Hey! Who Turned Out the Lights?
Electricity in Series and Parallel Circuits

Discovering the connection between toys, holiday lights, and electricity

Sharon Mastrobuoni
Isaac Sheppard Elementary School

Overview

This unit on electricity is intended to enhance and support the School District of Philadelphia's fourth-grade Science Core Curriculum through engaging hands-on investigations and relatable topics. In this unit, students will gain an understanding of how electricity works, what is needed to complete an electric circuit, and how to construct parallel and series circuits. The unit will incorporate hands-on learning using materials to produce a solution, cooperative learning, problem-based learning, and inquiry-based instruction, which will all offer means of actively engaging students in authentic problem-solving and understanding of the content.

Throughout this six-lesson unit, the focus will be on establishing what is needed to complete a circuit and what the difference is between an open circuit and a closed circuit. Students will use electronic toys and tools from home to observe what happens when the switches are on and when they are off. The unit will build on this concept and students will then be exploring the difference between series and parallel circuits and recognizing how electrons travel through the pathways and how the voltage is affected in each circuit. Students will be using holiday lights, wires, D-Cell batteries, and foil to explore series and parallel circuits. They will be challenged to build a circuit where one light bulb going out will not affect the rest of the light bulbs. They will then be working to incorporate resistors into the circuits and recording the affect they have on the brightness of light bulbs in the circuit. Finally, students will take what they learned about circuits and build their own toy. They will be given various materials to construct a working toy. By

working with common and familiar items such as their own toys and a strand of holiday lights, students will learn how different types of circuits affect uses and outcomes.

Throughout the unit students will consider these questions: What is electricity? What is a complete circuit? What is needed to complete a circuit? How do charges flow? What is a series circuit? What is a parallel circuit? What is a resistor? How does a resistor change the voltage of a circuit? The main objective of asking these questions is to bring awareness to how electricity is can be found all around them and used for things they encounter every day. By the end of the unit, students will have a foundation of electricity to carry with them throughout their educational experience.

Rationale

Learning in science begins in early childhood. This is a time when young minds are curious about science and the world around them. They are ready to engage in the practices and language of science that form a foundation to be built upon throughout a student's education. Concepts and ideas need to be introduced to children at a young age rather than ignoring these ideas and delaying the development of science language and practices until students encounter formal science class in middle and high school years. Some schools are in possession of the Magnetism and Electricity Module which addresses some of the same fundamental ideas regarding magnetism and electricity as this unit, but this extends on the connection students can make between their own belongings and things they play or interact with, and electricity. For those who are not in possession of a specific kit, this unit will be helpful in teaching electricity concepts using mostly common materials.

Many hands-on lessons are incorporated into this unit because students develop scientific understandings of concepts such as electricity through observation and interaction, rather than through behaviorist pedagogies that are implemented by many elementary teachers. Behaviorism is primarily based on a rewards system that is used to reinforce a desired behavior. The behavior and learning are observed, but the cognitive process in learning is not focused on. A student may not completely grasp the information presented, but may be able to answer the questions correctly. Many teachers rely on readings from textbooks and presentations provided by school district curriculums some of which focus mainly on closed questions that require a specific answer. Behaviorist teaching also typically relies on positive reinforcements such as prizes, good grades, or verbal praise when students provide the correct response (Skinner, 1976).

Teaching an abstract subject like electricity with limited reference to how it applies to real life and other scientific concepts will most likely result in the failure of students to grasp the concepts presented to them. They may memorize facts and definitions through the behaviorist method, but true comprehension will most likely not be achieved.

Teaching that emphasizes active engagement helps students process and retain information.

Many students form misconceptions when they are not given the opportunity to make observations and make sense of what they observe through hands-on activities, specifically regarding the concept of electricity. When students are unable to apply what they read or are taught, they have difficulty mastering these concepts. The following skill base needs to be understood thoroughly by the teacher and meaningfully taught to the students in order for them to grasp electricity as a whole.

Electricity

In order to understand electricity, teachers need to know that everything in the universe is made of atoms. The center of an atom is called the nucleus and it is made of particles called protons and neutrons. The protons have a positive charge and electrons have a negative charge and the opposite charges are attracted to each other. Electrons are moving around the nucleus, constantly spinning to stay as far away from each other as possible. The two electrons in the shell closest to the nucleus have a strong force of attraction to the protons. The electrons in the atom's outermost shell do not have a strong force of attraction to the protons and these electrons can be pushed out of their orbits. If a force is applied to them, they can move from one atom to another and these moving electrons are electricity (Energy Information Administration, 2013). These concepts are too abstract to expect elementary students to understand, but teachers need a firm grasp on these concepts are they teach electricity at a lower level. Students will eventually be expect to matter these concepts throughout their education so using language that will familiarize them with these terms would be beneficial.

Circuits

Electricity travels in circuits, or pathways, that must be a complete path before the electrons can move. If a circuit is incomplete, or open, the electrons cannot flow. When a light is switched off and on, the circuit is being opened and closed. For a bulb to light, it must be connected to the circuit at two points, the tip of the bulb (the metal part on the bottom of the bulb) and the base contact (the metal side of the bulb's base). When connected correctly, the charge flows from an electric wire, through the light bulb's filament (a thin wire inside of the bulb connected to the bottom of the bulb and the side of the bulb), and back out another wire (Energy Information Administration, 2013). When students construct a simple circuit in the second lesson, it shows the transformation of energy as the chemical energy from the battery transfers into light energy when it turns the light on. They will be able to make connections about what kind of energy their toys are producing from the chemical energy from the battery inside.

Series and Parallel

The basic idea of a series circuit is that components are connected end-to-end in a line to form a single path for electrons to flow. When one light bulb is removed from a string of lights in series, the whole string of lights will turn off because the circuit is incomplete. When the circuit is complete, electrons flow from the negative terminal of the battery through the wire conductor, then through the bulb (lighting it up) and finally back to the positive terminal of the battery. This flow is continuous and the electricity only has one path on which to travel. If anything interrupts the flow, the circuit is incomplete and electrons will not move.

The basic idea of parallel circuits is that there are many paths for electrons to flow, but only one voltage across all components. In this case, if one of the bulbs in a string of lights blew out, the other bulbs would still be able to light up because the flow of electricity to the broken bulb would not stop the flow of electricity to the unbroken bulb. The concept of series and parallel circuits is addressed in the fourth lesson where students will construct parallel circuits using holiday lights. They will check their construction by removing certain lights and observing if the circuit still works.

Resistance

The flow of electricity depends on how much resistance is in the circuit. In a series circuit, the resistance in the circuit equals the total resistance of all the bulbs. The more bulbs in the circuit, the dimmer they will light. In a parallel circuit, there are multiple paths through which the current can flow, so the resistance of the overall circuit is lower than it would be if only one path was available. The lower resistance means that the current will be higher and the bulbs will burn brighter compared to the same number of bulbs arranged in a series circuit. In lessons 3 and 4, students will be given the opportunity to experiment with different LED quantities in series and parallel circuits in order to observe the light brightness which results from the amount of resistance in the circuit. They will also explore resistance with pencil lead in lesson 5. They will insert varying lengths of mechanical pencil lead into a circuit and observe the effect it has on the brightness of the bulb.

Voltage and Current

Voltage is the amount of potential energy between two points on a circuit. Since one point has more charge than another, the difference in charge between the two point is called voltage. When describing voltage, current, and resistance, often times an analogy is provide using a water tank where the voltage is the water pressure, the charge is the water amount, and the current is represented by the water flow.

Common Misconceptions

There is an assumption that student misconceptions arise mysteriously within students when they reach a certain age or higher grade, when in fact these misconceptions are often specifically taught in earlier grades. Teachers need to be aware that it is often because of misinformation in curriculum texts or prior education that influences students' concept of electricity. Most textbooks do not make it a point to encourage teachers to address misconceptions, but this can be a powerful tool because learning which concepts are wrong helps students avoid these deterrents to learning (Sefton, 2002).

One misconception is that electricity flows from the battery to the light bulb to light it up. Many students are unaware that the charge continues to flow around the circuit in a circular motion (in a series circuits) over and over through the battery, through the wires, and through the light bulb. There is a path provided by flowing electrons or charged ions. Electric currents in copper wires are a flow of electrons, but these electrons are not supplied by the batteries but already exist in the wire. The electrons in a circuit are already there before a battery is even connected. Instead of thinking that batteries or generators create the electricity, the correct statement is that batteries and generators *cause* electric charge to flow.

Another misconception is when conductors are defined as something through which electricity can flow, instead of something that contains movable electrons or electricity. Insulators should be defined as something that does not contain moveable electrons or electricity. There is also a misconception that charge flows at different rates throughout the circuit. However, the charge flows at the same rate where it enters the light bulb as where it exits the light bulb. The charge is not stronger where it exits the battery or flows through the battery again. In fact, even when no current is flowing, the free electrons in the wire move randomly. The current flow in a series circuit occurs simultaneously at all points in the circuit. When an electron leaves the negative terminal of the battery, an electron enters the positive end of the battery at the same time and when one electron enters the light bulb at one end of the circuit, another electron exits the light bulb at the same time at the other end of the light bulb (Aydeniz, 2010).

Overcoming Misconceptions:

Students come into the classroom with prior knowledge, which will guide their understanding of new information. It's crucial for teachers to pay attention to the incomplete understandings, false beliefs, and misconceptions that are brought with students to science class. In order for students to develop understanding in an area of inquiry such as electricity, students must have accurate knowledge, understand the facts and ideas in the unit area, and organize the information and knowledge in a way where it can be applied in other situations. (Aydeniz, 2010).

Objectives

This unit will help students to develop an understanding of how electricity works and what is needed to complete an electric circuit through various investigations. Students will use a common household toy, 'Playdough', to create and learn about conductors and insulators in circuits. Students will be challenged to observe holiday lights and make observations to complete a series and parallel circuit and determine how voltage is affected in each circuit. They will discover how resistors work in a circuit and examine different resistor strengths. Students will use what they learned about electricity and circuits to construct their own toy using various materials at the end of the unit.

- Students will recognize electronic devises, such as toys or tools, in their homes and bring in examples to investigate at school.
- Students will be able to identify which type of energy their electronic toy or tool produces (light, movement, sound, heat, etc.).
- Students will understand that their toys receive energy from batteries.
- Students will discover how to complete a circuit using copper wires, batteries, and light bulbs or motors.
- Students will use two forms of 'Playdough' as conductors and insulators to demonstrate how conductors have less resistance than insulators.
- Students will construct and understand the difference between series and parallel circuits.
- Students will recognize that resistors act to reduce current flow and, at the same time, act to lower voltage levels in a circuit.

Standards

The lessons and ideas presented in this unit are appropriate for fourth grade students studying the concept of electricity. The lessons provide a basic understanding of circuits and terms associated with electricity like complete circuit, incomplete circuit, conductor, insulator, series circuit, parallel circuit, and resistor. This unit will provide a framework for further investigation of electricity including real world applications and physics courses in years to come. This unit will help students fulfill the Pennsylvania Academic Standards for: Science, Reading, Writing, Speaking and Listening. The Standards are listed in the Appendix.

Strategies

There are specific strategies used in this unit to ensure the highest level of engagement and understanding in students.

Activating Prior Knowledge Through Inquiry-Based Learning

Students come to formal education with a range of prior knowledge, skills, beliefs, and concepts that greatly influence how they view and interpret the environment around them. This affects their abilities to remember, reason, solve problems, and acquire new information. Therefore, teachers must pay attention to this prior knowledge and address the false concepts that the students bring with them (Polman, 2000).

In this unit, students are encouraged to ask questions, make predictions, test their hypotheses, and discuss results. In this way, students will be able to witness for themselves evidence of scientific concepts that either support or refute their beliefs. Each lesson is designed to build on the foundation of the previous lesson. The proceeding lesson is intended to require information learned earlier and combine it with new inquiries and investigations in order to establish more knowledge about electricity. This scaffolding will help students develop an accurate and organized understanding of electricity and associated concepts (Polman, 2000).

Problem-Based Learning:

The best way for students to learn science is to experience the problems and try to solve them. To do this, real-world problems are presented for students to investigate what they need to know and want to know. In a problem-based learning environment, students take responsibility for what is learned and how it is learned. The teacher guides the investigations through challenging questions and well-planned lesson structure, but the students use collaboration and inquiry to problem-find, problem-solve, and evaluate results. Students will demonstrate problem-solving in various lessons in this unit including the Holiday Lights lesson where they are challenged to create a circuit that does not go out when one light is turned off.

Cooperative Learning

This unit will incorporate cooperative learning where students need each other to complete a task and are expected to participate in tasks that are necessary for the group's success. The teacher circulates around the room as a facilitator, but the students carry out their tasks without constant instruction by the teacher. In cooperative learning, all members have the opportunity to make their own contributions, develop respect for all members, problem-solve constructively, and learn from one another.

When students participate in engaging learning activities in well-planned, structured, and supportive cooperative groups, their anxiety levels are reduced and they are able to receive information. Cooperative groups tend to generate more participation and stimulate multiple brain regions (Willis, 2007). The students are able to benefit from each other's strengths and communicate ideas to one another. Each group will need all students to participate in order to complete the task. Students are responsible for

accomplishing their tasks in the way that they think best, which will be seen throughout the unit. If the group work is successfully planned, it will help build a supportive classroom community, which will increase self-esteem and academic performance.

In cooperative learning, there is often more than one answer or more than one way to solve the problem or create the project. This leaves the options open for students exploring electricity and asking further questions. Following the cooperative learning that will be observed for assessment, students will complete individual responses to the activity in order to ensure individual student involvement and understanding (Willis, 2007).

Hands-On Learning

Students will be given materials to observe, explore, and learn from hands-on activities throughout this unit rather than the behaviorist method of teaching and learning. Constructivist instruction is demonstrated through hands-on learning because the students are generating their own knowledge through experiences anchored in real life situations. By observing their toys, the holiday lights, and using play dough throughout these lessons, they are interacting with common items and applying them to real life situations. While learning facts and definitions is important in any subject of science, children should be given the opportunity to connect this information to real life experiences in an electricity unit. They need to understand the relationship between the structure and function of the circuit and its components in order to understand electricity (Polman, 2000).

Science Notebooks

Science notebooks can be used in the science classroom to help students develop, practice, and refine their science understanding. Students can express themselves and their learning no matter what learning level they are on. They can respond to experiments and investigations by organizing their thoughts regarding the new information. Science notebooks also help students enhance their reading, writing, mathematics, and communications skills. They offer many opportunities to develop and enhance students' communication skills, written, visual, and oral. Even students who may have poor writing skills can use observational drawings and graphs to show their learning misconceptions and their correct conceptions. Teachers can use these notebooks to guide their teaching and take note of misconceptions and mastery of skills. They can formatively assess concept development at the students' ability level (Gilbert, 2005). Formative assessment is used to monitor student learning in order to provide ongoing feedback that can be used by instructors to improve their teaching and by students to improve their learning. It helps students identify their strengths and weaknesses and target areas that need work. It also helps instructors recognize where students are struggling and helps them address problems immediately.

Classroom Activities

Lesson 1: Introduction to Electricity

Objectives:
Students will identify what they know about electricity and what they want to learn about it.
Students will identify a toy they have a home that uses electricity to work.
Students will write about or draw pictures of what they know about electricity.

Materials:

- chart paper
- students' science notebooks

Procedure:
The teacher will introduce the topic of electricity and ask students what they already know. They will use their science notebooks to write their initial thoughts about electricity and anything they would like to learn. They will also explain what they want to learn about electricity. The teacher will allow students to use their science notebooks to respond to these two questions and then share out their answers and ideas. Students will pair up with a student next to them and share their ideas and then volunteers will share ideas for the teacher to add to the class chart paper. This lesson will inform the teacher of what the students already know and help set goals for the rest of the unit.

Duration: 30 minutes

Lesson 2: Electricity Through Toys

Objectives:
Students will determine what type of energy their toy from home produces (light, movement, heat, or sound).
Students will write about or draw how they think their toy works using electricity.
Students will construct a simple circuit using a copper wire, a D-Cell battery, and a light bulb.

Materials:

- an electronic toy or tool from home
- chart paper
- students' science notebooks
- circuit materials: copper wires, D-Cell batteries, light bulbs

Procedure:

The teacher will begin by asking students about the electronic toy that they brought from home. They will show a partner their toy, explain what type of energy it produces (light, sound, movement, heat, etc.), and discuss how they think it is able to work. The teacher will make a chart with the students' ideas of what is going on inside the toy including how the switch causes the toy or tool to turn on or off.

Students will begin thinking about how their common toys from home use electricity. They will determine what form of energy is produced from their toys (light, sound, movement, heat). They will collect materials to construct a circuit using a wire, battery, light bulb, and switch to explore open and closed circuits.

Students will then be asked to use the circuit materials (wire, battery, light bulb, and switch) to construct a complete circuit to make the light bulb turn on just as the toy turned on. The teacher will ask guiding questions to assist students struggling with constructing the circuit. Once their circuit is complete, students will begin to investigate how they think the switch works to turn the light bulb on and off and how the switch on their toy is similar to the switch in the circuit. The class will reconvene and discuss the terms complete circuit and incomplete circuit as well as open circuit and closed circuit. Students will understand that their toy cannot work unless the circuit is complete, allowing electrons to flow through the circuit pathway.

Duration: 45 minutes

Lesson 3: Conductors and Insulators Using Dough (Based off of Squishy Circuits by AnnMarie Thomas)

Objectives:
Students will follow two recipes to make dough that acts as a conductor and dough that acts as an insulator.
Students will identify objects around the room that are conductors and insulators.
Students will explain that the conductor play dough has less resistance because electrons flow through it to allow the light to turn on and the insulating play dough has more resistance and electrons cannot flow through it and allow the light to turn on.

Materials:

- Dough ingredients and recipes
- Safety Glasses
- LEDs
- Copper wires

Conductive Dough Recipe (multiply ingredients to suit the needs of your class size)
1 cup Water
1 ½ cups Flour
¼ cup Salt
3 Tbsp. Cream of Tartar
1 Tbsp. Vegetable Oil
Food Coloring (optional)

Insulating Dough Recipe (multiply ingredients to suit the needs of your class size)
1 ½ cup Flour
½ cup Sugar
3 Tbsp. Vegetable Oil
½ cup Deionized (or Distilled) Water (regular tap water can be used, but the resistance of the dough will be lower)

Procedure:
The teacher will review with students what they learned the previous days about electricity and circuits. They will understand that electricity flows in a loop called a circuit the electrons flow through the wires and other components of the circuit. The teacher will explain that electricity is like water and takes the path of least resistance. The students will then be instructed to follow the recipe and make the two types of dough. The teacher will model how to use the dough in the circuit and students will explore the difference between both kinds. Through exploration, students will learn that it is easier for the electricity to flow through the dough than through the LED, so if the dough on each side of the LED is touching, electricity will not flow through the LED at all and it will not light up. They will need to separate the dough or insert the insulating dough in between to separate the conductive dough. Through this activity, they will learn that insulators do not allow electricity to flow through them so it must go through the LED. Students will then be given time to find other examples of conductors and insulators around the room. They will make a list of their findings in their science notebooks and make observations about the similarities and differences between the conductors and insulators they found.

Note: The LED only works if the longer side goes to the positive side of the battery and the shorter side goes to the negative side of the battery. You must have dough between the LED and battery or else the LED will burn out because there is not enough resistance.

Duration: (2) 45 minute periods

Lesson 4: Holiday Lights

Objectives:

Students will examine strings of holiday lights to determine if they are series or parallel circuits.
Students will cut apart holiday lights in order to construct their own circuits in series and parallel.
Students will design a parallel circuit so that if one light goes out, the other lights will still shine.
Students will be able to explain that the electrons have other pathways to travel through in a parallel circuit.

Materials:

- LED holiday lights
- D-Cell batteries
- Aluminum foil
- science notebooks
- pencils

Procedure:
The teacher will review concepts from the previous day including closed circuit, open circuit, complete and incomplete circuits, and resistance. Then the teacher will present the following problem to the class. A family is decorating their house with holiday lights but as they are setting everything up, the whole string of lights turns off. The family cannot figure out why the lights turned off since they are still plugged into the wall socket. The kids are told they cannot go outside to play in the snow until the family solves the problem. The teacher will ask the class the following questions. Why do you think the lights turn off? What happens if a circuit is not complete? Use these holiday light segments and aluminum foil to design a string of lights that will not turn off if one light is removed. What kind of circuit would need to be used in this scenario?

Students will be given paper bulbs to design circuits that they will eventually test with a partner and real materials. After they have their designs made, they will be given pieces of the string of lights, aluminum foil (conductor), copper wire, and a D-Cell battery and will be encouraged to build a circuit that allows for electrons to move through different pathways so that if one burns out or is removed, the rest of the lights will still burn.

The teacher will rotate around the room questioning the rationale behind groups' designs. The teacher will use prompting questions to guide learning. Small groups will share their results and the teacher will explain the difference between parallel and series circuits. Students will learn that parallel circuits are best for holiday lights because the whole string of lights will not go out if one light is removed or broken.

Duration: (2) 45 minute periods

Lesson 5: Resistors

Objectives:
Students will use pencils to observe the affect that resistors have on voltage and the brightness of a bulb in a circuit.
Students will determine which resistor lengths have the strongest effect on the voltage.

Materials:

- pencils of different lengths cut in half with granite exposed
- varying lengths of lead from mechanical pencils
- copper wires
- LEDs
- science notebooks
- pencils

Procedure: Students will be given circuit materials and several length pencils with the granite exposed. They will insert the lead into the circuit and observe how the brightness of the light bulb is affected by each resistor. They will learn that the resistor is reducing the current flow through the bulb. As the length of the pencil resistor (graphite) decreases, the resistance also decreases in the circuit causing more current to flow in the circuit, which makes the bulb glow brighter. Students will apply this discovery to what they observed in the series and parallel activity. The more light bulbs they put into the series circuit, the more resistance occurred, which caused the bulbs to be more dim. They will understand that light bulbs, or any other component that uses the electrons to do work or slows down the current, are resistors.

Duration: 45 minutes

Lesson 6: Build Your Own Toy

Objectives:
Students will identify the components needed in a circuit in order to construct a toy with all of the necessary parts to produce some kind of energy when it is turned on.
Students will design and construct an electric toy using what they learned in this unit.
Students will be given various materials to construct a toy that produces light, sound, or movement.

Materials:

- LEDs
- science notebooks
- pencils
- D-Cell battery

- Copper wires
- Plastic “googly” eyes
- Pompoms
- Pipe Cleaners
- Tape
- Rules
- Paperclips
- Other various supplies

Procedure: Students will be given time to design a toy that will produce some kind of energy when its circuit is complete. They will use all of their notes and materials from previous lessons to brainstorm, design, and construct their toy. When they are complete, they will present their toy to the class and explain what kind of circuit it uses and how it works. The design process, the product, and the presentation will be the end of the unit assessment for the teacher.

Duration: Two 45 minutes class periods to complete design and construct the electronic toy.

Pennsylvania State Standards

The Core Curriculum of the School District of Philadelphia is aligned to the Pennsylvania Academic Standards for Science. Students will address all of these standards when they complete each lesson. They will be generation questions, using the scientific process to think about conducting investigations, build on explanations, observe the happenings in the investigation, record their findings, and state a conclusion that is consistent with the data that was gathered. These standards include instruction on the following areas:

Science:
• 3.1.4.A9: Distinguish between scientific fact and opinion. Ask questions about objects, organisms, and events. Understand that all scientific investigations involve asking and answering questions and comparing the answer with what is already known. Plan and conduct a simple investigation and understand that different questions require different kinds of investigations. Use simple equipment (tools and other technologies) to gather data and understand that this allows scientists to collect more information than relying only on their senses to gather information. Use data/evidence to construct explanations and understand that scientists develop explanations based on their evidence and compare them with their current scientific knowledge. Communicate procedures and explanations giving priority to evidence and understanding that scientists make their results public, describe their investigations so they can be reproduced, and review and ask questions about the work of other scientists.

Reading:
• E04.B-C.3.1 Demonstrate understanc
among informational texts.
• E04.B-C.3.1.3 Integrate information fi
demonstrate subject knowledge.

Writing:
• E04.C.1.2 Write informative/explanatory texts to examine a topic and convey ideas
and information clearly.
• E04E.1.1.2 Develop the topic w
other information and examples related to the topic.
• E04.E.1.1.5 Link ideas within categories of information using words and phrases (e.g.,
another, for example, also, because)
• E04.E.1.1.4 Use precise language and domain-specific vocabulary to inform about or
explain the topic.

Speaking and Listening:
• 1.6.4.A Listen critically and respond to others in small and large group situations. Respond with grade level appropriate questions, ideas, information, or opinions.

• 1.6.4.B. Demonstrate awareness of audience using appropriate volume and clarity in formal speaking presentations.

Next Generation Science Standards

Students in kindergarten through fifth grade begin to develop an understanding of the four disciplinary cored ideas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science. The expectations in elementary school grade bands develop ideas and skills that will allow students to explain more complex phenomena in the four disciplines as they progress to middle school and high school. These NGSS standards listed below are addressed in this curriculum unit through the various lessons and will help students develop a well-rounded understanding of electricity.

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.]

Annotated Bibliography/Resources

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http://www.fplsafetyworld.com/?ver=kkblue&utilid=fplforkids&id=16185.
This website is useful for electricity background, fun facts, and interactive games.