Light Bulb or Heat Bulb

Teacher Lesson Plan

Background Information

Using the physical science standards of light and heat, the concepts of energy efficiency and energy conservation are introduced. These terms can be defined as:

- Energy Efficiency - the use of technology that requires less energy to perform the same function.
- Energy Conservation - any behavior that results in the use of less energy.

An example of energy efficiency would be replacing an incandescent light bulb with a LED (light emitting diode) light bulb. An example of energy conservation would be turning the lights off every time you leave a room.

- Incandescent Bulb - A filament in the bulb gets so hot it emits light and glows. This also produces a lot of heat. 90% of the electricity going into the bulb is transformed into heat/thermal energy while only 10% is light/radiant energy.
- LED – LED's produce light when electrons move around within a semiconductor structure of two layers called a diode. The semiconductor is composed of a positively charged component and a negatively charged component. When electrical energy strikes the semiconductor, it activates the flow of electrons from the negative to the positive layer. The excited electrons emit light as they flow into the positively charged component. 90% of the electricity going into the bulb is transformed into light/radiant energy and 10% into heat/thermal energy.

Lighting accounts for 10-20% of a home's electricity bill. This experiment will prove which light bulb is more energy efficient and will save both electricity and money.

Content Standards

- **Physical Science**
  - Heat, electrical energy, light, sound and magnetic energy are forms of energy.
- **Earth Science**
  - Some of the earth's resources are limited.
  - Earth's non-living resources have specific properties.
- **Mathematics**
  - Represent and solve problems involving multiplication and division.
  - Solve problems involving measurement and estimation of intervals of time, liquid volume, and masses of object.
  - Represent and interpret data.

Student Activities

This experiment is divided into four parts. For Lesson 1, students compare the structure of each light bulb and the heat generated by each bulb measured by the change in temperature. For Lesson 2, students compare the costs of purchasing and operating each type of bulb. A 9.5 watt LED is the equivalent of a 60 watt incandescent bulb in terms of light output. Lesson 3 is a take home assignment and Lesson 4 considers energy saving behaviors around the school.

LESSON 1: Light Bulb vs. Heat Bulb

Lesson Materials:

- 8 lamp bases
- 8 digital thermometers
- 8 house-shaped boxes
- 4 - 60 watt, IL - Incandescent Light bulbs
- 4 - 9.5 watt, LED - Light Emitting Diode
- Student Lab Sheet Lesson 1
- Teacher Background Information
- Not Included: Stopwatch or timer

Preparation:

1. Prior to the classroom lesson, cut two windows. You may include a door in the boxes. Cover the windows with transparencies or packing tape. The electrical cord can be run out of the corner of roof or door. Insert a bulb and lamp base in the center of each box, making sure the bulb is not touching any of the walls. Close the roof.

Procedure:

1. Lighting Introduction
    a. Discuss the many uses of lighting.
    b. Instruct the students to note the type of lighting in the classroom. Ask students how it is different from the lighting they have at home.
    c. Show an incandescent and LED light bulb. Discuss the differences between the bulbs. The incandescent bulb is made of glass. The LED is made of plastic and has a ceramic base.
2. Before beginning the experiment, the students should answer the “Before” questions in the chart. They are on the left side. They should make a hypothesis based on the three questions on the student lab sheet for Lesson 1. A hypothesis can be defined as an educated guess. On the right side of the chart are the “After” questions which will be answered at the end of the experiment.
3. Have students observe the structure of each type of bulb in the lamp base. Ask students to sketch each bulb and put observations about the structure of each bulb on their student lab sheet. If a clear IL is available, it can be used.
4. Insert the thermometer in the hole on the floor of the house along a side wall or through an opening at the corner of the roof. Make sure the thermometer is not touching the light bulb.

The thermometer should be in the same position for each house. Be sure to close the roof of the box to keep heat from escaping.

5. The students will be measuring the change in air temperature each light bulb causes in each box. Take the starting temperature of each house before turning on the light bulb. Round to the nearest whole number. Have the students record the starting temperature on the data table.
6. At the same time, begin the stopwatch and turn on both light bulbs. Make sure the thermometer is not touching the light bulb.
7. At 1 minute, record the temperature in each house on the student worksheet. Round to the nearest whole number. Repeat every minute for 5 minutes. Students can take turns reading the thermometers. As the students read the thermometer, instruct them to put their hand near the roof of each house. Can they feel a difference in temperature between the two houses?
8. At the end of 5 minutes, take the final temperature reading and turn off the light bulbs. Calculate the change in temperature for each light bulb.
9. Optional Extension Activity: Graph (bar/line/picture) the change in temperature for each light bulb.
10. When the students have completed the calculations, discuss the results of Lesson 1.
    a. Discuss the variables that were controlled (kept the same) in the experiment (e.g. house, position of thermometer in the house, lamp bases, time interval). Discuss the variables that were changed (e.g. type of light bulb). Discuss how the experiment might be changed for improvement.
    b. Discuss the temperature change in each of the two houses. Why did the incandescent bulb get so much hotter?
        i. Incandescent Bulb-a filament in the bulb gets so hot it emits light and glows. This also produces a lot of heat. 90% of the electricity going into the bulb is transformed into heat/thermal energy while only 10% is light/radiant energy.
        ii. LED's produce light when electrons move around within a semiconductor structure of two layers called a diode. The semiconductor is composed of a positively charged component and a negatively charged component. When electrical energy strikes the semiconductor, it activates the flow of electrons from the negative to the positive layer. The excited electrons emit light as they flow into the positively charged component. 10% of the electricity going into a LED is transformed into heat/thermal energy and 90% is transformed into light/radiant energy.
    c. Return to the chart where the students made their experiment hypothesis. Have them mark the response that the experiment proved. Were their hypotheses correct?
    d. Based on the results from this lab, which light bulb is more energy efficient? Describe why. Could one bulb really be called a "heat" bulb instead of a light bulb?

LESSON 2: Incandescent Bulb vs. LED Bulb Cost Comparison

Lesson Materials:

- Watt Meter
- Student Lab Sheet Lesson 2

Preparation:

1. Explain that in Part 2 of the lab, they will compare the costs of purchasing and using incandescent and LED bulbs.

Procedure:

1. Electricity and Lighting Vocabulary - refer to the student worksheet chart LED vs. Incandescent Cost Comparison Sheet". Review the following vocabulary:

    - **Life Cycle Cost**: The actual cost to operate an appliance over its life. It includes the initial cost of the appliance (in our case the light bulb) + the operating (electricity) costs over the appliance life.
    - **Watt**: Unit of power. The rate at which an appliance or bulb uses energy.
    - **Kilowatt**: 1,000 watts. It is more useful to talk about kilowatts when discussing electricity because we use thousands of watts.
    - **Kilowatt-hour (kWh)**: The unit in which we buy electricity. It is equal to 1,000 watts used for one hour. The average cost of electricity in Ohio is $.11 per kWh.
    - **Lumens**: A measure of the brightness of light.
    - **Life Expectancy**: The average time a light bulb has been tested and expected to operate under normal use. Measured in hours.

2. Show the students the light bulb packaging (information also shown in student data table.) *Note: Depending on the light bulb vendor, information may vary slightly.*
    a. Compare the lumens between the two bulbs. Are they comparable? Which one is a little brighter? (LED)
    b. Compare the life expectancy of the two bulbs.
        i. If we are comparing 15,000 hours of light, how many LED's will we need? (one)
        ii. How many incandescent bulbs will we need? (6)
        iii. Calculate the cost of light bulbs for 15,000 hours of light.
            1. LED-one bulb = 15,000 hours of light X $3.00/bulb = $3.00
            2. Incandescent-one bulb = 2,500 hours of light X 6 = 15,000 hours of light X $.50 = $3.00.

3. Optional Extension Activity: Using the watt meter, measure how many watts the LED (9.5 watts) and the incandescent (60 watts) use. The watt meter might not measure the bulbs at exactly 9.5 & 60 watts, however, for our calculations; these are the numbers we will use.
4. From the data table, have the students fill in the cost of 15,000 hours of electricity for each bulb. Then calculate the life cycle cost for 15,000 hours of light.
5. Complete the chart by calculating the life cycle savings for installing a LED.

6. Discuss the life cycle energy savings for one light bulb.
    a. Which light bulb is more efficient? Why?
    b. Why do they think people still use incandescent bulbs?
    c. Have the students estimate how many light bulbs they have in their home. Would it be significant to replace all the incandescent bulbs in your home?

LESSON 3: Home Light Bulb Audit

Lesson Materials:

- Student Lab Sheet Lesson 3

Procedure:

1. Review the At Home Activity Sheet with your students.
2. Send home the LED with each student.

LESSON 4: Energy Conservation at Home & School

Lesson Materials:

- Energy Patrol Tickets
- Most Wanted Energy Waster Posters

Procedures:

1. Energy Patrol
    - Divide students into small groups (or select a small number of students) to serve as your school's Energy Patrol.
    - Copy Energy Patrol Tickets. Students patrol your building looking for energy wasting behaviors and leave a ticket if a violation is spotted.
2. Most Wanted Energy Posters
    - Take a picture of the "energy criminal." Report their offense on the Most Wanted Poster. Hang in the hallway to remind students to make smart energy choices.