MODULE IV

Lesson Plan 1

Summary

Title

Solar oven

Duration	165 minutes
The age range of students	10-14

Summary of the theme

In this topic, students will learn basic concepts about solar energy and how this resource can be harnessed to cook food. The importance of using renewable energy will be emphasised, and creativity and teamwork will be encouraged to design and build functional prototypes. This project will integrate Science, Technology, Engineering, Art, and Mathematics (STEAM) concepts in a practical and ecological context.

Learning outcomes

Aim/Learning Objectives.

- Understand the concept of solar energy and its practical application in everyday life.
- Learn how to design and build a solar oven using recyclable materials.
- Promote environmental awareness and the importance of the use of renewable energies.
- Reflect on the reduction of the carbon footprint by using renewable energies.

Cross-cutting objectives

- Encourage cooperation and teamwork.
- Develop critical thinking and problem-solving skills.
- Promote environmental awareness and sustainability.
- Develop creativity and problem-solving skills.

Connection with Sustainable Development Goals

This theme is aligned with SDG 7 "Ensure access to affordable, secure, sustainable and modern energy for all" (Target 7.2: By 2030, substantially increase the share of renewable energy in the energy mix) and SDG 12 "Ensure sustainable consumption and production patterns" (Target 12.2: By 2030, achieve sustainable management and efficient use of natural resources).

Implementation

Facilitation

- Make sure all materials are ready before the class.
- Divide students into small groups of 3-4 to encourage collaboration.
- It provides examples of solar ovens and explains how they work.
- Supervises and guides the students during the construction of the solar oven.
- Conduct a solar oven test by cooking something simple like a marshmallow or a piece of chocolate.

Resources / Materials needed

- An empty pizza box
- Aluminium foil
- Transparent film
- Black cardboard
- Scissors
- Adhesive tape
- Glue
- A thermometer (optional)
- Test foods (examples: marshmallows, chocolate)

Ideas to continue

- Evaluate the efficiency of solar ovens in different climatic conditions.
- Investigate other applications of solar energy.
- Design and build different types of solar cookers.

Source / Classroom materials and preparation

- Video: "Solar Thermal 101": This video explains the basics of how solar energy is captured and used, including how solar cells work and the everyday applications of solar energy. Link: https://www.youtube.com/watch?v=FgjfJGfusdE
- Video: "Renewable Energy 101 | National Geographic": This video discusses the environmental and economic benefits of solar energy, highlighting its role in carbon footprint reduction and sustainability. Link: https://www.youtube.com/watch?v=1kUE0BZtTRc
- Solar thermal projects: "Solar Energy for Kids - Solar Schoolhouse" and "Make s'mores with a solar oven". Solar Thermal Energy projects designed specifically for primary school students. Links: https://solarschoolhouse.org/pizzabox/ and https://climatekids.nasa.gov/smores/

- Instructables Tutorial: Step-by-step tutorial for building a solar oven using cardboard and tape. Link: https://www.instructables.com/Cardboard-and-Duct-tape-Solar-Oven/

Topic outline

Time	Step-by-step instructions
30 min	Introduction to the topic To begin the lesson, students are introduced to the global problem of excessive use of fossil fuels and their impact on climate change, highlighting how these practices contribute to pollution and global warming. This will begin with a brief explanation of what fossil fuels (oil, coal, and natural gas) are and how they are used as the main source of energy in the world. It can be mentioned that these fuels are the remains of organisms that lived millions of years ago and that their use has been fundamental for industrial and technological development. Continue by explaining how the burning of fossil fuels releases large amounts of carbon dioxide (CO2) and other greenhouse gases into the atmosphere. These gases trap heat from the sun, leading to global warming. It is helpful to illustrate this with data or graphs showing rising CO2 concentrations in the atmosphere and rising global temperatures. Figure 4.1.1 is recommended as an example to illustrate the increase in global temperatures. In this graph, temperatures are in °F. The conversion from °C to °F is done based on the following equation: $$°C = \frac{(°F - 32)}{1.8}$$ Thus, 2°F equals approximately -16.7°C, 1°F equals -17.2°C and 0°F equals -17.8°C. It may be noted that in other countries, Fahrenheit degrees are used as a temperature unit (e.g. United States). As an activity, it is proposed that a temperature graph be created. For temperature data, instead of exact numbers, terms such as "Colder" and "Warmer" can be used on the y-axis, with cold (blue) and warm (red) colours to represent temperature variation. Figure 4.1.2 can be used to illustrate the global temperature increase. Figure 4.1.3 shows a template for working on the data with students in the classroom. Below is an example with 10 data points representing average global temperature anomalies (in °C) compared to a 20th-century reference average: ● 1980: -0.2°C ● 1985: -0.1°C ● 1990: +0.1°C ● 1995: +0.2°C ● 2000: +0.3°C ● 2005: +0.4°C ● 2010: +0.5°C ● 2013: +0.6°C ● 2016: +0.8°C ● 2020: +1.0°C

Figure 4.1.4 shows the graph.

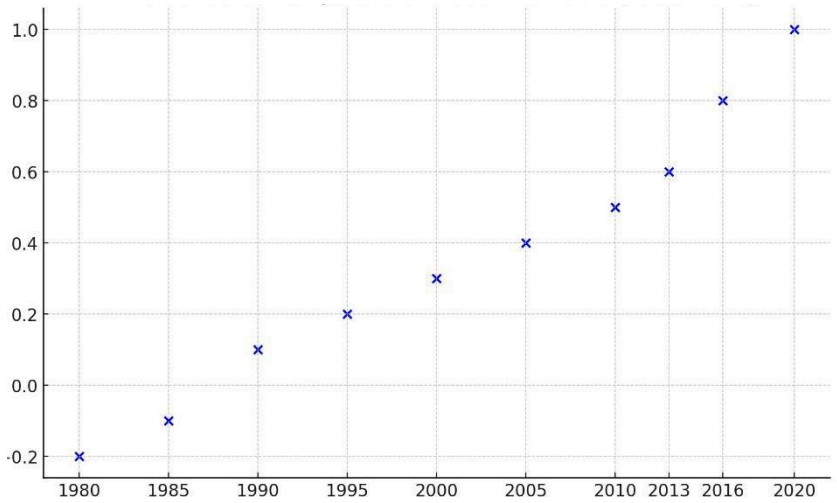


Figure 4.1.4 Evolution of temperatures over the years (graphic result)

If you wish to expand the study, you can use the following link to data for graphs: https://ourworldindata.org/co2-and-greenhouse-gas-emissions. In addition, you can compare the data for the last 20 years for the United States with China or India.

- The following resources are recommended:
  - Video: "Fossil Fuels for Kids". Link: https://www.youtube.com/watch?v=JasIvS7oYw4
  - Video: ""Climate Change: The Science" - NASA Climate Kids". Link: https://www.youtube.com/watch?v=EtW2rrLHs08
  - NASA website. "Do the Sun's natural cycles affect our climate?". Link: https://climatekids.nasa.gov/nasa-research/

15 min

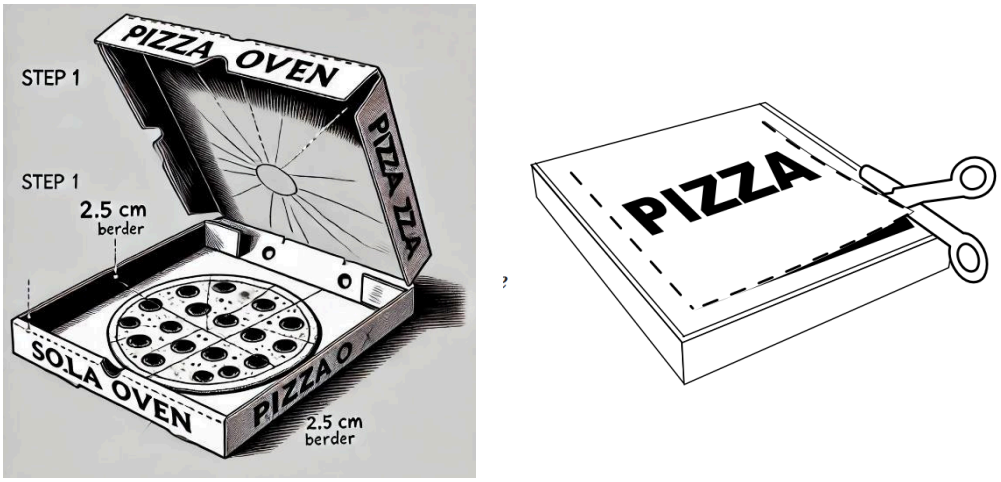
Solar thermal energy.

Solar energy is presented as a key solution, explaining that it is a clean and inexhaustible source that can reduce dependence on fossil fuels and mitigate climate change. Figure 4 can be used to show examples of thermal energy in the classroom. A practical demonstration can be done by inviting students to rub their hands together to feel the heat generated by friction and use a thermometer to measure the temperature change (see Figure 4.1.5). Point out that thermal energy can be produced in several ways:

- Friction: When two objects rub against each other, friction generates heat, increasing thermal energy.
- Chemical reactions: Some reactions, such as those that occur in a flame or gas cooker, release energy in the form of heat.
- Solar radiation: The sun emits energy in the form of light and heat, which can be captured by solar panels or absorbed directly by the earth, increasing the thermal energy in these systems.

It then specifically addresses solar thermal energy, defining it as the technology that harnesses solar radiation to generate heat, and details how it can be used in everyday applications such as cooking food in solar ovens and heating water for domestic use.

Educational videos to show in the classroom:

	- Explaining Solar Thermal Energy | Sustainability" video. Explains the basics of solar thermal energy, how it works, and its benefits, in an accessible and easy-to-understand format. Link: https://www.youtube.com/watch?v=X1aN9ADvgpw - Video "Solar thermal energy | Simply explained | Photovoltaics vs Solar thermal systems". Simply explain the difference between photovoltaic solar panels and solar thermal panels. Link: https://www.youtube.com/watch?v=JsAdmpq8zTU&t=2s
20 min	Presentation of examples and principles of operation of a solar oven. Describe the basic components of a solar oven, such as the reflective panels, the glass or transparent plastic that acts as a cover, and the thermal insulation, explaining how these elements work together to capture and retain solar heat: - Reflective panels: Generally coated with aluminium, they concentrate the sunlight inside the oven, increasing the intensity of the radiation. - Transparent cover: Allows sunlight to enter and retains the heat generated, creating a controlled greenhouse effect. - Thermal insulation: Materials such as cardboard or foam help to keep the heat inside the oven, preventing it from dissipating. To illustrate these concepts, visual resources are used, such as graphs showing the amount of solar energy available (Link to use: https://globalsolaratlas.info/map), highlighting the environmental benefits of solar energy, such as reducing the carbon footprint and promoting a more sustainable lifestyle. Also, indicate how solar thermal can contribute to energy security by providing a local and renewable energy source.
45 min	Construction of the solar oven in small groups. This activity has been developed based on the tutorials available at the following links: https://solarschoolhouse.org/pizzabox/ and https://climatekids.nasa.gov/smores/. Steps to Build the Solar Oven: Step 1. Preparation of the Pizza Box (Figure 4.1.6): - Cleanliness: Make sure the pizza box is clean and dry. - Cutting the Lid: With scissors, cut an opening in the lid of the box, leaving an edge of approximately 2.5 cm on three sides, creating a flap that can be lifted.  *Figure 4.1.6 Preparing the pizza box (step 1)* Step 2. Lined with Aluminium Foil (Figure 4.1.7): - Inside of the flap: Cover the inside of the raised flap with aluminium foil, making sure that the shiny side faces outward to reflect sunlight. Use masking tape to secure the foil.

- Inside the box: Also line the inside of the box with aluminum foil. This will help reflect sunlight and distribute the heat inside the oven.



Figure 4.1.7 Preparing the pizza box (step 2)

Step 3. Installation of the Insulation and Cooking Surface (Figure 4.1.8):

- Black Cardboard Base: Place black cardboard on the bottom of the box, on top of the aluminium foil. The black cardboard absorbs sunlight and helps to generate more heat.
- Securing Foil and Cardboard: Use glue or tape to secure the cardboard and foil in place, preventing them from moving.

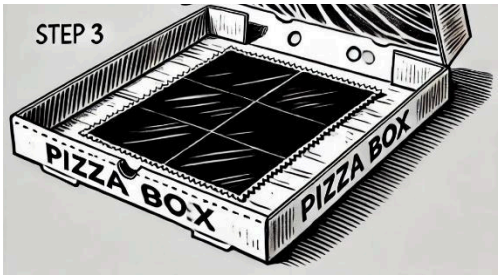


Figure 4.1.8 Preparing the pizza box (step 3)

Step 4. Cover with plastic wrap (Figure 4.1.9):

- Plastic Paper Window: Cut a piece of plastic wrap large enough to cover the flap opening. Attach the plastic wrap to the box using tape, creating a transparent "window." This step is crucial as the plastic wrap acts as a heat-retaining cover, creating a greenhouse effect inside the oven.

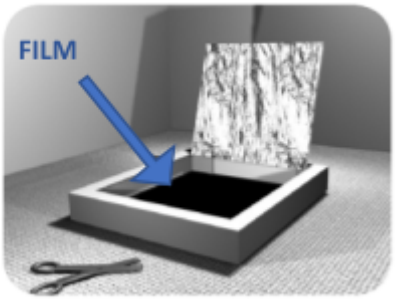
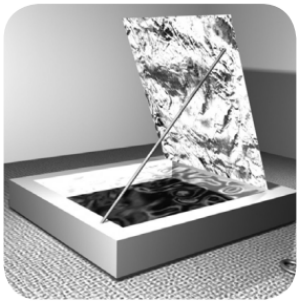


Figure 4.1.9 Preparing the pizza box (step 4)

Step 5. Adjusting the Reflective Flap (Figure 4.1.10):

	- Flap Angle: Use a skewer stick or rod to hold the flap at an angle that reflects as much sunlight as possible into the box. Adjust the angle according to the position of the sun to maximise the efficiency of the oven.  *Figure 4.1.10 Preparing the pizza box (step 5)* It is recommended to watch the following video with tips on solar oven development: https://www.youtube.com/watch?v=fsn4YW9d3aU
45 min	Test the solar oven by cooking simple food. - Location: Place the solar oven in direct sunlight. If possible, orient the box towards the south (if you are in the northern hemisphere) and towards the north (if you are in the southern hemisphere) to maximise solar exposure. You can use this time to use a compass or mobile app to help determine the correct cardinal orientation. o The following activity is proposed: ▪ Provide students with compasses and teach them how to use them. ▪ Ask them to determine the southern orientation in the northern hemisphere (or northern in the southern hemisphere) and position the solar oven in that direction. Explain that orientation refers to the direction in which the solar oven is placed to maximise exposure to the sun. ▪ Discuss how this orientation maximises sunlight capture. Use everyday examples, such as how plants grow better where they receive more sunlight, to illustrate the importance of orientation. Proper orientation allows the reflective flap to direct the maximum amount of sunlight into the oven, which is converted into heat. This increases the efficiency of the baking process by maximising the internal temperature. - Experimentation: The aim is for students to understand how the inclination of the reflective flap and the position of the oven affect the amount of sunlight captured. Explain that the angle at which the sun's rays hit the surface of the solar cooker affects the amount of energy captured. When the sun is lower in the sky, sunlight travels through more of the atmosphere, which reduces the amount of energy available. o The following activity is proposed: ▪ Conduct a small experiment in which solar ovens are placed in different orientations, and the internal temperatures are measured after some time. It is also recommended that some of the groups experiment with the lid open at an angle between 30° and 45° and others with the lid closed. Use thermometers for comparison. Ask the students to record the temperatures in a notebook (e.g. every 5-10 minutes). They should also record the total cooking time and the outside (room) temperature. ▪ After the explanation and the experiment, ask the students which orientation they think is the best and why. At the end of cooking the food, the records can be compared, and the temperature changes can be observed. Encourage students to think about how they could adjust the orientation throughout the day.

	o As the sun moves throughout the day, it may be necessary to adjust the orientation of the solar oven to maintain maximum exposure. This involves turning the oven slightly or adjusting the angle of the reflective flap. - Example of food to cook: Baking S'mores: Place the ingredients for s'mores (a biscuit with a marshmallow and a piece of chocolate on top) on a plate or directly on the black cardboard inside the oven. Close the box, ensuring the reflective flap directs light into the box. Depending on the sun's intensity, the s'mores should be ready in about 30 minutes to an hour. Monitor the process without opening the oven to avoid heat loss. - Temperature Measurement: If a thermometer is available, it can be used to measure the temperature inside the oven and observe how it changes over time.
10 min	Discussion and evaluation of the efficiency of the solar oven. Start by explaining to the students that the activity will focus on assessing the solar oven's ability to cook food and identifying the factors that influence its efficiency. Review the results of the groups. Ask if the food was fully cooked and how long it took. Compare the internal temperatures with the external temperatures and discuss the effectiveness of the ovens (according to the orientation and inclination of the lid). You can also discuss how the weather (cloudy, sunny, windy) might have influenced the efficiency of the solar oven. Invite students to think about how they could apply what they have learned to their daily lives to improve energy efficiency. Discuss the importance of orientation in a house (for air conditioning, both heating and cooling).

Formative evaluation

- Classroom observations.
  - Description: Teachers observe students during the construction and use of the solar oven, taking notes on their participation, collaboration, and application of concepts.
  - Objective: To assess students' level of understanding and their ability to apply the knowledge acquired in a practical activity.
  - The following heading is proposed:

Evaluation Rubric for Classroom Observations

Criterion	Excellent (5)	Very Good (4)	Good (3)	Adequate (2)	Insufficient (1)
Understanding Concepts	Demonstrates a thorough understanding of solar energy and its application, explaining it clearly and accurately.	It shows a good understanding, with some advanced ideas or applied examples.	Understands basic concepts, with generally correct explanations.	It has a basic understanding but needs clarification on several points.	Shows little understanding of concepts, with significant errors.
Practical Skills	The construction of the solar oven is carried out accurately and creatively, with attention to detail and without errors.	Completes the task accurately, making minimal errors that do not affect performance.	Complete most of the steps correctly, with some minor errors.	Complete oven with significant but functional errors.	It presents considerable difficulties, with an end product that does not meet basic requirements.
Teamwork	He collaborates exceptionally, leading, motivating, and actively helping others.	Collaborates effectively, contributing consistently and supporting colleagues.	Participate appropriately, with useful contributions and general cooperation.	Participates on a limited basis, with occasional contributions and need for guidance.	Minimal or negative participation, with little or no contribution to the team.
Active Participation	Participate actively in all activities and discussions, showing	Participates regularly, with interest and commitment	Participates adequately, albeit with less	Participates only when asked, showing little	Participates rarely or not at all, showing obvious

	enthusiasm and curiosity.	evident in most activities.	enthusiasm or frequency.	interest or commitment.	disinterest in the activity.
Reflection and Evaluation	It offers in-depth and critical reflections, clearly identifying lessons learned and areas for improvement.	It provides detailed reflections, with some critical ideas and suggestions for improvement.	Reflects on the process and results with a general understanding.	Reflects superficially, with few clear ideas for improvement.	It does not provide meaningful reflections or show a lack of understanding of the process and outcomes.

Usage Notes:

- Adaptation and Context: The rubric should be adapted to the specific context of the activity and the learning objectives of the class.
- Feedback: It is recommended that detailed feedback along with the marking is provided to help learners understand how to improve.
- Involve Learners: Consider using this rubric in self- and co-assessments to encourage self-reflection and collaborative learning.
- Calibration: Ensure that all evaluators (if there is more than one) use the rubric consistently to ensure fairness in the evaluation.

- Questionnaires.
  - Short questionnaires will be used at the end of the sessions to assess the understanding of key concepts and the effectiveness of the activity.
  - Aim: To obtain a quantitative measure of learning and retention of information.
  - The following quiz is proposed to be implemented in one of the sessions. It can be transferred to Quizziz or Kahoot and made interactive:

Questionnaire on the Principles of Operation of Solar Ovens

1. What is a solar oven?
   a) A device that converts sunlight into electricity.
   b) A device that uses sunlight to cook food.
   c) A type of oven that runs on electricity.
   d) A furnace using nuclear energy.

2. Which of the following materials is commonly used to build a solar oven and why?
    a) Metal, because it is heat resistant.
    b) Glass, because it lets in light but retains heat.
    c) Cardboard, because it is a good insulator.
    d) Wood, because it is cheap and easy to find.
3. What is the purpose of aluminium foil in a solar oven?
    a) It acts as an insulator.
    b) Attracts insects.
    c) Reflects sunlight into the oven.
    d) Prevents the oven from overheating.
4. How is heat maintained inside a solar oven?
    a) Using an electric heat source.
    b) Trapping solar radiation inside with a transparent cover.
    c) Using fans to circulate the hot air.
    d) Place charcoal in the bottom of the oven.
5. Why is it important that the lid of the solar oven is transparent?
    a) To cook food faster.
    b) To allow sunlight to enter and be converted into heat.
    c) To protect food from external contaminants.
    d) So that the inside of the oven can be seen without opening it.
6. Which of the following factors does NOT significantly affect the efficiency of a solar oven?
    a) The orientation of the oven towards the sun.
    b) The amount of aluminium foil used.
    c) The brightness of the day (whether it is cloudy or sunny).
    d) The type of food cooked.
7. Solar ovens are a form of renewable energy - what does this mean?
    a) The solar oven can be used many times.
    b) Using an energy source that is naturally replenished.
    c) It is cheaper than conventional ovens.
    d) That it is a new product on the market.

Correct Answers:

(b) A device that uses sunlight to cook food.
b) Glass, because it lets light through but retains heat.
(c) Reflect sunlight into the oven.
b) By trapping solar radiation inside with a transparent cover.
b) To allow sunlight to enter and be converted into heat.
d) The type of food cooked.
b) It uses an energy source that is naturally replenished.

Feedback

Net Promoter Score (NPS) is a widely used tool to measure the loyalty and satisfaction of customers or, in an educational context, students. It measures the likelihood that students will recommend the subject or course to others.
How to analyse and apply NPS is explained below:

Development of the NPS question:

- Main question: "On a scale of 0 to 10, how likely are you to recommend this topic to other students?
- Follow-up questions: "Why did you select this score?" and "How can we improve this issue?

Collection of responses:

- Digital surveys: Use online tools such as Google Forms, SurveyMonkey, or Typeform to collect student responses.
- Paper surveys: Paper questionnaires are distributed at the end of the lesson for students to complete. A template for collecting responses with paper surveys is shown in the Annex.
- Interactive applications: Interactive applications such as Quizziz, Mentimeter, or Kahoot! are used to collect answers in real-time.

Classification of responses:

- Promoters (Score 9-10): Students are very satisfied and likely to recommend the subject.
- Passive (score 7-8): Satisfied, but not enthusiastic students; they could easily change their minds.
- Detractors (Score 0-6): Dissatisfied students who are unlikely to recommend the subject; they could provide constructive criticism.

Calculation of NPS:

- Formula: NPS = % of promoters - % of detractors.
- Score interpretation: NPS ranges from -100 to +100. A positive score (above 0) is generally good, and a score above 50 is excellent.

Analysing and using comments:

- Review the comments to understand the reasons behind the scores.
- Identifies patterns and specific areas for improvement among detractors and passives.
- Use the promoters' positive comments to reinforce the positive aspects of the issue.

Annexes

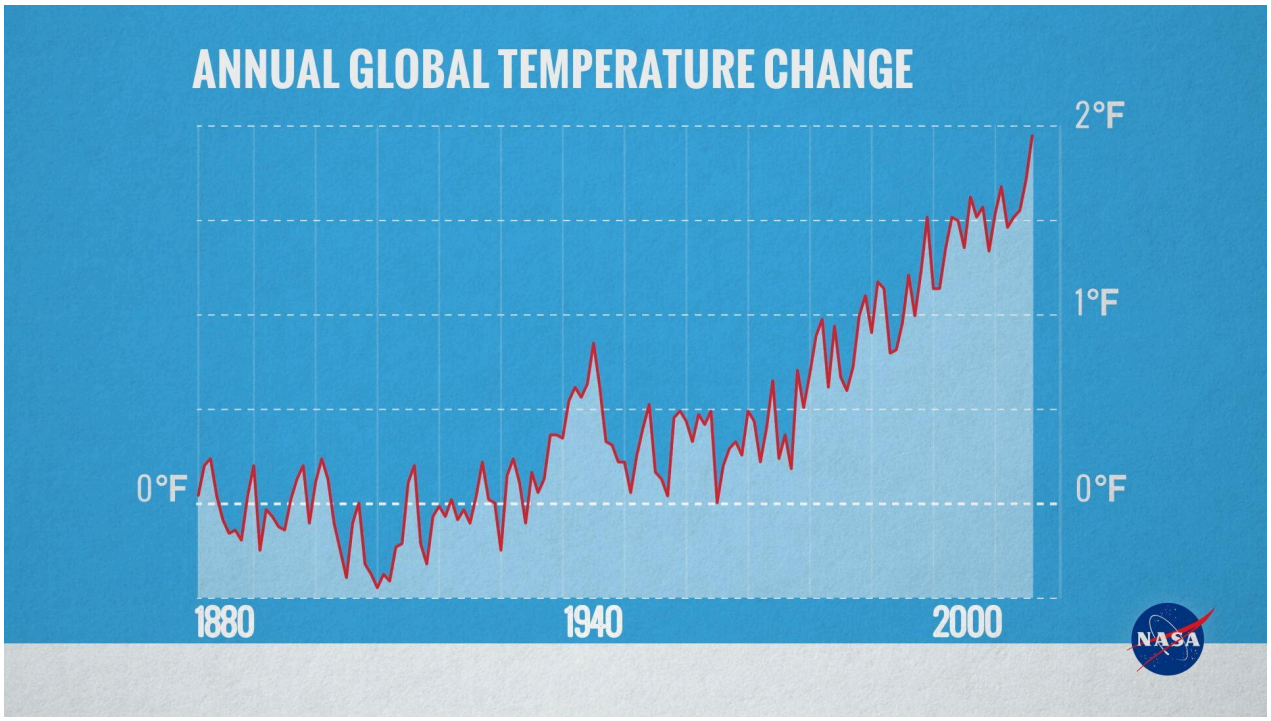


Figure 4.1.1. Graph of global annual mean temperature change. Source: NASA's Goddard Space Flight Center (https://climatekids.nasa.gov/climate-change-meaning/)

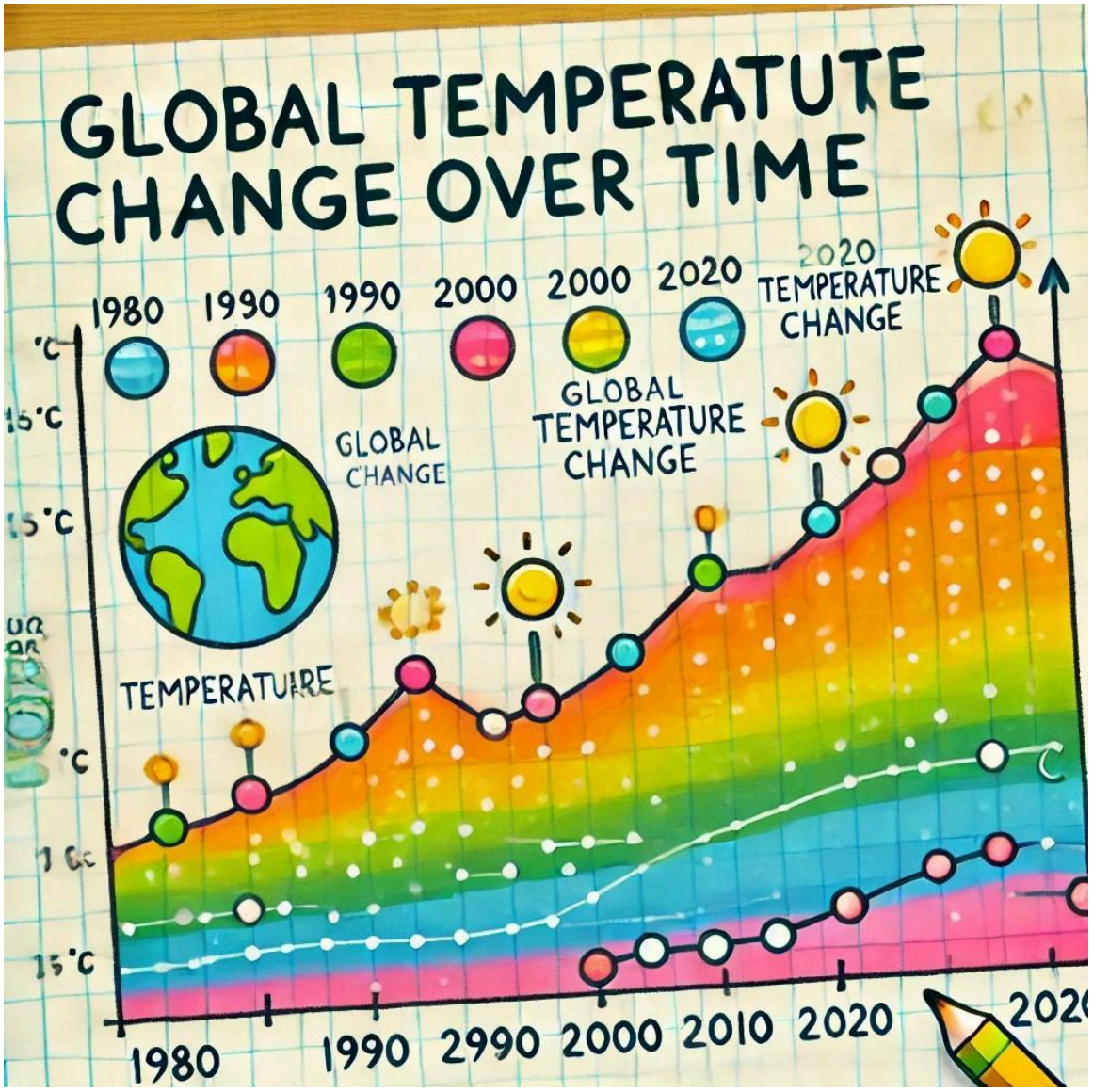


Figure 4.1.2. Example of a poster/graphic design to be used in the presentation of the topic. Source: Own elaboration

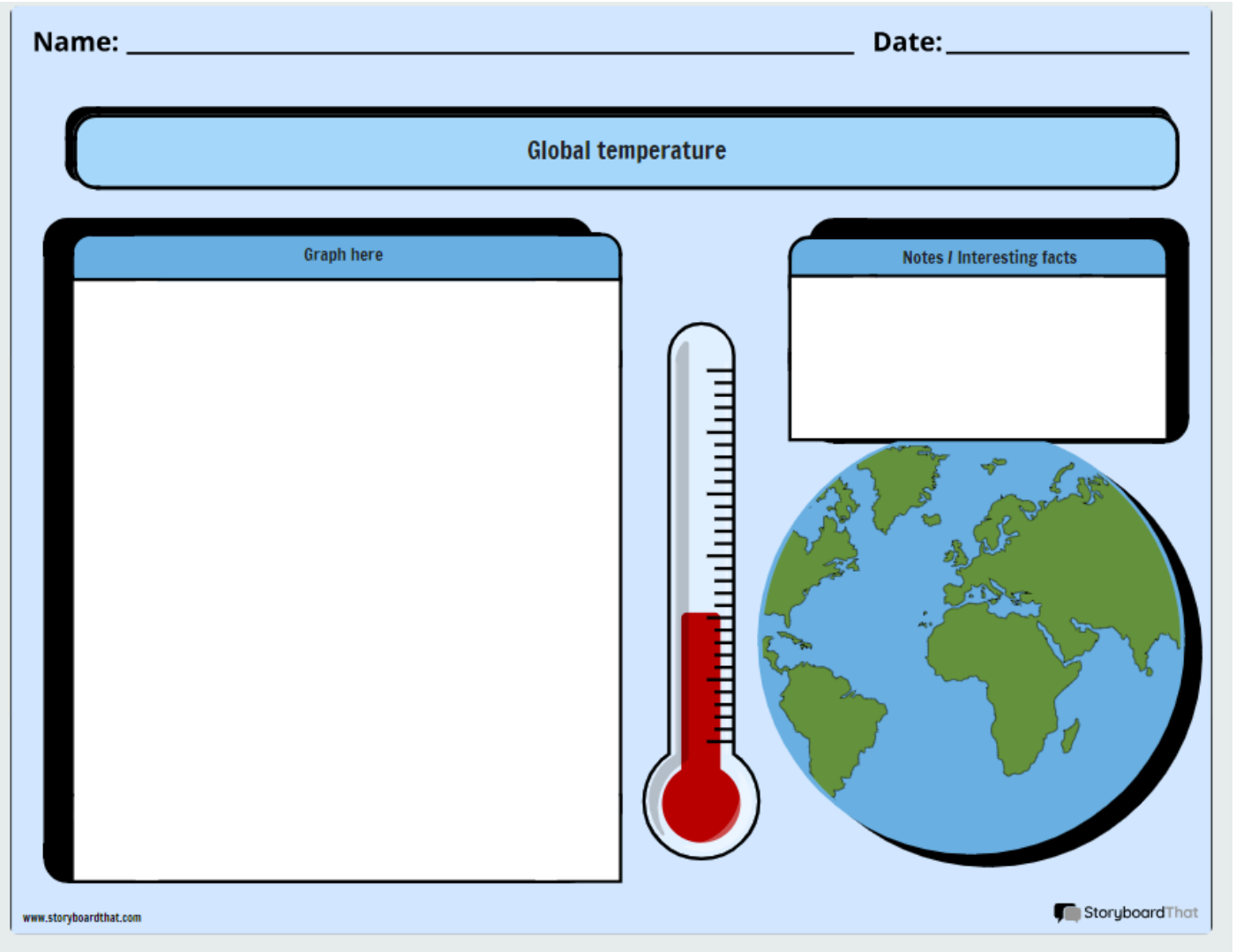


Figure 4.1.3. Template for temperature charting work. Developed with the Storyboardtaht tool (https://www.storyboardthat.com/).

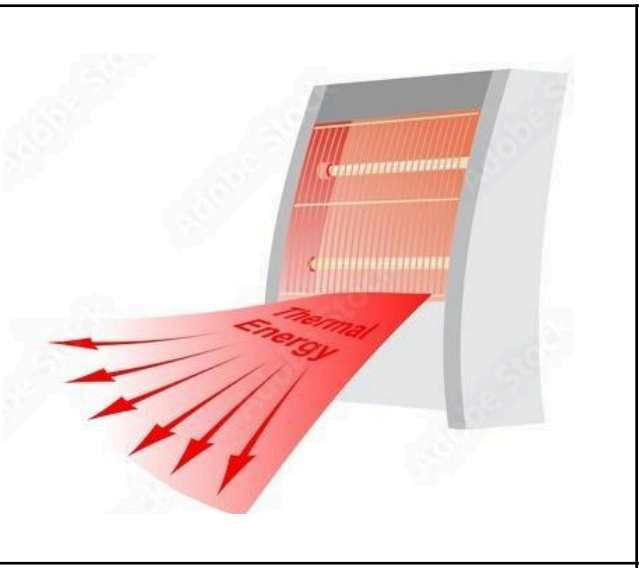
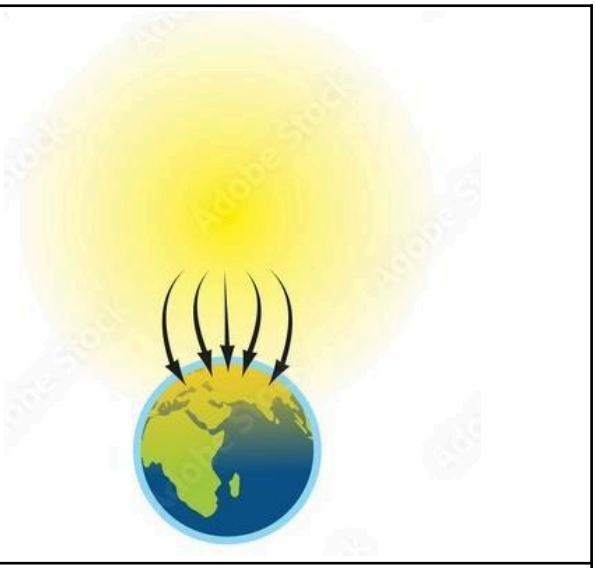
	
Heater	Solar radiation
	
Cooker / Stove	Hand rubbing

Figure 4.1.5. Examples of thermal energy. Source: www.stock.adobe.com

QUESTIONNAIRE TO COLLECT FEEDBACK ON THE TOPIC

On a scale of 0 to 10, how likely would you recommend this subject to other students?

0	1	2	3	4	5	6	7	8	9	10

Not likely at all Extremely likely

Why did you choose that score?

How could this issue be improved?