THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

Lights Out!

How can energy be transferred from electric current to light?

GRADE 4

Physical Science

VAN ANDEL EDUCATION INSTITUTE
VAEI.ORG

INQUIRY-BASED SCIENCE

Physical

Lights Out!

Grade Level/Content	4/Physical Science
Lesson Summary	*Lights Out!* is the engineering design application to the lesson Light the Bulb. In this investigation, students are challenged to design and build a lighting device within given criteria and constraints.
Estimated Time	2, 45-minute class periods
Materials	D cell batteries, 1″ round head paper fasteners, 5 oz paper cups, 8 oz paper cups, 12 oz paper cups, 16 oz paper cups, empty 12 oz plastic water/pop bottles, empty 20 oz water or pop bottles, 6″ x 6″ cardboard box, 8 ½″ x 11″ sheets of cardstock, index cards, aluminum foil, non-stranded speaker wire, cardboard rolls, electrician's tape, masking tape, duct tape, miniature lamps (2.5V, 0.3A), Engineering Design Form, journal
Secondary Resources	Energizer: How do Flashlights Work? Discovery Kids: Electrical Circuits Explain That Stuff: Electricity BBC Bitesize: Electrical Circuits *Flick a Switch: How Electricity Gets to Your Home* by Barbara Seuling (Holiday House) *Electrical Circuits* by Lewis Parker (Perfection Learning)
NGSS Connection	**4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. **3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
Learning Objectives	• Students will design and build a lighting device within given criteria and constraints. • Students will provide evidence of how energy can be transferred from electric current to light.

Building a lighting device

Electricity—we depend on it every minute of every day. And yet to many of us, electricity seems like a mysterious force. Before Ben Franklin did his kite flying experiment, electricity was thought to be a type of fire. In 1847, the year Thomas Edison was born, most people considered electricity to be some sort of dangerous fad. By the time Edison died in 1931, entire cities were powered by electricity.

Although it has been used as an energy source for more than 100 years, the basic principles of electricity are not understood by many people. In the lesson Light the Bulb, students developed an understanding of electrical currents as they figured out how a bulb, battery, and wire(s) are connected to light the bulb. In this investigation, students are challenged to apply this knowledge to design and build a lighting device.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science. In all investigations:

Students don't know the "answer" they are supposed to get.

Students play a driving role in determining the process for learning.

Teachers and students construct meaning together by journaling.

Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Students need the following materials:

- Engineering Design Form
- Journal
- Supplies for students to choose from that would be available in a home to build a lighting device:
  - D cell batteries
  - 1″ round head paper fasteners
  - 5 oz paper cups
  - 8 oz paper cups
  - 12 oz paper cups
  - 16 oz paper cups
  - empty 12 oz plastic water/pop bottles
  - empty 20 oz water/pop bottles
  - 6″ x 6″ cardboard box
  - 8 ½″ x 11″ sheets of cardstock
  - index cards
  - aluminum foil
  - non-stranded speaker wire
  - cardboard rolls
  - electricians tape
  - masking tape
  - duct tap
  - miniature lamps (2.5V, 0.3A)

Part 2

INVESTIGATION FACILITATION

Before students begin the investigation, introduce the problem scenario:

The power just went off in your new house and you can't find where any flashlights ended up after unpacking. Night is coming and you need to find a solution fast. You find a box of miscellaneous wires, batteries, and light bulbs and decide to design and build a device that lights up. You need to hurry because it won't be light for very long!

Problem *Introduce the problem statement.*

Build a lighting device that turns on and off so we can see in the dark.

- Post and go over the criteria and constraints for the problem:

  Criteria for a successful lighting device:
  - ☐ It needs to be portable.
  - ☐ It needs to turn on and off.
  - ☐ It needs to be as bright as possible.* (i.e. bright enough to see a classroom sign in the dark from 8′ away)

  Constraints students must build within:
  - ☐ They can only use materials that are provided.
  - ☐ They must continue building, testing, and improving designs for the entire time given, even if they have found a solution.

STUDENT ENGAGEMENT

Ask students if they have ever experienced a power outage. Discuss what problems arose when faced with no power and solutions that were used to address those problems.

* You determine how to quantify this criteria based on your environment

Continued

RICH LANGUAGE

If students are new to the engineering design process, review the concepts of criteria and constraints and how engineers need to account for both of these in their designs.

- **Criteria**
  The requirements for a successful design solution. Criteria may include what the solution will do, how and in what way, durability, cost, and other considerations that are important to the end user. When possible, criteria should be quantifiable so the design's performance in meeting them can be measured.
- **Constraints**
  The limitations that must be taken into account when creating a possible solution. Constraints include such details as materials, time, money, societal or environmental impacts, aesthetics, etc. Constraints must also include consideration of scientific principles and other relevant knowledge. They may be measurable quantities such as size, weight, cost, efficiency (in use of energy, for example), etc.

Personal Knowledge

Students capture what they already know about electrical currents.

- Have students review what they learned from the previous lesson, Light the Bulb.
- Generate a class list.

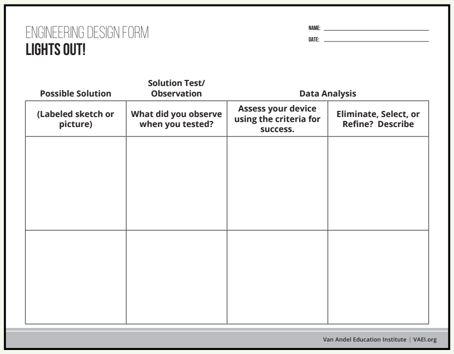
COLLABORATION

Conduct a collaborative *Brain Sketch*. Place the students in small groups. Provide each student with a sheet of plain white paper and a pencil. Ask each team member to do a quick sketch to show how to light a bulb using a battery and wires. After a designated time, have the students pass their sketches to the person on the right. This person may add to the sketch by drawing more, adding labels, or adding descriptions. After a designated time rotate the drawings until each student has an opportunity to contribute to each drawing. Then, allow groups time to share their finished drawings and what they know about electrical currents. Share these ideas to a class list.

Possible Solutions

Students brainstorm design solution(s) to solve the problem within the criteria and constraints.

- Students use their knowledge to brainstorm ideas for possible solutions with a partner. Have each pair write down their ideas in their journals:
  1. lighting device options
  2. different ways the device could be built with available supplies
  3. different ways the device can turn on and off
  4. ways to design the device to meet the brightness criteria
- Students select ideas from each category above to use in their first design. Have them draw a sketch of their first possible solution on the Engineering Design Form.



ENGINEERING DESIGN FORM
LIGHTS OUT!

NAME:
DATE:

Possible Solution	Solution Test/ Observation	Data Analysis	
(Labeled sketch or picture)	What did you observe when you tested?	Assess your device using the criteria for success.	Eliminate, Select, or Refine? Describe

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Engineering Design Form

CREATIVITY AND CRITICAL THINKING

Encourage students to "mess about" with the materials provided. Have them make observations to help them think creatively as they brainstorm. From that list, students will need to be critical thinkers as they select the ideas for their design solution.

Solution Test

Students build and test a possible solution within the criteria and constraints.

- Have students build and test their possible solution.

INTEGRITY

Encourage students to work within the constraints. Although it may be tempting to do otherwise, they are to only use the materials they are provided.

Observation

Students document their observations.

- Ask students to make observations of their solution test and record their findings on the **Engineering Design Form**.
- Students may be tempted to begin refining or developing a new possible solution once they test their lighting device. Encourage them to continue through the observation and data analysis process to provide evidence that informs their new design.

Data Analysis

- Have students **analyze** their data using the established criteria for success:
  - It needs to be portable.
  - It needs to turn on and off.
  - It needs to be as bright as possible to meet the established brightness criteria.
- Have students **interpret** their results by indicating if the design needs to be eliminated, refined, or selected as a solution. If their design can be refined, have them summarize and record their ideas on the **Engineering Design Form**.
- Challenge students to design another possible solution and repeat the process (possible solution, solution test, observation, and data analysis) during the allotted time on the **Engineering Design Form**. You may have students take pictures of their subsequent designs as they refine and/or create new possible solutions. Even if the students find a solution, have them continue designing, building, and testing improved solutions for the entire time they are given.

CRITICAL THINKING AND SELF-DIRECTION

Engineering design is an iterative process where students use the data they collect on their design to refine, eliminate, or select their possible solution. Highlight for students that the process of continuous refinement within the boundaries of criteria and constraints is how engineers design solutions. As students refine or create a new possible solution, they need to be self-directed, critical thinkers throughout the engineering design process.

Secondary Knowledge

Students use secondary sources to understand how electrical circuits work and why their flashlights did or did not light.

- Use these resources (or your own) to help students understand electrical currents and circuits and how flashlights work.

  Energizer: How do Flashlights Work?

  Discovery Kids: Electrical Circuits

  Explain That Stuff: Electricity

  BBC Bitesize: Electrical Circuits

  Flick a Switch: How Electricity Gets to Your Home by Barbara Seuling (Holiday House)

  Electrical Circuits by Lewis Parker (Perfection Learning)
- Students use this information in the reasoning portion of their solution.

PERSEVERANCE AND CURIOSITY

Use this secondary knowledge during or after the investigation as appropriate. If the students struggled with their lighting device design, use this knowledge to encourage persistence as they learn about circuits and flashlights and then return to their design. This demonstrates to students the nonlinear nature of the science process.

Part 3 DEVELOPMENT OF CLAIM

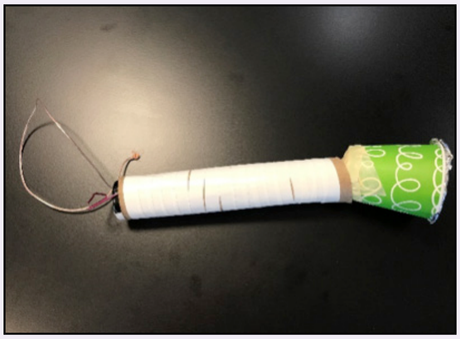
Solution

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from their analyzed data to write a solution to the problem statement. Have them write their solution in their journal.
- Have students develop a **Claim** that solves the problem statement: A lighting device that turns on and off needs to be built so we can see well after dark.
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the information obtained from this investigation as well as science principles they have learned.

Claim

We claim our 3rd design is the best solution that solves our problem. (See picture).



Lighting Device

Continued

Evidence

We analyzed each flashlight design using the criteria. All of our designs could turn on and off and were portable. Only design three met the brightness requirement because we added two batteries and a reflection cone. We tested all our designs in a dark room, and design three was the brightest.

Reasoning

Investigation: We are very confident in our evidence because we did a fair test by following our plan carefully. We analyzed each design and improved it each time.

Science: We learned from our "Light the Bulb" investigation and other readings and discussions that chemical energy from the battery was transformed into light and heat. We turned our flashlight off using the idea of a circuit switch.

Evaluation

Students reflect on the investigation.

- Ask students what surprised them.
- Ask students what problem they would like to solve next.

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION

Application

Students share their solution in a Present and Defend.

- Have teams share their solution (**claim**, **evidence**, and **reasoning**) with the class.

DISCOURSE

Have students conduct a Present and Defend to develop presentation skills as well as audience participation. Research teams present a summary of their investigation to the class. The class analyzes the information presented and asks clarifying questions, challenges and/or supports the arguments made, and even presents alternative explanations as appropriate. Research teams defend their solution with evidence and reasoning.

Assessment

Students present a solution (**claim**, **evidence**, and **reasoning**) that solves the problem statement within the given criteria and constraints.

Take This Lesson Across the Curriculum

Show Time!

The Academy Awards honor the year's greatest achievements on the silver screen, but your classroom has achievements to celebrate as well. In this project, you and your students will produce your own awards show!

Reading/Language Arts	Math	Science	Social Studies
Make Your Case Write opinion pieces supporting your choices for this year's winners. CCSS.ELA-LITERACY.W.4.1	**Count the Votes** When the votes are in, use your understanding of number sense to compare the numbers and determine the winners. CCSS.MATH.CONTENT. 4.NBT.A.2	**Light the Bulb** We need lights to produce the show, so let's understand how electrical circuits work to ensure the lights don't go out on our big night. NGSS: 4-PS3-2	**Do Your Part** We want the awards to be fair and just, so let's make sure the voting public has the necessary information to vote knowledgeably. NCSS: D2.Civ.2.3-5

Intruder Alert!

Sometimes you just need some alone time. In this project, students will contrast the themes of abandonment and privacy as they learn the math and science skills needed to design and build an alarm system for their bedroom door. They'll then take their design to the marketplace to see if there are any buyers!

Reading/Language Arts	Math	Science	Social Studies
All Alone Use the novel, *The Secret Garden*, to discuss themes of isolation and abandonment. Compare that with a natural desire for privacy. CCSS.ELA-LITERACY.RL.4.2	**It's in the Angle** Use your understanding of angles to design and install your alarm system on your bedroom door. CCSS.MATH.CONTENT. 4.G.A.1	**Light the Bulb** Understand how electrical circuits work so you can design an alert system to light up when someone tries to open your bedroom door. NGSS: 4-PS3-2	**Any Buyers?** Is there a market for your alert system? Articulate the benefits of your system and determine what classmates would be willing to pay for it. NCSS: D2.Eco.1.3-5

For additional lessons or to customize this lesson, go to www.nexgeninquiry.org.

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NAME: ______________________

DATE: ______________________

Possible Solution	Solution Test/ Observation	Data Analysis	
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