Learning and Evaluation Situation

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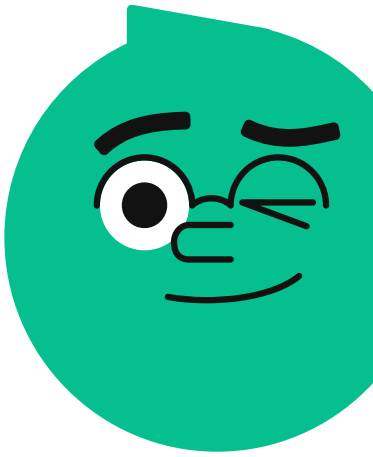


Science and Technology (ST)
Applied Science and Technology (AST)

Secondary IV

Making the "Bright" Choice

Teacher Booklet

120 minutes

Activity Summary

In this learning and evaluation situation, students will compare different types of light bulbs to determine which is the most efficient. In the process, they will learn about the relationship between power and electrical energy, as well as energy efficiency.

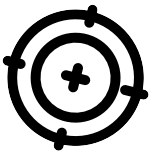
Prerequisites

Students must have mastered or be in the process of learning the following skills:

Energy

- Describing different forms of energy
- Identifying the forms of energy involved in a transformation
- Defining the joule as the unit of measurement for energy (except for AST)

Learning Objectives



The following objectives are addressed during the LES.

Relationship Between Power and Electrical Energy

- Describing qualitatively the relationship between the power of an electrical appliance, the electrical energy it consumes, and the amount of time it is in operation
- Applying the mathematical relationship between electrical energy consumed, the power of an electrical appliance, and the amount of time it is in operation

Energy Efficiency

- Defining the energy efficiency of a device or system as the proportion of energy consumed that is transformed into effective work
- Explaining how to improve the energy efficiency of an electrical appliance

Materials

- 1 copy of the Student Booklet for each student
- 1 copy of the Appendix for each student
- 1 copy of the Evaluation and Challenge document for each student

Planning

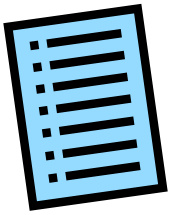
This LES is designed to be completed over 120 minutes following the schedule below.

Activity	Duration
Scenario	5 min.
Reactivate Your Prior Knowledge!	10 min.
What Makes a Light Bulb Efficient?	10 min.
Which Bulb Uses the Least Energy? *The relationship between electrical power and the electrical energy consumed*	20 min.
Which Bulb is the Brightest? *Luminous flux*	10 min.
Which Bulb is the Most Efficient? *Energy efficiency*	20 min.
Apply Your New Knowledge! *Evaluation and challenge*	45 min.
Total	**120 min.**

Recommended Steps

Scenario

5 minutes



The students read through the Scenario section individually.

Reactivation of Prior Subject Knowledge

10 minutes

The students read through the Reactivate Your Prior Knowledge section.

After a few minutes, the teacher checks the students' comprehension by leading a group discussion. Here are a few sample discussion questions.

Question	Expected Response
When you bake something in the oven, is energy being transferred or transformed?	*During baking, thermal energy is **transferred** from the oven to the baking dish.*
When a plant undergoes photosynthesis, is energy being transferred or transformed?	*During photosynthesis, radiant energy is **transformed** into chemical energy.*

Clarification About Electrical Energy

Electrical energy is the mechanical energy associated with the movement of electrons.

However, in the context of energy transformation by an electrical component, electrical energy and mechanical energy should be treated as separate energy types.

What Makes a Light Bulb Efficient?

10 minutes

The teacher leads a group discussion. The aim is to help students come to the conclusion that an efficient light bulb gives off a lot of radiant energy but consumes little electrical energy. Here are a few sample discussion questions.

Question	Expected Response
If something is efficient, does it give you ok results or great results?	*Great results.*
What would be a “great result” for a light bulb?	*- It’s bright.* *- It emits a lot of radiant energy.*
If something is efficient, does it require a lot of effort or a little effort to get results?	*It requires a little effort.*
What would “a little effort” mean for a light bulb?	*- It doesn’t need a lot of electricity..* *- It doesn’t consume a lot of electrical energy.*
How would you describe an efficient light bulb?	*The light bulb gives off a lot of radiant energy but consumes little electrical energy.*

After the group discussion, students answer question 1.

Which Bulb Uses the Least Energy?

Electrical Power and Electrical Energy Consumption

20 minutes

Students read the sections What is Electrical Power and What is Electrical Energy, then do the example problem.

The teacher reviews the example with the class, paying particular attention to the following points.

- In the formula $E=P\Delta t$, the time of operation must be expressed in seconds. Thus, students will need to convert from hours and minutes to seconds.
- Multiplying watts by seconds gives you joules.

Example

According to the label, a water heater has a power of 3,800 W.
Calculate the electrical energy consumed if it runs for 2 hr. 30 min.

$$P = 3\ 800\ \text{W}$$
$$\Delta t = 2.5\ \text{h} \times \frac{3\ 600\ \text{s}}{1\ \text{h}} = 9\ 000\ \text{s}$$
$$E = \ ?\ \text{J}$$

$$E = P\Delta t$$
$$E = 3\ 800\ \text{W} \times 9\ 000\ \text{s}$$
$$E = 34\ 200\ 000\ \text{J}$$

The water heater consumes 34,200,000 J of electrical energy

Students answer questions 2 to 4.

Note: They will need the Appendix for questions 2 and 3.

Which Bulb is the Brightest?

Luminous Flux

10 minutes

Students read the What is Luminous Flux section, then answer question 5.

After a few minutes, the teacher leads a group discussion. The goal is to lead students to the observation that the brightest of three light bulbs is not the one that consumes the least energy. Thus, we can't immediately determine which light bulb is the most efficient. This discussion allows us to segue into the topic of energy efficiency. Here are a few sample discussion questions.

Question	Expected Response
Which bulb type uses the least energy?	*Type 3*
Which bulb type is the brightest?	*Type 2*
Based on the results we've gotten so far, can we eliminate one bulb type?	*Yes, we can eliminate Type 1. It's the dimmest and it consumes the most electical energy.*
If two bulbs consume the same amount of electrical energy, how can you tell which is more efficient?	*- The more efficient bulb will be brighter.* *- The more efficient bulb will have a higher luminous flux.*
If two bulbs have the same luminous flux, how can you tell which one is more efficient?	*- The more efficient bulb will consume less electrical energy.* *- The more efficient bulb will have a lower power.*

Students answer question 6.

Note: Students may ask about the relationship between luminous flux and electrical power. This is called luminous efficacy and is expressed in lm/W.

Which Bulb type is the Most Efficient?

Energy Efficiency

20 minutes

Students read the What is Energy Efficiency section, then do the example problem.

The teacher goes over the example with the class.

Example

A water heater that has consumed 34 ,200 ,000 J of electrical energy transfers 26 ,676 ,000 J of energy to the water in the tank in the form of thermal energy. The rest of the energy is dissipated into the ambient air in the form of heat.

What is the energy efficiency of the water heater?

$$\begin{aligned} \text{Energy consumed} &= 34\ 200\ 000\ \text{J} \\ \text{Useful energy} &= 26\ 676\ 000\ \text{J} \\ \text{Energy efficiency} &= \ ?\ \% \end{aligned}$$

$$\text{Energy efficiency} = \frac{\text{Useful energy}}{\text{Energy consumed}} \times 100$$

$$\text{Energy efficiency} = \frac{26\ 676\ 000\ \text{J}}{34\ 200\ 000\ \text{J}} \times 100$$

$$\text{Energy efficiency} = 78\ \%$$

The water heater's energy efficiency is 78 %.

b) How much energy is dissipated?

$$\begin{aligned} \text{Dissipated energy} &= \text{Energy consumed} - \text{Useful energy} \\ \text{Dissipated energy} &= 34\ 200\ 000\ \text{J} - 26\ 676\ 000\ \text{J} \\ \text{Dissipated energy} &= 7\ 524\ 000\ \text{J} \end{aligned}$$

The amount of energy dissipated is 7 524 000 J.

The teacher can address the following points.

- Using an energy-efficient appliance saves energy and money.
- When comparing two similar appliances, the one with the lower energy consumption will usually be more energy efficient.
- To improve the energy efficiency of an appliance, we can minimize the amount of energy that is dissipated (e.g., by putting insulation around a water heater).

Students answer questions 7 to 9.

Note: They will need the Appendix for questions 7 and 8.

Data and Results Table - Answer Key

Bulb Type	Power (W)	Energy Consumed (J)	Useful Energy (J)	Energy Efficiency (%)
1	*40*	*72 000*	*3 600*	*5*
2	*23*	*41 000*	*32 292*	*78*
3	*9*	*16 200*	*13 446*	*83*

Apply Your New Knowledge!

Evaluation and Challenge

45 minutes, individually

Students complete the evaluation and challenge.

The evaluation can be summative or formative at the teacher's discretion.