Idea Sparks

- Build a paper circuit with your students using copper tape, coin batteries, and diodes to discuss the different parts of a circuit in a fun artistic way.
- Take a tour of your school to identify different areas where circuits might be functioning. Ask your building maintenance staff to allow students the opportunity to see control rooms and all the circuits that are functioning there.
- Invite guests like electricians (from the district) into the class for a Q&A session as well as allowing them to discuss what they know with kids.
- Purchase or invite Build-a-Blinkie to your school to learn more about circuits as well as soldering in a hands-on activity.

Writing Prompts

- Circuits are everywhere. Create and explain a simile or metaphor for both the parts of a circuit and the circuit as a whole relating them to things in our world we use often. For example, a power source is like a solar panel field providing energy everywhere. Or the 5V is like an amazon truck delivering what we need to our houses. Ground is like the amazon warehouse where all the trucks come back to be stored.
- What are the different forms of energy?
- Explain why using different colored jumper wires for the 5V and ground are important. Why do people tend to keep 5V red and ground black?

Discussion Prompts

- Circuits allow electricity to flow and generate light. What other things might circuits allow us to control? How did you draw those conclusions?
- Batteries are considered storage devices. What does that mean? What are they storing? How do they release their stored content?
- When you plug your phone in, you are completing a circuit – how? What does this mean? How does it charge your battery?

Mini Lessons

1. The Human Circuit

Lesson Overview: The Paper Circuit knowledge checks are really helpful to have students diagram out what a circuit can be before they get their hands on the materials. It allows the educator to see that students understand the topic as well – consider this an informal observation or formative assessment.

Standards:

Standard	Statement
6-8.CS.03	Design projects that combine hardware and software components to collect and exchange data.

Vocabulary:

- Voltage – the push that makes the charged particles move through a circuit; it measures how strong a current is.
    - Voltaje - el empuje que impulsa a las partículas cargadas a través de un circuito; mide la intensidad de la corriente.
- Battery - The source of electron differentials. Typically, the power of the circuit.
    - Batería - la fuente de diferenciales de electrones. Normalmente, la potencia del circuito.
- Diode – a tiny light bulb that converts electricity from the circuit into light energy when the circuit is complete.
    - Diodo - una pequeña bombilla que convierte la electricidad del circuito en energía luminosa una vez completado.
- Switch - a component that controls the flow of electric current by opening or closing the circuit
    - Interruptor - un componente que controla el flujo de corriente eléctrica abriendo o cerrando el circuito.
- Current - the flow of electrons or charged particles through a circuit, the direction of flow of the charged particles.
    - Corriente - el flujo de electrones o partículas cargadas a través de un circuito, la dirección del flujo de las partículas cargadas.
- Resistors – materials used to control the flow of electricity in a circuit; these will typically help to not overload a circuit.
    - Resistencias - materiales utilizados para controlar el flujo de electricidad en un circuito; generalmente ayudan a no sobrecargarlo.

Materials:

- Space to stand and connect

Procedures/Steps:

1. Have everyone stand up (if possible) and hold hands in a giant circle.
2. The teacher will be the battery. The battery will send a current (motion) through the circuit. Make a wave with your left arm and encourage the students to mimic your actions.
3. Tell the students that we are attempting to show how electricity flows through a circuit.
    a. Allow the current to continue for a short time. In that time discuss how electricity is flowing from the positive side and returning to the negative side but as long as the battery has a charge it will continue to send out a current.
    b. Discuss how the more voltage a battery has the more power it has to send electrons through the circuit.
    c. Work on being a higher and lower voltage by increasing the speed and power at which you move your arms.
4. Now that the battery has been running for some time, as the students what might happen if you introduced resistance. What do you imagine their role will be?
    a. Call on one student to be your resistor. Their job is to take the current from the battery and slow it down.
    b. They are adjusting how much energy is sent through the circuit.
5. Next, we are going to see what happens when we have a switch, how would that work?
    a. Call on another student to be the switch. The switch will release the hand of the person next to them (from the battery side) effectively stopping the energy from flowing.
    b. Explain to kids that energy is still flowing from the battery, but, because the switch is in the off position, the energy stops there.
    c. Have your human switch turn the circuit on and off a few times. The resistor should still be slowing the flow of energy that passes through them!
6. Finally, ask the students about a diode. What is a diode? (Answer – a form of resistance or a resistor). So, what would happen if we added a diode to our circuit? (Answer – it would introduce more resistance, slowing down the circuit even more.)
7. Play around with different iterations of the circuits until the students understand how they work and how energy flows.
8. Afterwards, spend some time discussing how the circuit worked and verifying that students understand the flow of electricity through a circuit.
9. Add on some more consideration questions like the following:
    a. Different batteries have different voltages (amounts of electricity that they provide). Why do you think that is?
    b. Can you add infinite LED Diodes to a circuit? Why or why not? Be sure to use examples from the activity to explain.
    c. What do you think would happen if we had too much voltage running through a circuit? What might happen to the diodes?

Instrucciones en Español:

1. Pida a todos que se pongan de pie (si es posible) y se tomen de las manos formando un círculo gigante.
2. El profesor será la batería. Esta enviará una corriente (movimiento) a través del circuito. Haga un gesto con el brazo izquierdo y anime a los estudiantes a imitar sus acciones.
3. Diga a los estudiantes que estamos intentando mostrar cómo fluye la electricidad a través de un circuito.
    a. Deje que la corriente continúe durante un breve periodo de tiempo. Durante ese tiempo, comenten cómo la electricidad fluye desde el lado positivo y regresa al lado negativo, pero mientras la batería tenga carga, seguirá enviando corriente.
    b. Explica cómo, a mayor voltaje de una batería, mayor es su capacidad para enviar electrones a través del circuito.
    c. Practica aumentar y disminuir el voltaje incrementando la velocidad y la fuerza con la que mueves los brazos.
4. Ahora que la batería ha estado funcionando durante un tiempo, pregunte a los estudiantes qué podría pasar si se introduce una resistencia. ¿Cuál imaginan que será su función?
    a. Pida a un estudiante que sea su resistencia. Su función es tomar la corriente de la batería y reducir su velocidad.
    b. Están ajustando la cantidad de energía que se envía a través del circuito.
5. A continuación, veremos qué sucede cuando tenemos un interruptor. ¿Cómo funcionaría?
    a. Pida a otro estudiante que actúe como interruptor. El interruptor liberará la mano de la persona que está a su lado (del lado de la batería), deteniendo así el flujo de energía.
    b. Explique a los niños que la energía sigue fluyendo desde la batería, pero, como el interruptor está apagado, la energía se detiene ahí.
    c. Haga que su interruptor humano encienda y apague el circuito varias veces. ¡La resistencia debería seguir ralentizando el flujo de energía que pasa a través de ella!
6. Finalmente, pregunte a los estudiantes sobre un diodo. ¿Qué es un diodo? (Respuesta: una forma de resistencia o un resistor). Entonces, ¿qué pasaría si añadiéramos un diodo a nuestro circuito? (Respuesta: añadiría más resistencia, ralentizando aún más el circuito).
7. Experimente con diferentes iteraciones de los circuitos hasta que los estudiantes comprendan cómo funcionan y cómo fluye la energía.
8. Después, dedique un tiempo a comentar cómo funciona el circuito y a verificar que los estudiantes comprendan el flujo de electricidad a través de él.
9. Añade algunas preguntas de reflexión adicionales como las siguientes:
    a. Cada batería tiene un voltaje diferente (cantidad de electricidad que proporciona). ¿A qué crees que se debe esto?
    b. ¿Se pueden añadir infinitos diodos LED a un circuito? ¿Por qué sí o por qué no? Asegúrate de usar ejemplos de la actividad para explicarlo.

c. ¿Qué crees que pasaría si hubiera demasiado voltaje en un circuito? ¿Qué les sucedería a los diodos?

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2. Paper Circuit Knowledge Review

Lesson Overview: The Paper Circuit knowledge checks are really helpful to have students diagram out what a circuit can be before they get their hands on the materials. It allows the educator to see that students understand the topic as well – consider this an informal observation or formative assessment.

Standards:

Standard	Statement
6-8.CS.03	Design projects that combine hardware and software components to collect and exchange data.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Vocabulary:

- Battery - The source of electron differentials. Typically, the power of the circuit.
    - Batería - la fuente de diferenciales de electrones. Normalmente, la potencia del circuito.
- Diode – a tiny light bulb that converts electricity from the circuit into light energy when the circuit is complete.
    - Diodo - una pequeña bombilla que convierte la electricidad del circuito en energía luminosa una vez completado.
- Current - the flow of electrons or charged particles through a circuit, the direction of flow of the charged particles.
    - Corriente - el flujo de electrones o partículas cargadas a través de un circuito, la dirección del flujo de las partículas cargadas.
- Resistors – materials used to control the flow of electricity in a circuit; these will typically help to not overload a circuit.
    - Resistencias - materiales utilizados para controlar el flujo de electricidad en un circuito; generalmente ayudan a no sobrecargarlo.

Materials:

- Scissors
- Knowledge Check Tables
- Markers or Pencils
- Whiteboard tables or Construction Paper

Procedures/Steps:

1. Cut out the squares along the lines. Each of these represents a part of a circuit. You will need to use different parts to create different circuits.
2. Using a whiteboard table or a sheet of construction paper with markers, build a simple circuit using the power source, 5V, Ground, a resistor, and one LED Diode.
3. BE SURE YOU HAVE WIRES (drawn lines) CONNECTING ALL PARTS OF YOUR CIRCUIT!
4. Don't forget to use arrows to show how the electricity is flowing!
5. Then once you have a check off, build one in series and one in parallel.
6. Collect the pieces when you are done.

Instrucciones en Español:

1. Recorta los cuadrados por las líneas. Cada uno representa una parte de un circuito. Necesitarás usar diferentes partes para crear circuitos diferentes.
2. Usando una pizarra o una hoja de cartulina con marcadores, construye un circuito simple usando la fuente de alimentación, 5 V, tierra, una resistencia y un diodo LED.
    a. ¡ASEGÚRATE DE TENER CABLES (líneas dibujadas) QUE CONECTEN TODAS LAS PARTES DE TU CIRCUITO!
    b. ¡No olvides usar flechas para indicar cómo fluye la electricidad!
3. Una vez que hayas marcado una parte, construye una en serie y otra en paralelo.
4. Recoge las piezas cuando hayas terminado.

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Knowledge Check – Cut out the squares/ Comprobación de conocimientos: Recortar los cuadrados

Power Source Fuente de Energía	LED Diode/Diodo	5V (5 volts/voltios)	LED Diode/Diodo
LED Diode/Diodo	Resistor/ Resistencia	Ground/Suelo	Resistor/ Resistencia

Knowledge Check - Cut out the squares/ Comprobación de conocimientos: Recortar los cuadrados

Power Source Fuente de Energía	LED Diode/Diodo	5V (5 volts/voltios)	LED Diode/Diodo
LED Diode/Diodo	Resistor/ Resistencia	Ground/Suelo	Resistor/ Resistencia

3. Circuit Playground

Lesson Overview: This activity encourages students to take a hands-on approach to interacting with the circuits. Other lessons in the unit will encourage students to show off their knowledge and skills while developing circuits. However, in this short activity, students can work through the basics without fear of getting it wrong. After students have practiced vocabulary, learned through hands-on activities, and developed skills, it's time to allow them to build their first full circuits.

Standards:

Standard	Statement
6-8.CS.03	Design projects that combine hardware and software components to collect and exchange data.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Vocabulary:

- Battery - The source of electron differentials. Typically, the power of the circuit.
    - Batería - la fuente de diferenciales de electrones. Normalmente, la potencia del circuito.
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- Resistors – materials used to control the flow of electricity in a circuit; these will typically help to not overload a circuit.
    - Resistencias - materiales utilizados para controlar el flujo de electricidad en un circuito; generalmente ayudan a no sobrecargarlo.
- Breadboard - a plastic board used to create different temporary circuits for testing.
    - Placa de pruebas - placa de plástico que se utiliza para crear diferentes circuitos temporales para realizar pruebas.
- Jumper Wires – short wires that have metal connectors on each end that connect two points in an electrical circuit, they are used to extend a circuit or connect two points temporarily.
    - Cables puente - cables cortos que tienen conectores de metal en cada extremo que conectan dos puntos en un circuito eléctrico; se utilizan para extender un circuito o conectar dos puntos temporalmente.
- Circuit – the complete circular path electricity flows through; a circuit is the completed path something takes that arrives at the same place it departed.
    - Circuito - el camino circular completo que recorre la electricidad; un circuito es el camino completo que toma algo para llegar al mismo lugar del que partió.

Materials:

- LED Diodes
- Jumper Wires
- Resistors
- Breadboards
- 9V batteries
- Wired battery adapter

Procedures/Steps:

1. After students have practiced vocabulary, learned through hands-on activities, and developed skills it's time to allow them to build their first full circuits.
    2. Hand each student a kit or the materials listed above.
    3. Instruct them to take out their breadboard, battery, LEDs, Jumper wires, and Resistors
    4. They should use the 9V battery and adapter to power the board.
        a. Attach the battery to the adapter first.
        b. Next connect the black wire to the ground or (-) location on the breadboard.
        c. Complete the power by attaching the red wire or (+) to the breadboard.
        d. From there, students should be welcome to play and learn!
        e. Remind them they need to connect it all in a giant circle in order to complete their circuit!
    5. Encourage students to try different arrangements, numbers of LEDs, types of resistors, switch locations, series and parallel circuits, and more!
    6. Have fun!

Special Notes: Please be mindful that this is an introduction and that students tend to struggle to start out with. Utilizing spare LED Diodes is important! They might burn a few of them out (also watch for smoke and be prepared to work through challenges!). A few notes to follow:

1. Ensure students understand there are two different sides of a diode and place them appropriately! (Misplacing LED diode sides can lead to smoke happening and the LED to burn out.)
2. This playground shouldn't require students to insert any buttons or other items outside of an LED diode, resistors, bread board switches, and a battery source. If you would like to add a board for power, you can!

Instrucciones en Español:

1. Después de que los estudiantes hayan practicado el vocabulario, aprendido mediante actividades prácticas y desarrollado habilidades, es hora de que construyan sus primeros circuitos completos.
2. Entregue a cada estudiante un kit con los materiales mencionados anteriormente.
3. Indíqueles que saquen su placa de pruebas, la batería, los LED, los cables puente y las resistencias.
4. Deberán usar la batería de 9 V y el adaptador para alimentar la placa.
    a. Primero, conecta la batería al adaptador.
    b. Luego, conecta el cable negro a tierra o al polo negativo (-) de la placa de pruebas.
    c. Completa la alimentación conectando el cable rojo o al polo positivo (+) de la placa de pruebas.
    d. ¡Ahora, los estudiantes pueden experimentar y aprender!
    e. Recuérdales que deben conectar todo en un circuito cerrado para completarlo.
5. Anima a los estudiantes a experimentar con diferentes configuraciones, cantidades de LED, tipos de resistencias, ubicaciones de interruptores, circuitos en serie y en paralelo, ¡y mucho más!
6. ¡Que se diviertan!

Notas Especiales: Tenga en cuenta que esto es una introducción y que los estudiantes suelen tener dificultades al principio. ¡Es importante usar diodos LED de repuesto! Podrían quemar algunos (también tenga cuidado con el humo y prepárese para superar las dificultades). A continuación, algunas notas:

1. Asegúrese de que los estudiantes comprendan que un diodo tiene dos lados diferentes y colóquelos correctamente. (Colocar mal los lados del diodo LED puede provocar humo y el LED se queme).
2. Este juego de prueba no debería requerir que los estudiantes inserten botones ni otros elementos aparte de un diodo LED, resistencias, una placa de pruebas y una fuente de alimentación. Si desea agregar una placa para la alimentación, ¡puede hacerlo!

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