Title: *Discover temperature … Look the screen!*

Topics: Heat, Temperature and Energy	**Time**: 5-6 lessons per 45 minutes	**Age**: 09 – 11 years old pupils

Differentiation:	**Guidelines, ICT support etc.:** LIM, PC,
SEN students: To discuss the topic with the use of LIM could help SEN students **Gifted and talented students:** Topic motivates creativity and metacognition.	

Equipment needed for this activity:

- Real-life, everyday objects
- Temperature and Heat sensors (Go-temp from Vernier and the software accompanying it, Logger-Lite, www.vernier.com)
- LIM

Required knowledge: basic knowledge about variable relation and simple graph representation

Health and Safety:

Learning outcomes for this activity: The cognitive problem (that is, the object of knowledge that activates the modelling process) that arises students is related to heating. We start from the initial observation that heating is obtained in different ways (by contact, friction , by radiation) in order to build a common *explicative model* of what happens at the macroscopic levels in the different modes of heat transfer.

The activity is divided in two phases. In the first one students starting from simple experimental activities, familiarize with the concept of temperature.

In the second phase a concrete approach to warming experienced in daily life and thermal energy obtained by friction is developed in the laboratory. The students are encouraged to verbally describe the phenomenon.

Lesson description:

<u>Starter Activity</u>

Math teachers and Science ones discuss and cohoperate each other, trying to define their need as "independent teacher" of the two disciplines.

As Maths teacher, in winch way I can use this activity? As Science teacher, in winch way I can use this activity? And ... what if we define a collaborative work?

(Math and Science competences).

After this first discussion phase, a collaborative work with pupils will be activated.

Is it possible to study a real phenomena and to observe it trough a mathematical lent?

<u>Main Activity</u>

<u>The first lesson</u>

- *Brainstorming* about temperature and heat. Example from real file.

- *Observation*: The pedagogical sequence begins with the simple observation of the world around us, which leads to catalogue real substances in the three states of aggregation. The sequence continues through a quantitative characterization of variables, such as volume, mass and temperature (Activity 1).

The basic idea of this first activity is related to the link between the concept of temperature and the sense of touch!

- *Written report* (or drawing) of the activities by students.

<u>The second/third lesson</u>

- *Temperature variation:* heating of the bodies is presented qualitatively (the way in which the temperature varies). Heating can occur by contact with heat sources, by friction and radiation, and then heating by heat is experimentally analysed (Activity 2).

Possible teacher stimuli questions: *When have two objects the same temperature? When has one object a grater/less temperature than the other one?* …

Cause-effect relationship: finally, teacher discusses the equivalence of the three typical mechanisms of heat transfer in terms of the same behaviour in a cause-effect relationship (Activity 4). Example could be a pot of boiling water, the ice melting, expansion of metals ...

- *Written report* (or drawing) of the activities by students.

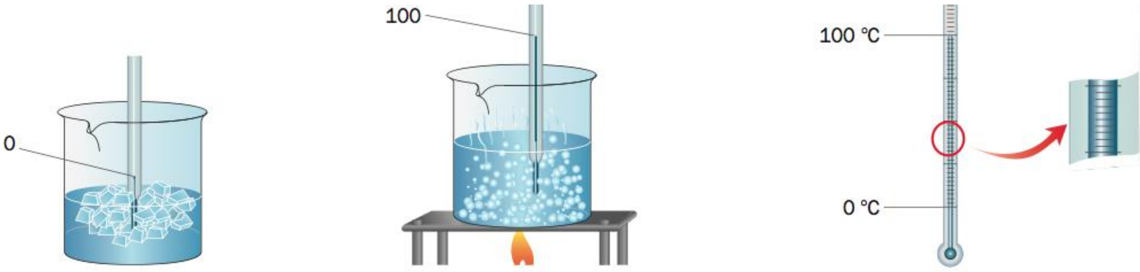
The fourth lesson

- *The thermoscope: discover and construction*. During this phase Math and Science teachers will construct a thermoscope.

Possible teacher stimuli questions: *What can we observe using it?, Who can we build it? What are the variable that we have to control studying the thermoscope behaviour?*

- *The thermometer*: after a long discussion with students, the teacher presents a common tool for students to measure temperature, i.e. the clinical thermometer, asking students about its "use": *What can we observe using it?*

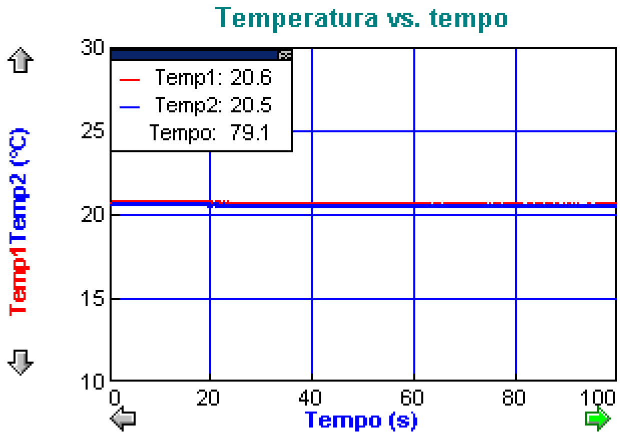
- With the aim to underline the structure of the scale of the thermometer scale, teacher presents the Celsius scale, its history and its experience:



- *Written report* (or drawing) of the activities by students.

The fifth/sixth lesson

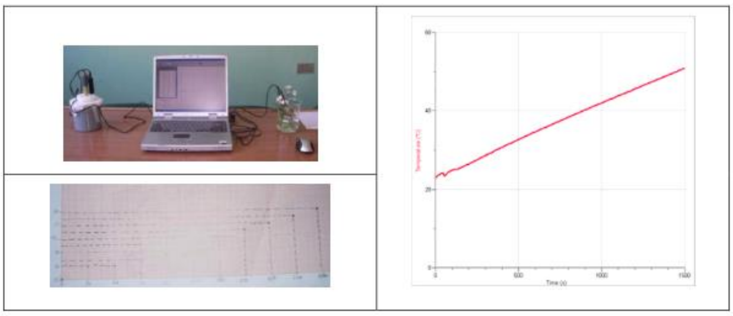
- Measurement ... Look the screen... What can we say?

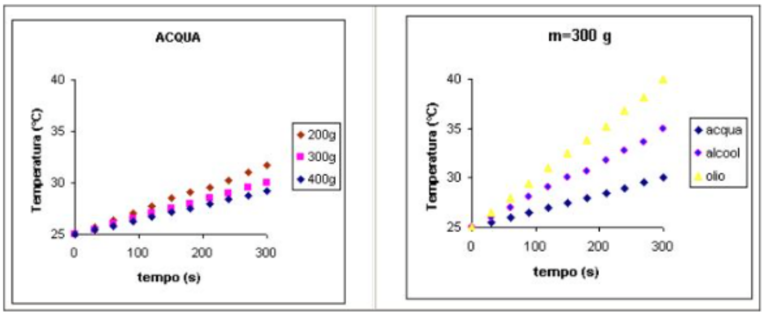


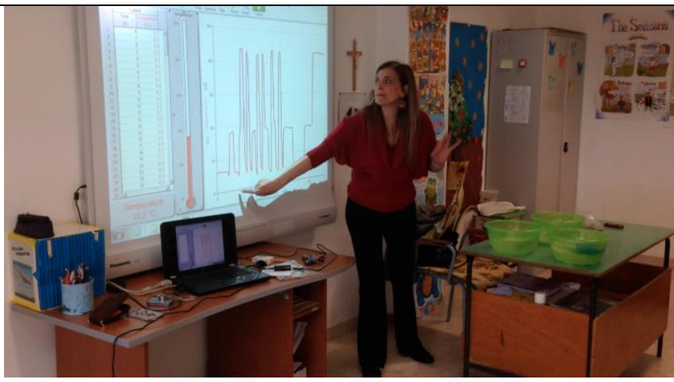
After the free trial phase, a typical water heating experiment is carried out through a heater aquarium. Students are asked to reflect on the possibility that different substances or different quantities of the same material may warm differently, asking them to make *predictions* about the role of the variables "mass" and "nature of substance ".

- *Discussion and comparison*: other experiments are performed by varying the masses or the substances. From the experiments the teacher extracts a possible data table that students report on a graph. The student expectations are compared in large group, with the results that emerge from the comparison of the graphs (analysis of temperature variations, analysis of the line slope). This leads to the construction of a simple predictive model on the variation of temperature in relation to the mass and to the substance.

Possible teacher stimuli questions: *can we predict the temperature of a body? How can we interpret this phenomena studying the graph and its geometry?*







- *Generalization*: Teacher presents a gallery of different temperature phenomena compositions. Students discuss about graphs and identification of possible pattern.

- *Written report* (or drawing) of the activities by students.

Plenary Presentation

Discussion about the activities made by pupils, to other classes: various aspects of the topic and possible integration.

The seventh lesson

In the first phase, concluded in the precedent lesson, the concept of temperature was introduced in a simple way. By means of simple experimental activities the students familiarized with the temperature concept.

In this phase we propose experimental activities with regard the real life problem. In particular we want deal with the thermal insulation of a house.

Testing a house model

Learning Path

This sub unit introduces basic concepts such as heating/cooling rates, energy conservation, conduction, convection, and radiation. It also aims at recalling previous learned concepts of heat, temperature and thermal equilibrium by taking into account the well known misconceptions held by students at this school level.

At the end of this unit, students should have a basic understanding of some physical processes, such as how heat transfer occurs between the house and the environment under different weather conditions.

Students will be involved in constructing a scale model house using a hands-on kit supplied by the teacher. They will learn to use sensors to measure the heat gain or loss and evaluate insulation. They will explore different heating and cooling factors using the tools provided and other low-cost materials on hand. For instance, a light bulb (covered by an aluminium foil) models the heather, the effects of wind can be simulated using an electric fan, and sun shining heating by using a lamp.

The unit involves 3 student learning activities:

a. Activity 1 aimed at the construction of different kinds of house models and at evaluating the main difficulties in maintain them warm;

b. Activity 2 aimed at analysing the distribution of temperature inside the house model;

c. Activity 3 aimed at analysing the heating effects of light on the house models.

The following table characterises the three activities

Activity	***Student Task***
1	Discussing and experimenting how to maintain warm a house model
2	Experimenting distribution of temperature inside the house model
3	Hypothesizing and experimenting the sunshine effects on the house model temperature

Activity 1: How to maintain warm your house model

The Problem:

In winter we need energy to maintain warm our house. By using suitably designed house models it is possible to analyse how much energy it takes to warm each model house 5°C warmer than the air around it.

Learning aims:

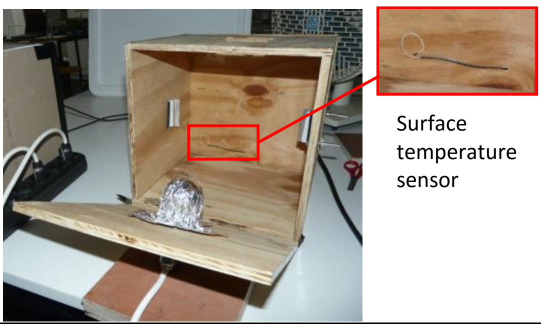
The main objectives of such activity are to:

- design an experiment to measure the heating and cooling of different house models by using the same heating procedure;
- identify the different factors that can influence the heat dispersion and control them in the design;
- Measure how much energy is necessary to warm each house model 5°C warmer than the environment.

Materials:

- Boxes of different materials (of equal dimensions) modeling different kinds of house.
- Temperature sensors to put in the wall opposite to the heater.
- Heaters (light bulbs covered by aluminium sheets)

Suggestions for use:



Different groups of students can be supplied with different house models having the same dimensions and constructed using different materials. The heater and the sensor are placed as reported previously.

The main problem is to test how fast their house models heat up and then cool down with a known power source (the heater).

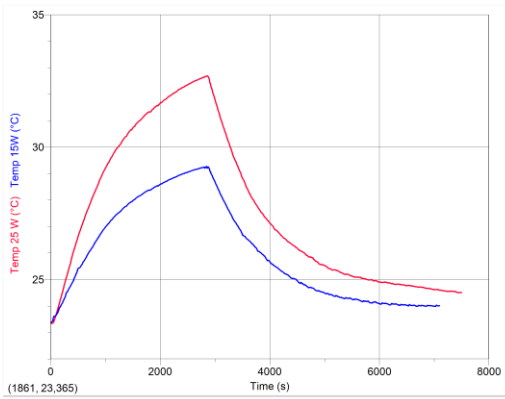
Students are asked to :

- Turn on the heater and register the temperature until it reaches approximately the value of T_{env} (Room temp) +5°C.
- Then, turn off the heater so that the temperature lowers until room temp.
- Record the times in which the heater is turned on and off.
- Calculate the time amount the heater has to be on to keep the house warm (T_{env} +5°C).

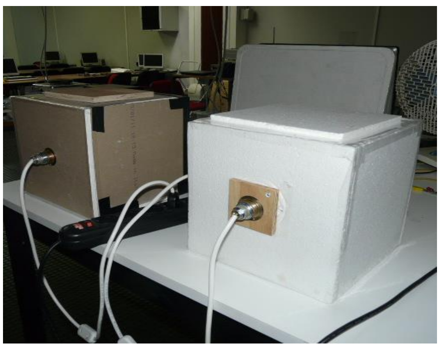
Each group will report to the whole classroom its results in order to point out what model is better for saving energy.

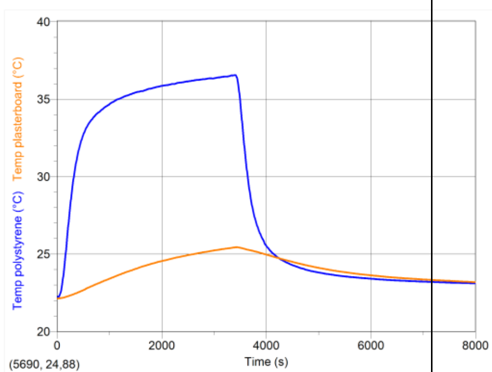
The following images show some temperature data from different houses under different thermal conditions.

1. Heating-cooling cycle of the wooden house model warmed by a 15 W lamp (blue line) and 25 W lamp (red blue line):



2. Heating and cooling curves of house models constructed with plasterboard core vs. po





NOTE

In this activity the teacher can introduce students to the different types of thermometers. Starting from the familiar mercury-in-glass one, the teacher can present and discuss the use of modern digital thermometers, based on semiconductor probes, and infrared ones, that allow to measure the temperature of distant objects, without having to have a "physical" contact with it.

Then, microcomputer based temperature sensors can be presented and, in particular, the surface type one, that will extensively used in this and in the following activities.

As a last step, photos of thermograms can be shown, in order to introduce students to thermal/colour analysis, a subject that will be deepened in the fourth sub-unit.

Possible questions:

How do you think you could reduce the power necessary to maintain warm a worm house ? What would you change about your to minimize the necessary power to keep the house warm and why?

Activity 2: How is the temperature distributed inside your house model ?

The Problem:

It is easy to observe that inside a heated room different places are not at the same temperature. How can we identify places at higher temperatures?

Learning aims:

The main goal of such an activity is in understanding that variations of temperature are present inside the house in places at different distances from the heater and at different heights from the floor.

Materials:

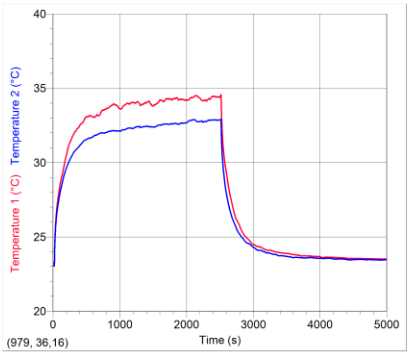
Materials are the same as Activity 1, yet for each group of students two temperature sensors are necessary.

Suggestions for use:

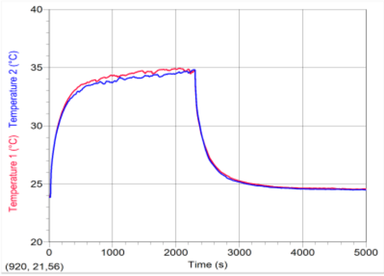
Students are requested to analyse temperature distribution inside the house.
A preliminary discussion will guide students to identify the factors that affect the temperature in a given position. Distance from the heater and height from the floor can be identified as relevant factors.

Students are requested to design appropriate experiments that take into account the control of the relevant variables.

- **Two sensors at the same distance from the heater and at different height from**
- **the floor**



○ **Two sensors at the same distance from the heater and at the same height from the floor**



Possible questions:

- What can you say about the efficiency of a heater mounted high on the wall of a room
- Can you infer a mechanism explaining why cool air goes upward?

Activity 3: What is the effect of sunlight on the temperature inside your house model?

The Problem:

It is easy to observe that bodies are heated by the sun shining. This can be also the case for walls of our house models. How materials can influence the temperature inside the house?

Learning aims:

The main goal of such an activity is the analysis of solar effects on the house temperature. Specific objectives are the following:

- to point out the effect of wall colours on the radiation absorption;
- to make evident that the house model temperature is affected by absorption and condu
- to be able to make prediction on the basis of everyday experience;
- to be able to justify evidence on the basis of everyday experience.

Materials:

- Boxes of different materials (of equal dimensions) modeling different kinds of
- house (see Activity 1.
- Temperature sensors to put in the wall opposite to the heater
- A light bulb simulating the sun.

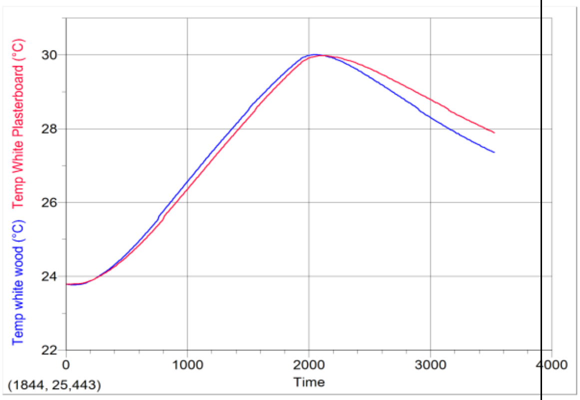
Suggestions for use:

In order to analyse the effect of an outdoor heating source we add a very bright light bulb (200 W) outside as the "sun".
Students are requested to test the effect using a temperature sensor posed on the wall opposed to the lightened wall.

A different experiment can be performed by using both the heaters (internal and external), for example by turning the internal heater on and off, but leave the sun on all the time.

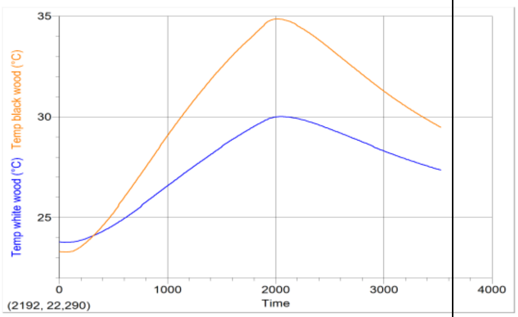
- **Two different boxes (wood and plasterboard) heated with the same "sun".**

Two models with walls of different materials are heated by the same lamp. Figure shows two heating and cooling curves.



- **Two external wall of the same box painted of different colours**

The experiment is performed by painting black and white two outer walls of one house model and lightning them by the same lamp. The figure shows the two heating and cooling curves.



<u>Teacher notes</u>

The selected topic and idea are linked to the possibility to reflect:

- to develop an adequate ability to analyse problem situations in different areas;

- to solicit observation, reflection, the ability to formulate hypotheses and to make conjectures, - to lead to a correct and aware of the tools of the discipline;

- to start a rigorous use of language-specific;

- to solicit support hunches, guesses, procedures with arguments of justification;

- to define a critical analysis of results and their verification.