LES 5

O B S E R V A T O R Y
APPLIED SCIENCE AND TECHNOLOGY (AST)
Teacher's Guide A
Second Year of Secondary Cycle Two

THE SOLAR FURNACE

STUDENT LOG

WORKING DOCUMENTS

EVALUATION DOCUMENTS

PROCEDURE AND EVALUATION: SSC1 – TECHNOLOGY

Observatory / Guide
11129-A

Name: _____ Group: _____ AST

The project

Each day on Earth, almost three billion of the poorest humans use wood as a combustible energy source in order to cook their essential food.

Often located in the southern regions of the world, which are abundant with sun, these destitute populations are already feeling the energy shortage.

In view of this shortage, Bolivia Inti–Sud Soleil proposes simple and practical solar cooking tools "to harness the sun's energy for development."

Source: Bolivia Inti–Sud Soleil [Home page] (accessed June 9, 2009).

The heat is on!

Solar furnaces have proven their worth. In the Andes, for example, 1353 of these devices were in use in 2007, benefiting 30 000 people. What's more, every solar cooker reduces CO_2 emissions by 1.5 tonnes a year!

The humanitarian organization To the Rescue is calling on young people to encourage populations in other regions of the world to use solar cookers. The organization is asking volunteers to design a prototype of a solar furnace, according to certain specifications. Proud to contribute to international development, students of our school are responding to this challenge.

Support Committee for Peoples in Need

In this context, you will play the role of the designer of a solar furnace.

The project (*continued*)

SPECIFICATIONS

General purpose of the solar furnace

- Using only the sun's energy, the solar furnace must be able to raise the temperature of 50 mL of water by at least 5°C within 15 minutes.

Material constraints

- The furnace must be made by bending and gluing a single part no larger than 500 mm × 500 mm.
- The furnace must be able to hold a 100-mL Erlenmeyer flask.
- Only materials approved by the teacher may be used to make the solar furnace.

Human constraints

- Water must be heated as rapidly as possible.
- The solar furnace must be portable.

Financial constraint

- The solar furnace must be inexpensive to build.

Aesthetic constraint

- The solar furnace must be neat in appearance.

Environmental constraint

- Unused materials must be recycled.

The project (*continued*)

The solar furnace

A solar furnace is a device that transforms radiation energy from the sun into thermal energy (heat). Small furnaces used to cook food are usually called *solar cookers.* Food can thus be cooked with solar energy—a renewable and entirely eco-friendly form of energy.

A solar furnace works through a combination of concentrated solar radiation and the greenhouse effect.

To cook food today, the usual sources of energy are coal, natural gas, electricity and wood. However, using each of these energy sources has certain harmful effects on the environment.

- Coal and natural gas are fossil fuels. When they burn, they emit greenhouse gases, and they are both nonrenewable energy resources.
- Cooking with electricity has limited consequences for the environment. Although electricity can be generated by environmentally sound methods, it must be converted into heat in an oven, which is not very energy-efficient.
- Wood is a renewable and eco-friendly energy resource as long as it comes from a forest under sustainable management, which means that its use does not contribute to deforestation in certain regions.

Solar cookers could therefore be the most environmentally friendly way to cook food.

Why are solar furnaces not used more widely?

Many factors explain their limited use. First, most people simply do not know that food can be cooked with solar energy. The more the idea spreads, however, the greater its appeal, especially in areas where there is a shortage of wood for cooking. In addition, certain conditions must be met for poor populations to have daily access to solar furnaces. The most successful solar cooker projects to date answered a real need among the population, benefited from a suitable climate and promoted the long-term adoption of a new lifestyle. A good example is the work done by the Solar Cookers International group at the Kakuma refugee camp in Kenya.

At what time of the year can they be used?

In tropical regions and in neighbouring temperate zones, a solar furnace can generally be used all year round. In northern regions like Canada, cooking with solar energy is possible during daylight hours throughout the year, except during the three coldest months.

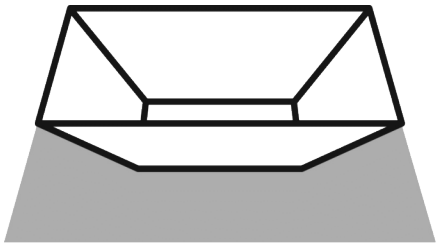
Do they become hot enough?

A solar cooker can reach a temperature of 121°C, which is sufficient for cooking most of the time. The majority of foods contain water, which cannot reach a temperature of more than 100°C. Traditional cookbooks suggest higher temperatures to shorten cooking times and to brown food. Cooking food in most solar cookers does take longer, but since the sun heats the cover of the pan directly, the food browns just as well as in a conventional oven.

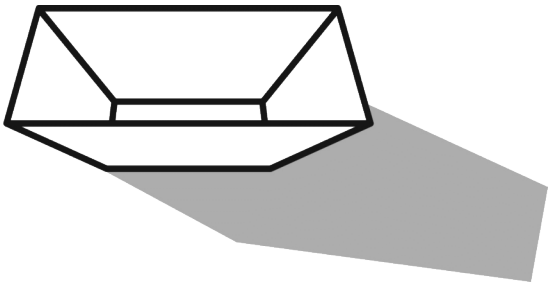
The project (*continued*)

How to optimize the temperature in a solar furnace

A furnace must always face the sun. If the device does not face in the right direction, the heat inside will be insufficient. The best way to make sure that the furnace is placed correctly is to look at the shadow it casts on the ground. The shadow must always be symmetrical. Do not rely on the light given off by the reflectors.



The furnace is placed correctly.



The furnace is placed incorrectly.

If the temperature in the furnace is to be kept high, it is important to reposition the device about every half-hour.

The angle of the furnace in relation to the sun

Depending on the time of year, the slant of the solar furnace should be adjusted because the angle formed by the Sun in relation to the Earth changes by about 30° between the winter and summer solstices. Since most furnaces are designed to be used in the summer, they must be raised at the back in the winter. Whatever the season, the most reliable indicator of correct or incorrect positioning of the furnace is its shadow, which must be symmetrical and as small as possible.

Before using a solar furnace

It is extremely importance to heat the empty solar furnace before it is used for the first time so that the glue and joints can dry completely.

Source: Adapted from Ékopédia, “Four solaire pour cuisson” [Web page] (accessed June 9, 2009). *[Translation]*

Name: _____ Group: _____ AST

Creating the context

I ask myself questions

1. What is solar energy?

2. Name some examples of applications of solar energy.

3. What are the advantages of using solar energy?

4. What are the disadvantages of using solar energy?

5. What is a development?

6. What type of drawing is used to represent a development?

7. What should you check to make sure your solar furnace configuration meets specifications?

Creating the context (*continued*)

I must

8. Reformulate the goal of the project.

_____

_____

_____

_____

I think

9. What design approach do you think is the most appropriate for the solar furnace? Draw the design plan for your furnace based on this approach. Make sure you specify the direction in which light rays must strike the device to maximize its efficiency.

Reflection

	Yes	No
• Does my design plan meet the project specifications?	☐	☐
• Do I fully understand the technological and scientific concepts related to this project?	☐	☐

Planning the project

I plan

1. Draw the development of the part you will bend and glue to form the solar furnace. Make sure you indicate the necessary dimensions.

NAME:	DATE:
TITLE:	SCALE:

Planning the project (*continued*)

2. Draw the technical diagram for your solar furnace. Make sure you include the following information:

- the materials
- the linking components
- the angles for bending the part
- any other useful information for making the solar furnace

Draw as many views of the furnace as you think necessary.

Planning the project (*continued*)

3. Make a list of the equipment and materials you will need to build your solar furnace.

4. What safety rules should you follow while building your solar furnace?

5. Make a list of the materials you will need to test the efficiency of your solar furnace.

Planning the project (*continued*)

6. How will you test the efficiency of your solar furnace? Describe the main steps of your test procedure.

7. Prepare a table for recording your results. Remember to give it a title.

Reflection

	Yes	No
Have I considered other approaches to building my prototype?	☐	☐

Completing the project

I build

1. Build your solar furnace, following your development drawing of the part and your technical diagram. If you alter your plan of action, make the appropriate changes in your diagrams and in the list of equipment and materials.

2. Did you work safely while you were building your solar furnace? Justify your answer with at least two examples of safety-conscious behaviour.

Reflection

	Yes	No
Did I record and justify each of the changes I made to my plan of action?	☐	☐

Name: _____ Group: _____ AST

Testing the prototype

I evaluate my prototype

1. Test the efficiency of your solar furnace. Record the results in the table you prepared on page 10.

2. Does your prototype fulfill the general purpose of the solar furnace? Explain your answer.

3. Does the prototype meet all the requirements of the project specifications? If not, explain your answer.

4. Did you inspect the furnace part during the machining and building phases? If so, what tools or instruments did you use? Explain your answer.

Testing the prototype (*continued*)

5. Did you alter your plan of action? If so, explain your answer.

6. Did you have any problems building your prototype?

7. What are the advantages of your solar furnace?

8. What are the disadvantages of your solar furnace?

9. What improvements would you make to your solar furnace design?

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My evaluation

Use the evaluation grid on the following page to evaluate yourself. Write A, B, C, D or E in the "Me" column of the chart below.

SSC1—Seeks answers or solutions to scientific or technological problems				
Criteria*	Observable indicators	Me	Teacher	Comments
1	**Creating the context** Definition of the goal and completion of the design plan		☐ With help	
2	**Planning the project** Relevance of the elements of the plan of action: development drawing, technical diagram and list of materials		☐ With help	
3	**Completing the project** Compliance with the plan of action and with safety rules		☐ With help	
4	**Testing the prototype** Analysis of the efficiency of the solar furnace		☐ With help	

*** Evaluation criteria**

1 Appropriate representation of the situation
2 Development of a suitable plan of action for the situation
3 Appropriate implementation of the plan of action
4 Development of relevant conclusions, explanations or solutions

Evaluation grid

Name: _____ Group: _____

AST

SSC1 Seeks answers or solutions to scientific or technological problems

Criteria*	Observable indicators	A	B	C	D	E
1	**Creating the context** Definition of the goal and completion of the design plan	The goal of the project is very clearly defined and relevant, AND the design plan is complete and relevant.	The goal of the project is clearly defined and relevant, AND the design plan contains a few minor errors.	The goal of the project is not very clearly defined or relevant, OR the design plan contains many errors.	The goal of the project is not very clearly defined or relevant, AND the design plan contains many errors.	The work must be done again.
2	**Planning the project** Relevance of the elements of the plan of action: development drawing, technical diagram and list of materials	The development drawing and technical diagram are complete and relevant. The list of materials is complete.	The development drawing and technical diagram contain a few minor errors. The list of materials is almost complete.	The development drawing and technical diagram contain many errors, OR many elements are missing from the list of materials.	The development drawing and technical diagram contain many errors, AND many elements are missing from the list of materials.	The work must be done again.
3	**Completing the project** Compliance with the action plan and with safety rules	The solar furnace respects the dimensions of the development drawing and the technical diagram, AND the work was done safely.	A few elements of the solar furnace do not respect the dimensions of the development drawing and the technical diagram, AND the work was done safely.	Many elements of the solar furnace do not respect the dimensions of the development drawing and the technical diagram, AND the work was done safely.	The solar furnace does not respect the dimensions of the development drawing and the technical diagram, OR the work was not done safely.	The work must be done again.
4	**Testing the prototype** Analysis of the efficiency of the solar furnace	The solar furnace is efficient and meets all the requirements of the project specifications. The advantages and disadvantages described are relevant.	The solar furnace meets most of the requirements of the project specifications. Most of the advantages and disadvantages described are relevant.	The solar furnace meets most of the requirements of the project specifications, but the advantages and disadvantages described are not very relevant.	The solar furnace does not meet most of the requirements of the project specifications.	The work must be done again.

***Evaluation criteria**

1 Appropriate representation of the situation
2 Development of a suitable plan of action for the situation
3 Appropriate implementation of the plan of action
4 Development of relevant conclusions, explanations or solutions