Aktivität 3.6. Heisse Kiste! Einen Sonnenofen bauen

Cultural Background

Most students live in a technology-driven world, with homes and appliances dependent upon both renewable and non-renewable energy sources. Our homes, cars, communication systems, and entertainment are predominately powered in some form - especially when we cook. Very few can imagine cooking without electricity, or even the natural gas required to power our refrigerators, ovens, and microwaves. This unit requires students to get creative with their German and their knowledge of the sun, heat, light, reflection, absorption, and cooking and baking, combining all of those into self-made ovens to heat and cook snacks and meals of their own making.

In *Waldsee*

Harnessing the power of the sun by building a solar oven is a favorite activity at *Waldsee*. Students design their own *Sonnenofen* either by using very basic materials, such as a pizza box, aluminum foil, plastic wrap, scissors and tape, or by working on more sophisticated models focusing more on insulating their ovens, using reflectors to maximize the solar gain and covering the oven with glass to better retain heat. Students are instructed in the background information needed to build their own solar ovens, and compare the effort of building various types with their resulting ability to heat and cook various dishes. Students compare their results with others, cooking at least one item identical to all other groups, and then are given the opportunity to showcase their creativity with ingredients and the advantages of their particular solar oven design and production.

The unit begins with introductory instruction in light reflection and absorption, materials for capturing or reflecting heat, and possible insulators for minimizing and/or eliminating airflow--with an emphasis on found materials, or items likely to be in your home, or easily accessible in a local grocery store. As our students lack the ability to get to a local store, we provide the required items for them (after brainstorm sessions with the students, where they will share ideas, but also their known availability in their home area). Students will be given the option to work on their own, or in pairs, and design a solar oven. The *Waldsee BioHaus* has its own solar oven experiment, which we will show and explain at the beginning of the unit, and use in conjunction with their own designs, throughout the lesson, comparing the cooking results of the *BioHaus* solar oven to those of the students, as they work to design, construct, and cook in their own ovens. Example solar oven designs are showcased: pizza box solar oven, shoe box solar oven, sunbrella, and windshield shade models (explanations of each found at https://sunshineonmyshoulder.com/6-homemade-solar-oven-projects-for-kids/).

Students are welcome to modify these designs as they see fit, based upon materials readily available at *Waldsee.* Teams each cook a “s’more” in their oven, and track internal oven temperatures over the same time duration, on the same day, to maximize experimental conditions and minimize variance beyond their oven design and construction. After their initial cooking attempt, and comparing their results to those of the other groups, students are given more time (at least 24 hours) to modify and/or redesign any component necessary to improve their oven results. They then all cook a bread dough of the same size/recipe, and again compare their results with the other groups, and the *BioHaus* solar oven dish. The unit ends with them using their German to explain, with photos and diagrams, how they built their oven, how their design results in capturing heat and preventing airflow/temperature loss, and modifications one could make with typical household items to produce a more efficient and/or effective solar oven. Students go on to explain the advantages of using solar power to cook

food, and situations in which it may be more beneficial to have such supplies on hand, or to keep them available (such as multi-day hikes, emergency situations, natural disasters, etc.).

In the Classroom

This activity can be easily adapted to the classroom. Allocating two class periods for the introduction and the actual construction of the solar oven plus an additional class period to prepare a dish which then can be cooked in the oven will provide students with a very engaging project and enough opportunities to reinforce new vocabulary.

Depending upon which time of day students have class, it is possible they will have to set out and/or conduct their baking experiments at home, or over a longer period of time in order to capture the maximum amount of sunlight. This experiment may not work well during certain times of the year, depending upon the area in which you are located, and average sun exposure at certain times of day, but these factors could also be part of the post-unit analysis and summary by students.

Objectives

- **Communication**
  - Students will use German language constructions and vocabulary to build and use a solar oven.
  - Students will be able to formulation if/then hypothesis and series of inquiries in German.
  - Students will use their German to present an oven design to other groups.
  - Students will explain results using conditional statements and coordinating/subordinating clauses.

- **Connections**
  - Students will reflect on the energy sources required to cook within their own homes.
  - Students build further connection into their environments, both in the sense of energy sources available to them, and in the materials readily found and at their disposal.
  - Students will be able to prediction anticipated results from various designs.

- **Comparisons**
  - Students will use their German to compare and contrast design elements, advantages, disadvantages.

- **Culture**
  - Students will estimate similar results depending on geographic area, season, or time of day. They will consider the role these elements play in the success of each design, and what design elements would change if one of these variables changed in the initial setup.
  - Students will learn about the prevalence of solar energy production and usage in Germany-speaking Europe and the United States, and how such efforts compare to traditional oven energy sources in those same areas.

- **Communities**
  - Students will develop community feeling within the classroom and the school through teamwork that results in a final joint project.

Language Functions in Focus

- Comparing and contrasting
- Describing procedures and processes
- Evaluating
- Expressing opinions
- Giving directions
- Giving reasons and explaining causality
- Presenting information

Materials

The following materials are needed for assembly of one solar oven:

- 2 used cardboard boxes of different sizes (the smaller box needs to fit inside the larger box, leaving approximately 5 cm or 2 inches of space on all sides and bottom for insulation).
- The smaller box should be large enough to hold either a small baking sheet (*Kuchenblech*) or 1-2 cooking pots, and 10 inches or less deep.
- 2 scissors (perhaps a utility knife to be used only with appropriate age group and under direct supervision).
- Ruler (preferably with metric dimensions)
- Washable marker or pencils
- Packing tape or clear duct tape (1.5-2 inches thick)
- Black washable or non-toxic paint (enough to paint the inside of the box)
- Aluminum foil
- String or yarn
- Glass or plastic (⅛-¼ inch thick) that is 1-2 inches wider and longer than the opening of the small box

Materials needed for baking in the oven:

- Small baking sheet
- 1 cooking pot (preferably with black enamel)
- 1-2 thermometers (at least up to *100 Grad Celsius*). You might be able to borrow them from the science lab. These are also available at any large department store.

Preparation

Students require understanding of measuring temperature on the Celsius scale, and common reference points (0ºC, 20ºC, 100ºC, etc.). Students should have a basic understanding of solar energy gain and loss (absorption by darker colors, reflection off of metal, etc). Students need to have a basic understanding of angles of reflection, even if just in a general sense, for maximizing sun exposure on the reflecting surfaces of their solar ovens. Students should be familiar with common major kitchen appliances, and their associated energy sources.

For the construction and assembly of the solar oven, it is best to divide your class into groups of 4-5 students. Make sure that you have sufficient materials for the number of groups in your class. Consider whether students will be allowed to modify their solar over as they build it or if you would like them to build it according to the given instructions. It might be helpful to build a solar oven yourself prior to using this activity with your students. This way you can provide them with a visual idea of what they are supposed to build later.

It is best to have a simplified German version of the instructions displayed on a large piece of paper or on the board as a visual aid for the students.

In preparation for a brief demonstration to be used during the introduction to the topic, fill two or the same glasses (or beakers) with equal amounts of water. Place one of them on the windowsill where it is exposed to direct sunlight. Place the second one on the windowsill of a shaded window. These will be used to show how the sun can be a powerful heat source. Set this up at least an hour prior to the start of your class.

Generating Interest

Read together with your students the following story. Discuss the story with them or ask them to prepare their own summary of the story for homework, using a particular language construction you would like them to practice:

Die Sonne und der Wind *von Johann Gottfried Herder*

Einst stritten sich die Sonne und der Wind, wer von ihnen beiden der Stärkere sei. Sie sahen auf der Erde einen Menschen, der einen Mantel trug. Die Sonne und der Wind waren einig, dass der Stärkere derjenige wäre, der den Menschen dazu bringen könnte, seinen Mantel abzulegen. Der Wind begann zu stürmen; Regen und Hagelschauer unterstützten ihn. Der arme Mensch jammerte und zagte; aber immer fester wickelte er sich in seinen Mantel ein und setzte seinen Weg fort, so gut er konnte. Jetzt kam die Sonne. Mit milder und sanfter Glut ließ sie ihre Strahlen herabfallen. Himmel und Erde wurden heiter; die Lüfte erwärmten sich. Der Mensch konnte den Mantel nicht länger auf seinen Schultern erdulden. Er warf ihn ab und erquickte sich im Schatten eines Baumes, während sich die Sonne ihres Sieges freute.

Ask your students, *"Woher kommt die Energie?"* A simple discussion of major appliances could start things off. Create a large-format (poster/whiteboard) list, and under each, write the resources needed for optimal function (water, electricity, natural gas, etc.) Then, have students prioritize the appliances on the list, from must-have to can live without. Have them list alternate ways to accomplish the same task (using laundromats, eating out, etc.). Finally, have students brainstorm which appliances they could mimic, or create their own version of, were something like a major power outage to occur, and they no longer have the same access to the required resources.

In the case of electricity, ask the students if they know where the electrical power for their stove and oven comes from. What is the fuel source for generating their electrical power? In most cases, the fuel source will be coal, hydro or nuclear power.

Together with the students, generate a list of fuel sources grouped by the following categories:

fossile Brennstoffe	***erneuerbare Energieträger***	***andere Energieträger***
das Erdgas	*das Holz*	*die Atomkraft*
die Kohle	*der Mais*	
das Öl	*die Erdwärme*	
	die Sonnenenergie	
	das Biogas (Methangas)	
	die Windenergie	
	die Wasserkraft	

Ask them: "*Von welchem Energieträger kann man am einfachsten, billigsten und überall auf der Erde Energie gewinnen, besonders zum Kochen und Backen?"*

Then point the students' attention to the glasses of water on the windowsill. Have two volunteers measure the temperature of the water and discuss the findings.

Finally, tell the students: "*Heute bauen wir ein Gerät, mit dem wir die Sonnenenergie einfangen und dazu nutzen, um Essen zu kochen. Wer hat schon einmal schon ein Gerät gesehen oder sogar gebaut?"*

Presentation and Practice

Begin by introducing German names and verbs associated with the tools, equipment and materials used to construct and assemble the *Sonnenofen.*

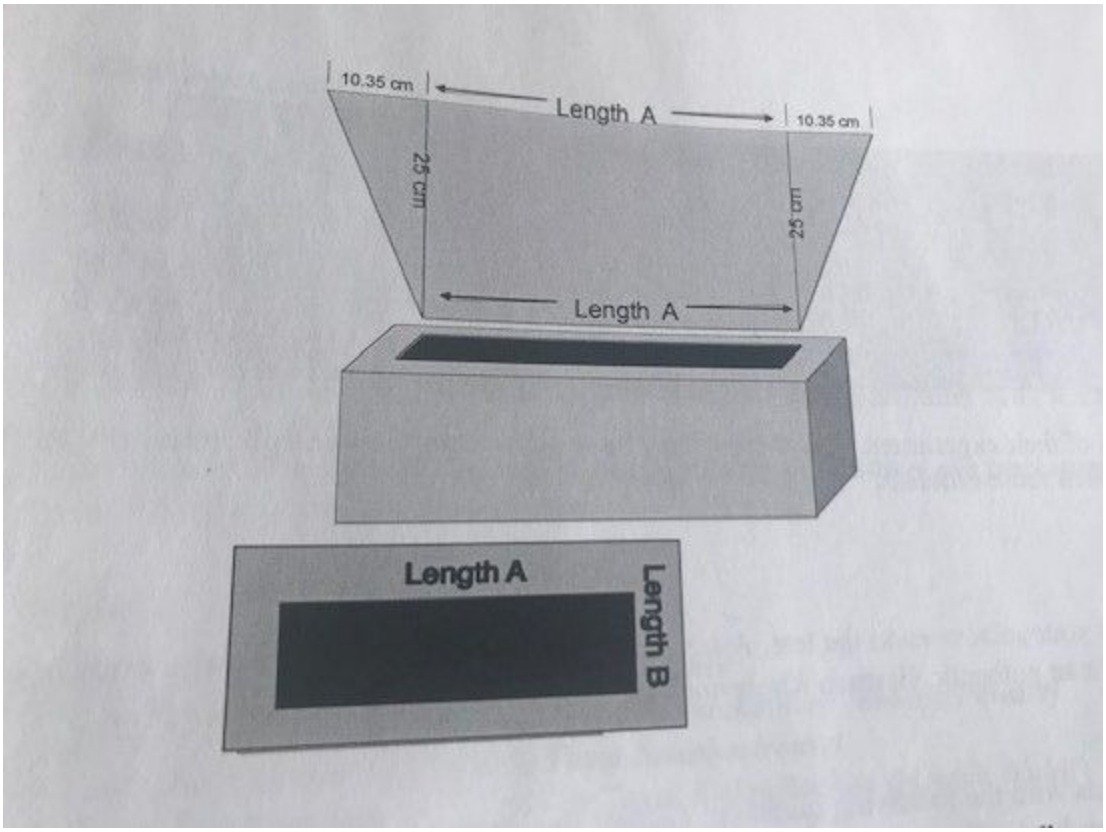
Wortschatz

der Ofen	*erneubar*	*Metal*
solar	*Nicht erneuerbar*	*der Kunststoff*
die Sonne	*die Energie*	*das Plastik*
die Hitze	*die Kraft*	*die Pappe*
die Wärme	*kraftsparend*	*das Fenster*
erhitzen	*energiebewusst*	*lichtdicht*
heizen	*die Energiequelle*	*luftdicht*
erwärmen	*der Energiespender*	*der Luftstrom*
kühl	*das Material*	*erhöhen*
abkühlen	*der Baustoff*	*steigen*
erkalten	*der Stoff*	*wachsen*
kalt werden	*die Reflexion*	*Sinken*
die Luft	*die Absorption*	*verringern*
die Temperatur	*die Aufnahme*	*abfallen*
heißer (als)	*das Metall*	*effizient*
kühler (als)	*das Glas*	*ineffizient*

Divide your class into groups of 4-5 students and have them read through the instruction sheet in German while you move from group to group to answer any questions. Show them one or more examples of what a solar oven might look like. Discuss how different designs or materials used may influence the effectiveness of the *Sonnenofen*. Finally, hand out the materials and have the groups begin to build their own solar oven.

1. Cut the smaller box to the proper length large enough to fit a small baking sheet or 1 cooking pot inside. The smaller box itself needs to fit into the larger box allowing enough space (5 cm) for insulation.
2. Using packing tape, tape the cut pieces of your box back together (If you find an inner box that is already the right size, you will not need to do these first two steps).
3. Place the smaller box into the larger box to make sure it fits and allows for approximately 2 inches of insulation on all sides as well as on the bottom.
4. Paint the inside of the smaller box with black paint.

5. Prepare the insulation by cutting extra cardboard to fit along the inside of the larger box. Begin with the short sides of the box. Measure the length and height of these sides to know how big to cut each insulation piece. Place 4-5 pieces along each of the short sides.
6. Now measure the long side of the box, taking into account that it is shorter because of the newly placed insulation process.
7. To insulate the bottom of the solar oven, cut 5 cm wide strips of cardboard.
8. Roll up the cardboard strips and place them tightly along the bottom of the larger box.
9. Next, make a cut approximately 5 cm in along the left and right edges on each of the four side flaps, to ensure that you can fold the flaps into the inside of the box. These cuts should be pointing towards the opening and should be long enough to allow the middle of the flap to fold cleanly over the insulation and into the center of the box.
10. Now, fold the long flaps into the center of the box, making sure to bend each flap over the inner corner of the insulation. Leave the 5 cm wide pieces along the top of the insulation on the short sides.
11. Fold the short flaps into the center, bending the flaps over the inner corner of the insulation, and leading the 5 cm wide pieces along the top of the long sides.
12. Then place the smaller box inside the larger box, making sure it completely settles.
13. Fold the flaps of the smaller box outward, over the flaps of the large box. Tape them into place along the outside of the larger box, by encircling the entire solar oven 1-2 times with packing tape, making sure the tape goes across the flaps of the inner box.
14. Next, using the diagram below, calculate the size of the reflectors.



15. Using a ruler or tape measure, measure the length of the opening along the longer side (= length A) of your solar oven (the inner box). Mark this distance on a piece of paper, which is a least 25 cm wide and 20.7 cm longer than length A (this will be the template for the reflectors). On one side of the template, measure 10.35 cm from each end and mark those points (called outside points). Now draw

a line from the outside points down to the opposite corners of the rectangle (this should make a trapezoid). Cut out the template. This is the paper template for the two reflectors along sides A of your solar oven. Repeat this for the length of side B.
16. Once the templates are made, cut out four reflectors from cardboard (two following each template).
17. Cover the inside of the four reflector pieces with aluminum foil, using glue to secure the foil to the cardboard.
18. Punch 4 holes in each reflector. Each hole should be placed near a corner, no closer than 1 inch from the edges of the reflector. Using a thin string or yarn, tie the reflectors together to form a rectangular funnel-shape.
19. Ideally you should cover your solar oven with a piece of clear glass (clear hard plastic will work too) and then place your reflectors on top of the box.

Hooray! You are ready to collect the energy of the sun to bake or cook food.

With the oven(s) finished, each group can now test the effectiveness of their oven. Have students place a thermometer in the solar oven and expose it to the sun, recording the temperature change inside the oven for the next 10-15 minutes. In addition, the students can place a beaker with about 100 ml or about 4 oz. of water into the oven (if beakers are not available, jelly jars will also work), insert a thermometer inside the beaker and record the temperature changes of the water over time. Display the test results in a simple data table (example below). The students can now compare the effectiveness of their different solar ovens.

Temperatur in Grad Celsius	***Zeit (in Minuten -5-***	***Zeit (in Minuten -10-***	***Zeit (in Minuten -15-***	***Zeit (in Minuten -20-***	***Zeit (in Minuten -25-***
Luft im Ofen					
Wasser					

Discuss the results of the experiment. Ask them if they have gained any new insights into how to make their solar ovens more efficient.

Expansion

Now it is time to put your solar oven to the test. Ask your students if they have a favorite cookie or cake recipe or suggest an authentic German *Kuchenrezept*, like *Sandkuchen, Marmorkuchen, Apfelkuchen, usw.*

Challenge your students with the following question: *“Glaubt ihr, dass euer Sonnenofen gut genug ist, um einen Kuchen zu backen?”*

If your class has worked in small groups and each group made their own solar oven, your students could choose their own recipe after having done a quick internet search on www.google.de, or a similar German search engine, for a German recipe. If the oven reached 100 C or hotter in the test, most simple cake recipes will work, as long as cake batter is not too thick (1-1.5 inches is good). If the ovens only reached 70-90 C, it is recommended that you use recipes without eggs or milk as a precaution (many cookie recipes can be found without eggs or milk). Have your students bring the ingredients for their cake to class, where they will prepare their own *Kuchen*.

Find a place outside where you have good solar access for at least 3 hours. Set up your solar ovens before you start preparing the cake to preheat them. Place the cake mix in a black pot with a lid and place it into the center of your solar oven. Make sure that you place a thermometer in your oven to monitor the temperature during the baking process. The baking time might range from 1½ to 3 hours, depending on the ingredients, outside temperature and consistency of your solar energy access.

Check after 1½ hours by inserting a toothpick or fork carefully into the center to see if the cake is done. Like baking in a conventional oven, the toothpick should come out clean. If you can not check the oven right away, do not worry. Solar baking is much gentler on foods, and leaving the cake in for an extra hour should not harm it. Because the solar oven may reach very high temperatures (300-400 degrees Fahrenheit), make sure that students use appropriate hot pads or oven mitts when opening the oven and checking on the cake.

Lieblingsrezepte

<u>Kuchen:</u>

2 Eier *2 Tassen Zucker*
½ Tasse Öl *2 Teelöffel Natriumcarbonat (baking soda)*
2 Tassen Mehl *2 Teelöffel Zimt*
1 Teelöffel Salz
4 Tassen Äpfel (klein geschnitten) - Bananen sind auch gut! (aber dann noch ein Ei dazu geben)

Zuerst alle Flüssigkeiten mischen. In einer anderen Schüssel alle trockenen Zutaten mischen, und dann alles zusammen mischen.

<u>Kekse:</u>

½ Tasse Wasser *½ Tasse Zucker*
⅓ Tasse Öl *½ Teelöffel Backpulver (baking powder)*
1 Teelöffel Vanilla *½ Tasse Schokostreusel*
1 Tasse Haferflocken *¼ - ½ Tasse Kokosflocken (je nach Wahl)*
1 Tasse Mehl

Zuerst alle Flüssigkeiten mischen. In einer anderen Schüssel alle trockenen Zutaten mischen, und dann alles zusammen mischen.