, lead a discussion of what designs performed the best, having the groups share their design decisions, construction problems, experiences, lessons learned, and thoughts for further solar cooker designs.

Evaluation and Student Assessment
Using the rubric below, assess each student/group performance during the activity. Point assessment will be determined by the instructor.

	Exemplary (all skills mastered)	**Average** (Most skills mastered)	**Novice** (Needs Improvement)
Team productivity – completed on time in a professional manner			
Diagram and scale – neat and easy to read			
Material list – neat and matches the procedure list			
Procedure list – logical with key terms and concepts included correctly			
Analysis – is complete, correct, and written using proper terms and/or concepts			
Team work – collaboration and effectiveness in achieving a common goal			
Cooker construction – overall appearance and quality of the work			
Cooker testing – how well did the cooker perform to a scientifically applied test			
Class discussion – all team members participate in class discussion			

Key Words and Definitions
- **fresnel** – a thin optical lens consisting of a number of small lenses arranged to make a lightweight lens of large diameter and short focal length
- **hybrid** – combining the characteristics of two things
- **parabolic** – the set of all points whose distance from a fixed point, the focus, is equal to its distance from a fixed line, the directrix. The algebraic graph of a quadratic equation is a parabola. A satellite dish is an example of a parabola.
- **reflector** – a surface that reflects (bounces) light in a desired direction

Related Research
1. Enter the best designs in the Solar Energy Cook-Off, held as part of the EnergyWhiz competition at the Florida Solar Energy Center each May.

2. Research where (geographically) each type of cooker design is used the most, and why this type of cooker is preferred. Do large companies produce these cookers, or are they made by individuals? How do they benefit the local residents?
3. Have groups of students research and report on international solar cooker initiatives. Examples include: the Barli Development Institute for Rural Women, Federal Intertrade Haiyuan Solar Cooker Project, TNO Solar Socket, Cameroon Sustainability Sun Bakeries Programme, Solar Liberty Foundation – Empower Haiti Project.
4. Identify a charitable organization that assists with disaster relief and donate the most effective cookers, or several that are built specifically for this purpose.

Related Reading

- ***Cooking With Sunshine: The Complete Guide to Solar Cuisine with 150 Easy Sun-Cooked Recipes*** by Lorraine Anderson and Rick Palkovic (DaCapo Press, 2006)
  This book includes simple, straight-forward recipes suitable for homemade box and panel cookers.
- ***Solar Cooking for Home & Camp: How to Make and Use a Solar Cooker*** by Linda Frederick Yaffe (Stackpole Books, 2007)
  This book written by a lifelong camper, includes instructions for building a box and a panel cooker, easy to prepare solar recipes and great tips for solar cooking while camping.

Internet Sites

http://www.fsec.ucf.edu/go/energywhiz
Florida Solar Energy Center's annual solar cooking competition, the Solar Energy Cook-off for grades 4 through 12. Includes rules and information on how to enter a team. The page also includes links to cookbooks of the winning student recipes from the competition.

http://solarcooking.org/
Solar Cooking International, solar cooking archive includes solar cooking plans, documents and a list of resources and manufacturers.

https://www.sunoven.com/basics-of-cooking-with-the-sun-a-free-interactive-online-class/
Sun Ovens International. Basics of Cooking With the Sun, free online solar cooking class. Although this video is presented to showcase the Sun Oven (that they sell), the video includes many helpful hints that are good for any solar cooker.

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Florida NGSS Standards & Related Subject Common Core

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Nature of Science																					
Standard 1	**SC.912.N.1.**				X																
Standard 4	**SC.912.N.4**	X																			
Physical Science																					
Standard 10	**SC.912.P.10.**				X																
Language Arts Standards		**Grades 9 & 10:** LAFS.910.SL.1.1, LAFS.910.SL.1.2, LAFS.910.SL.2.4 **Grades 11 & 12:** LAFS.1112.SL.1.1, LAFS.1112.SL.1.2, LAFS.1112.RST.3.7, LAFS.1112.RST.3.9																			

Science–Standard 2: The Practice of Science

- SC.912.N.1.4 - Identify sources of information and assess their reliability according to the strict standards of scientific investigation.

Science–Standard 4: Science and Society

- SC.912.N.4.1 - Explain how scientific knowledge and reasoning provide an empirically based perspective to inform society's decision making.

Science–Standard 10: Energy

- SC.912.P.10.4 - Describe heat as the energy transferred by convection, conduction, and radiation, and explain the connection of heat to change in temperature or states of matter.

Language Arts–Speaking and Listening

- LAFS.910.SL.1.1 & LAFS.1112.SL.1.1 - Initiate and participate effectively in a range of collaborative discussions with diverse partners on grades 9 - 10 (11 - 12) topics, texts, and issues, building on others; ideas and expressing their own clearly and persuasively.
- LAFS.910.SL.1.2 & LAFS.1112.SL.1.2 - Integrate multiple sources of information presented in diverse media or formats, in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
- LAFS.910.SL.2.4 - Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.

Language Arts–Reading Standards for Literacy in Science and Technical Subjects

- LAFS.1112.RST.3.7 - Integrate and evaluate multiple sources of information presented in diverse formats and media in order to address a question or solve a problem.
- LAFS.1112.RST.3.9 - Synthesize information from a range of sources into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

National Next Generation Science Standards

Energy

- HS-PS-3-3 - Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Earth and Human Activity

- HS-ESS3-2 - Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

Engineering Design

- HS-ETS1-1 - Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2 - Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3 - Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Note: Related Common Core Language Arts Standards are listed in the Florida section above.

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Cooker Design Research

1. Create a table or chart for the designs your group researched using the items below:

    - Category of design (i.e. box cooker, parabolic)
    - Manufacturing company or website where design was found
    - Advantages of design
    - Disadvantages of design
    - Materials used in construction of this cooker
    - Advantages of these materials
    - Disadvantages of these materials
    - Type of cooking that can be done in this type of cooker

2. For each design your group researched, the group should decide what part of the design you like the best, and whether it is something that can be incorporated into your own cooker design. List below the different parts that you will incorporate in your design.

3. Determine the tasks that need to be accomplished in the construction of your cooker. Assign tasks (and job titles) among your group. List everyone's contribution below.

Cooker Construction

4. Diagram and label your solar cooker, either below or on a separate sheet.

Scale: _____

5. List below all your construction materials and the costs. Use additional pages if necessary.

Material	Amount	Cost (each)	Total Cost

6. List the construction directions for your cooker below. These should be complete enough that someone who did not see your cooker would be able to construct one.

7. On the following page, or on a separate sheet, create the cover artwork for your cooker design and construction pamphlet. Include your company name, company logo, and team member names.

Analysis of Design and Construction

8. Explain what previous solar cooking experiences influenced you in developing your cooker design.

9. What constructing materials did you use as absorbers, conductors or insulators? Organize your answer in a data table with your columns labeled.

10. What issues or tasks challenged the group?

11. What went well during the design and building of your cooker?

12. How would you change your design given more time? .....more money?