UNIT 4: Testing a Model Building

This unit is comprised of 3 activities which are outlined in table 4.1. These activities have been informed by the ENERGE Energy Literacy Framework. A guide to the ENERGE Energy Literacy Framework can be found in UNIT 0. This unit deals with the idea of a model house that uses less energy to heat the rooms and makes use of scientific discoveries and technological resources to minimize energy consumption. The house analysis will be the starting point to explore some important scientific concepts related to heating and cooling of bodies and to heat transfer. Through constructing models of polystyrene, wood, plastic and cardboard, warmed by a light bulb placed inside, students apply the same principles of science and engineering that are taken into account in the construction of a real house. In many countries a large percentage of energy consumption is due to heating and cooling of buildings. Therefore, the search for more efficient methods of construction to improve the energy efficiency of buildings is extremely important. Less energy means less fossil fuels and thus a lower amount of carbon dioxide in the atmosphere The activities in this unit are suitable for lower and upper second level students. The energy literacy outcomes, the associated skills & competencies addressed and how the activities link to the national curricula are outlined in tables 4.2-4.2.

OVERVIEW of UNIT 4 My Energy Footprint

Table 4.1 Activities and titles are given, the time required to complete the activity and the ISCED classification.

	Activity Title	**Estimated time (min)**	**Level**	
			ISCED 2	**ISCED 3**
Activity 4.1	Investigating how to maintain warmth in a house model	30-45	X	X
Activity 4.2	Investigating how heat is a distribution of temperature	30-45	X	X
Activity 4.3	Investigating the effects of sunshine on internal temperature	30-45	X	X

Activities Mapped to Subjects in National Curricula

Table 4.2 Activities are mapped to subjects in National Curricula

	Science	Technology Informatics	Engineering	Mathematics	Home Economics	Geography	English	Design architecture	Civics & politics	Society & Health	Business Economics
Activity 3.1	X	X	X		X			X			
Activity 3.2	X	X	X		X			X			
Activity 3.3	X	X	X		X			X			

Activities Mapped to Energy Literacy Characteristics

Table 4.3 Activities are mapped to Energy literacy Characteristics.

	C1	C2	C3	C4	C5
Activity 4.1	X	X	X		
Activity 4.2		X	X	X	X
Activity 4.3		X	X	X	X

Skill & Competencies Addressed

Table 4.4 Activities are mapped according to Skills & Competencies addressed.

	Decision Making	Problem Solving	Design/innovating	Data Analysing	Collaborating	Communicating	Research	Critical Thinking	Numeracy
Activity 4.1		X	X	X	X	X	X	X	
Activity 4.2	X	X		X		X	X	X	X
Activity 4.3		X	X	X				X	X

Activity 4.1 Investigating how to maintain warmth in a home model

In this activity, students design experiments to measure the heating and cooling of different house models by using the same heating procedure. Students identify the different factors that can influence the heat dispersion and control

Suggestions for use:

them in the design and measure measure how much energy is necessary to warm each house model 5°C warmer than the environment. This activity was adapted from the ESTABLISH project which included a consortium of over 60 teachers across European countries. The ESTABLISH Teaching and Learning Units conform to the ESTABLISH definition of Inquiry Based Science Education (IBSE) and link to real world and industrial applications.

Duration	
• 30-45 minutes	
Energy Literacy Characteristics addressed:	
C1	Has a grounded understanding of the science and how energy is harnessed and used to power human activity.
C3:	Students are sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources.
C4	Students are cognisant of the impact of personal energy-related decisions and actions on the global community.
Skills & Competencies addressed:	
• Critical Thinking • Problem Solving • Numeracy	• Designing • Data Analysis • Collaborating

Subject links in National Curricula:	
• Technology & Informatics • Design & Architecture	• Science • Engineering
Level	
• ISCED 2 • ISCED 3	

1. 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 in Fig.

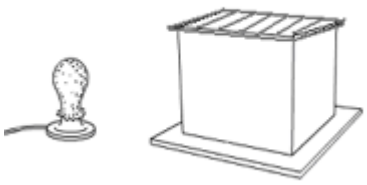


Fig. 1. Building Model Setup

2. The main problem is to test how fast their house models heat up and then cool down

with a known power source (the heater). Ask students to:

- turn on the heater and register the temperature until it reaches approximately the value of Tenv +5°C.
- Then, turn off the heater so that the temperature lowers until Tenv. 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 (Tenv +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.

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

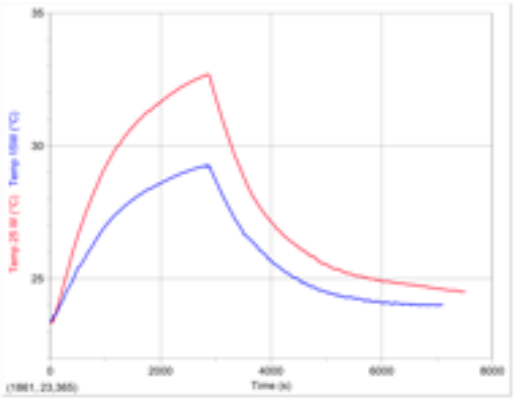


Fig. 2. Heating-cooling cycle of the wooden house

4. Heating and cooling curves of house models constructed with plasterboard core vs. polystyrene with a 25 W heater.

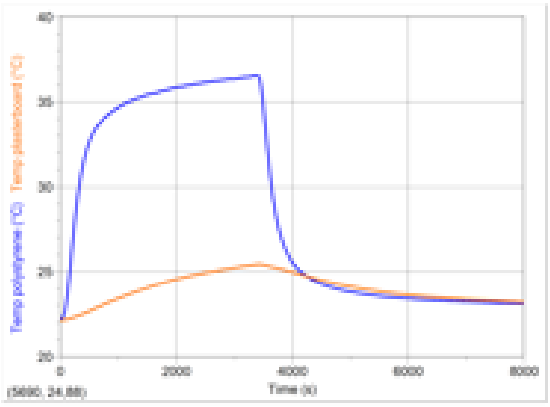


Fig. 3. Heating and cooling curves of house models

5. 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.

6. 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.

7. Ask students the following Question:

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

Extensions to Activity 2.1

1. As a last step, photos of thermograms can be shown, in order to introduce students to thermal/colour analysis.

Materials

- Activity 4.1 Student Worksheet (word)
- Activity 4.1 Student Worksheet (pdf)
- Boxes of different materials (of equal dimensions) modelling different kinds of houses.
- Temperature sensors to put in the wall opposite to the heater.
- Heaters (light bulbs covered by aluminium sheets)

Activity 4.2 How is the temperature distributed inside the model home?

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? The main goal of such an activity is in understanding that variations of temperature

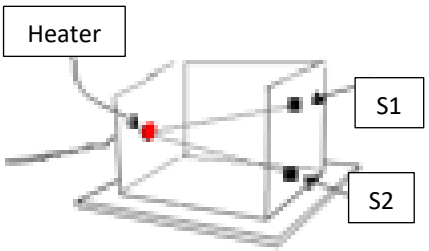
Suggestions for use:

are present inside the house in places at different distances from the heater and at different heights from the floor. This activity was adapted from the ESTABLISH project which included a consortium of over 60 teachers across European countries. The ESTABLISH Teaching and Learning Units conform to the ESTABLISH definition of Inquiry Based Science Education (IBSE) and link to real world and industrial applications.

Duration	
• 30-45 minutes	
Energy Literacy Characteristics addressed:	
C1	Has a grounded understanding of the science and how energy is harnessed and used to power human activity.
C3:	Students are sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources.
C4	Students are cognisant of the impact of personal energy-related decisions and actions on the global community.
Skills & Competencies addressed:	
• Critical Thinking • Problem Solving	• Designing • Data Analysis
• Numeracy	• Collaborating
Subject links in National Curricula:	
• Technology & Informatics • Design & Architecture	• Science • Engineering
Level	
• ISCED 2 • ISCED 3	

1. 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.

2. 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:



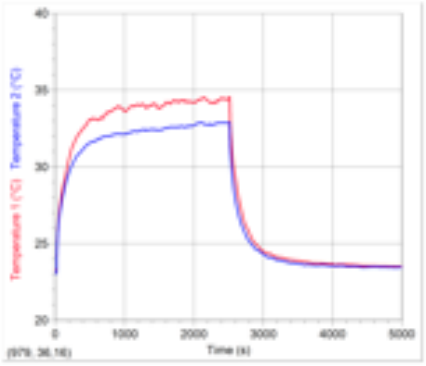


fig. 4.

Fig. 5. Two sensors at the same distance from the heater and at the same height from the floor

3. Ask students the following 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?

Extensions to Activity 4.2

Materials

- Materials are the same as Activity 4.1 , yet for each group of students two temperature sensors are necessary.
- Activity 4.2 Student Worksheet (word)
- Activity 4.2 Student Worksheet (pdf)

Activity 4.3 What is the effect of sunlight on the home model internal temperature?

• Technology & Informatics	• Science
• Design & Architecture	• Engineering
Level	
• ISCED 2	
• ISCED 3	

It is easy to observe that bodies are heated by the sun shining. This can be also the case for walls of a model home. How can materials influence the temperature inside the house? In this activity, students will analyse of solar effects on the house temperature. Students will point out the effect of wall colours on the radiation absorption. Student explorer that how the house model temperature is affected by absorption and conduction of wall materials; Students make predictions on the basis of their everyday experiences and are asked to justify evidence on the basis of everyday experience.

Suggestions for use:

1. In order to analyse the effect of an outdoor heating source we add a very bright light bulb (200 W) outside as the "sun".

2. Students are requested to test the effect using a temperature sensor posed on the wall opposed to the lightened wall.

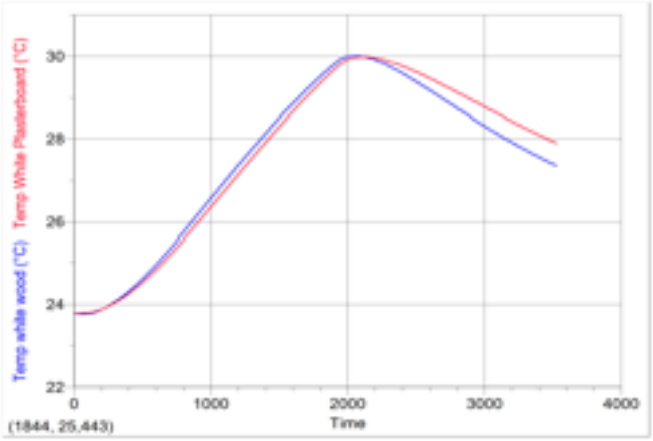
3.

Duration	
• 30-45 minutes	
Energy Literacy Characteristics addressed:	
C1	Has a grounded understanding of the science and how energy is harnessed and used to power human activity.
C3:	Students are sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources.
C4	Students are cognisant of the impact of personal energy-related decisions and actions on the global community.
Skills & Competencies addressed:	
• Critical Thinking	• Designing
• Problem Solving	• Data Analysis
• Numeracy	• Collaborating
Subject links in National Curricula:	

Fig. 6. Experimental setup

4. 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.

5. 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.



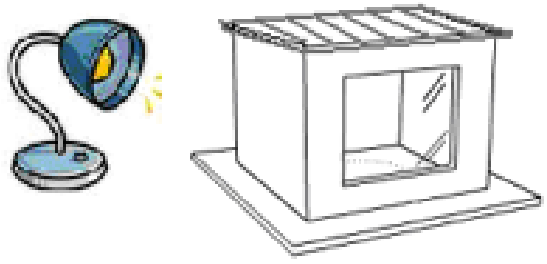
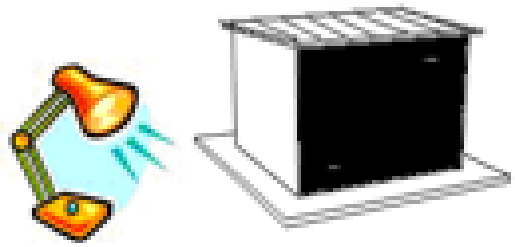


Fig. 7. Experimental setup

6. 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.



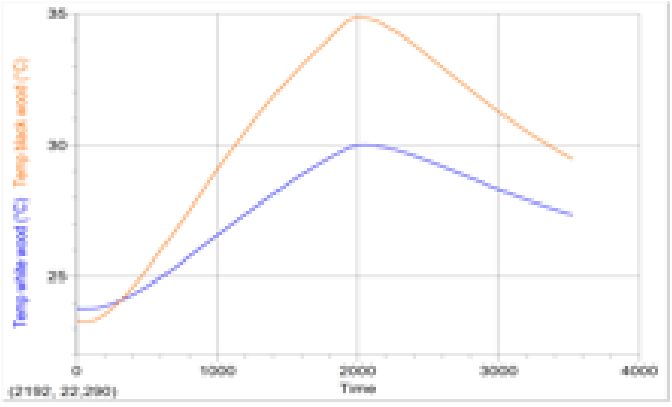


Fig. 8. Experimental setup

Extensions to Activity 4.2

Materials

- Materials are the same as Activity 4.1 , yet for each group of students two temperature sensors are necessary.
- Activity 4.2 Student Worksheet (word)
- Activity 4.3 Student Worksheet (pdf)