D E P A R T M E N T O F
Biomedical Engineering
College of Engineering University of Wisconsin-Madison

Potato Power: *Learning about Electricity and Energy*

Organization: University of Wisconsin-Madison Department of Biomedical Engineering

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General Description

Tabletop activity

Students will be organized into small groups as they work together to build a circuit and light up an LED using multiple potatoes as the battery for the circuit. A multimeter will be used to measure the voltage supplied by a single potato, and students will continue adding batteries (potatoes) to the circuit until there is sufficient voltage to light up the light emitting diode. Along the way, students will explore the concepts of energy, chemical to electrical energy conversion, batteries, voltage, current, and resistance. Additionally, participants will learn how to successfully work as a team to reach their goal of lighting up the LED.

Program Objectives

Big idea: Electrical energy is a daily part of our lives and is used all around us! Engineers have helped design and implement today's technology and appliances that require electrical energy, such as TVs, ovens, lamps, and more.

Learning goals:

As a result of participating in this program, visitors will be able to:
1. Describe how batteries work and the concepts of voltage, current, and resistance.
2. Describe the flow of electrical energy in a simple circuit.
3. Explain why an LED or other device may require multiple batteries to light up.
4. Explain what role electrical engineers play in the development of electricity sources and the products that use electricity.

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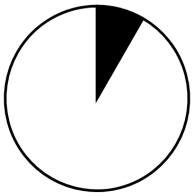
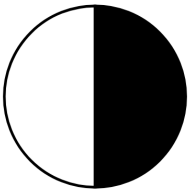
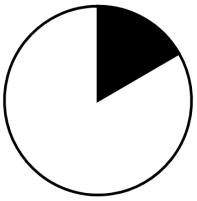
Time Required

Set-up	Program	Clean Up
		
(5 minutes)	(30 minutes)	(10 minutes)

Background Information

Definition of terms

Conductor: An object that allows the transfer of electrons.

Current: The movement, or flow, of electrons.

Electrical energy: Energy produced through the movement of electrons (voltage x current).

Electrolyte: A solution that conducts electricity due to the presence of positive and negative particles.

Energy: The ability to do work.

Insulator: An object that inhibits the transfer of electrons.

Resistance: Objects or substances that prevent the passage of a steady electric current.

Voltage: The amount of energy produced.

Program-specific background

Power sources, such as batteries, are used in daily life for a variety of applications and are especially important in engineering. Engineers use batteries to store energy in a wide range of situations. A solid electrolyte battery is most suitable in very extreme weather conditions, while nickel-zinc batteries work best in electric vehicles. Energy engineers continually evolve technology to improve the performance and life-cycle costs of batteries that store solar and wind energy. When designing a battery, engineers keep in mind the needs of the application, and use different substances to create current flow. Each of these aspects is important to take into account in engineering design. They consider characteristics such as power output, ability

to recharge, reliability, size, safety, heat generation, length of life cycle, abuse tolerance, cost and ability to be recycled. Isn't the power of engineering creativity amazing?

References

Activity outline, definitions, and worksheets adapted from Teach Engineering:

"Potato Power: Hands-On Activity," *TeachEngineering*, 17-Jun-2022. [Online]. Available: https://www.teachengineering.org/activities/view/cub_energy2_lesson04_activity2. [Accessed: 30-Nov-2022].

Materials

Potato Power Activity Supplies:

- Copper pennies or copper strip (3/group)
- Galvanized zinc nails (3/group)
- Alligator clips, 15-20 cm (6-8 inches) long (5/group)
- Low-current LED (1/group)
- Multimeter (1/group OR 1-2 for the class to share)
- Activity worksheet provided online with answers (1/student)
- Potatoes (3-5/group)

Alternatively, a kit specifically designed for this activity can be purchased online.

Set Up

Time: (5) minutes

Step 1:

Divide the class into groups of approximately 2-4 students.

Step 2:

Hand out supplies to each group (potatoes, alligator clips, nail, penny, LED, and multimeter if available). Provide each student with a worksheet.

Program Delivery

Time: (30) minutes

Safety:

Ask students if anyone has a potato allergy. Additionally, try not to touch the metal wires once the circuit is complete. If adjustments need to be made to the circuit, try to only make contact with parts that are insulated. Refrain from placing any part of the circuit in one's mouth.

Procedure and Discussion:

Step 1:

Explain the basics of a circuit and the purpose of each component given to the groups. Briefly go over definitions included in this outline.

Step 2:

Guide the groups in carefully piercing the potato with the zinc nails and copper pennies (one nail and one penny in the same potato). Be sure to check that the metals are not touching each other.

Step 3

(If you have a multimeter) Explain what a multimeter is and how it is used; tell students that a multimeter is an instrument that measures current, voltage and resistance of a circuit, and is a tool created by and often used by engineers.

Set the multimeter on a low "DC volts" scale for voltage and "DC milliamps" for current, so students can observe the charge generated by a single potato. The potato should produce just under 1 volt. Encourage students to convert the decimal readout from the multimeter to a fraction (for example, 0.82 volts = 82/100 volts).

Step 4:

Instruct the students to determine the number of potatoes needed to light the LED. Be sure to provide students with the voltage needed to power an LED. For example, if their potato produces a voltage of 0.8 volts, then they may need two potatoes to power a 1.5 voltage LED.

Step 5:

Have students experiment to figure out how to connect two potatoes together. To connect two potatoes in series (to add more voltage), place a penny and nail into a second potato, and connect the wire from the zinc nail in the first potato to the copper penny in the second. Then, add a third wire to the zinc nail in the second potato. Always remember to connect the copper (positive) end of the potato (battery) to the zinc (negative) end of the next potato

Step 6:

Expect two potatoes in series to be able to light an LED; however, you might need three. Show students how to connect the LEDs to the potato in the correct manner, that is, the positive end of the LED to the negative end of the potato battery (zinc nail) and the negative end of the LED to the positive end of the potato battery (copper penny).

Step 7:

Start a discussion among the groups of students about how the potatoes provide the electrolyte (solution) for the chemical battery to work. Ask for suggestions of other foods we could try (for example, lemons, berries, apples).

Step 8:

Ask students to complete the worksheet either individually or in pairs. After they finish, have them compare answers with a peer or another pair, giving all students time to finish.

Discuss the correct answers with the students to wrap up the activity and answer any lingering questions.

Tips and Troubleshooting:

If there are issues with the lighting of the LED, verify the setup of the potato battery. Be sure that all ends are connected from negative (zinc nail) to positive (copper penny). Check the setup of the potato. Perhaps the ends are not all connected from negative to positive, or perhaps there is not enough potato voltage. Check the voltage of the potato using a multimeter or voltmeter. Another possibility is having enough voltage, but not enough current to light the bulb, which is why it is recommended to use only very low-volt LED clocks or bulbs. Also, try using more potatoes (i.e., 5 potato halves) to strengthen conductivity. Try different LED colors (for example, the blue LED may work better than the red).

Some people have more conduction success using copper strips instead of copper pennies (can also wrap the pennies in copper ribbon).

Soaking the potatoes in Gatorade overnight can make them more conductive due to the stronger presence of electrolytes.

Common Visitor Questions

Can other foods be used as a battery to power an LED?

Yes! Lemons and oranges also work well for this activity. For best implementation, first roll them on a tabletop. This breaks down the cells inside so more juice flows through the fruit (current).

Going Further…

At the end of the activity but before disassembling the potato batteries, it is fun to have the entire class connect their fruit batteries in series, making "a serious tater circle."

Have students try the activity again using different fruits or vegetables if time remains or encourage students to try this at home! Many fruits and vegetables work, such as lemons, limes, apples and carrots. Have students compare and contrast the performance of different fruits and vegetables.

Have students complete the activity again using an electrolyte solution, such as salt water or vinegar if time remains or encourage them to do this at home. Have them compare and contrast the performance of different electrolyte solutions.

To add a math component, have students use the multimeter to compare the flow of electricity for several different fruits (lemons and oranges) as well as to the total amount of fruits used. Ask them to graph the results and hypothesize what is happening (optional).

Clean Up

Time: (10) minutes

Have the groups disassemble their circuits. Instruct the groups to have one student bring their group's materials to the designated materials bin. The instructor(s) will properly dispose of the potatoes or other fruits/vegetables used in the activity.