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| **1. Making Circuits  LESSON PLAN**  **—** | | | | | |
| **PROJECT ACTIVITY**  **1.** Please [click here to read p12](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=12) from the 1. Preconceptions section of the EEF Improving Secondary Science Guidance Report  **2.** Please follow this [link](https://docs.google.com/forms/d/e/1FAIpQLSd3cZpugkPu-QjunQEIO2ZinVhd95Xl1GLRtBoxNNohYuZ7-w/viewform?pli=1) to answer the questions below.  **a.** (Multiple choice) How often have you used ‘cognitive conflict’ in your teaching previously?  **b.** (Optional) Please share any examples/ideas that you have for using cognitive conflict to resolve misconceptions (NB these ideas do not have to be for Yr7/8 electric circuits). | | | | | |
| **LESSON SUMMARY**  This lesson lays the foundation for pupils understanding a circuit as a whole loop, rather than imagining a sequence of causes and effects between individual components. The lesson uses the rope loop model to achieve this system-level thinking. | | | | Then students are introduced to batteries. By the end of this lesson students should understand that for a current to flow we must have a complete loop and a source of energy. | |
| **OBJECTIVES** | | | **1.** Understand that a circuit must be a complete loop.  **2.** Understand what a battery is. | | |
| **EQUIPMENT LIST** | | | **•**  Mini-whiteboards  **•**  DEMONSTRATIONS:   1. A large-scale circuit (12V source, 2 long wires, 12V bulb) 2. A 4m length of nylon rope with the ends melted together (if unavailable, 4m of rope tied into a loop). If possible, this rope should be speckled. 3. Six citrus fruits (lemons or limes work best)   Six clean pieces of copper and six clean pieces of zinc (each about 5mm x 40mm)  A microammeter and an LED  8 wires and 12-16 crocodile clips to complete the circuit | | |
| **RESOURCES** | | | **•**  PowerPoint presentation  **•**  Worksheets | | |
| **DIFFERENTATION/**  **ADAPTATIONS** | | | **•**  Remove box of words for gap-fill in Activity 2  **•**  Paraphrase the Activity 2 paragraph during explanation (see slide notes) | | |
| **TIMETABLE & DESCRIPTION OF ACTIVITIES** | | | | | |
| TIME  ACTIVITY  RESOURCES | DESCRIPTION | | | RESEARCH | |
| 00:00 – 00:10  Starter  Demo equipment:   * Large-scale circuit   PowerPoint | **Slide 6:**  What is happening here?  Students see circuit set up at the front of the room as they come in. They sit down, get equipment out and write their best explanation of what is happening. This written explanation will facilitate discussion later. | | | 1a. Preconceptions: Understand the preconceptions that pupils bring to science lessons – it is important to get pupils’ ideas into the open quickly at the start of a topic**.** [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=11) | |
| 00:10 – 00:35  Understand that a circuit is a complete loop  Demo equipment:   * Large-scale circuit * Rope loop   PowerPoint  Worksheet | **Slide 9:** Pupils discuss what is happening. Take note of their misconceptions. During the module (e.g. in rope loop model demos) remind the relevant students of what they thought at the beginning and get them to explain how their thinking has changed.  **Slide 10:** Rope loop demonstration. Please see the notes below slide 10 for detailed instructions. The teacher represents the battery, passing rope from hand to hand. A student grips the rope lightly to represent a bulb. Based on an IOP activity. See details in the notes beneath the slide (this is an important model for this module: many of the subsequent lessons refer back to it).  Discussion of the similarities between the rope loop and the real circuit.  **Task 1:** Identify similarities between rope model and real circuit. Complete sentences explaining how rope loop analogy helps us understand circuits.   * Think-pair-share question: How does the rope loop show us that a circuit needs to be a complete loop to work? | | | 7a. Feedback: Find out what your pupils understand - It is important that you build up an accurate picture of the current understanding of all your pupils [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=38)  1c. Preconceptions: Allow enough time to challenge misconceptions and change thinking – throughout teaching sequences it is useful to revisit misconceptions**.** [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=13)  3a. Modelling: Use models to help pupils develop a deeper understanding of scientific concepts – models help pupils to link observations to the sub-microscopic and symbolic levels and to build a richer understanding**.** [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=19)  Misconceptions research on IOP Spark: It is common for students to use the term ‘electricity’ in an ambiguous fashion that does not differentiate between the concepts of current, potential difference, energy and related terms with precise meaning. [Link](https://spark.iop.org/students-often-struggle-define-electricity-precisely)  6a. Language of science: Carefully select the vocabulary to teach and focus on the most tricky words – often it is words that pupils are familiar with from everyday language that cause the most problems e.g. ‘electricity’. [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=33)  Misconceptions research on IOP Spark: Many pupils see circuit behaviour as a sequence of causes and effects, rather than seeing the whole circuit as an interacting system. [Link](https://spark.iop.org/many-pupils-see-circuit-behaviour-sequence-causes-and-effects-rather-seeing-whole-circuit)  Misconceptions research on IOP Spark: Some younger pupils hold a 'consumer-source' model of the simple circuit. [Link](https://spark.iop.org/some-younger-pupils-hold-consumer-source-model-simple-circuit)  Misconceptions research on IOP Spark: Most pupils see the battery as the source of electrical effects in a circuit. [Link](https://spark.iop.org/most-pupils-see-battery-source-electrical-effects-circuit)  Misconceptions research on IOP Spark: Many pupils think that a battery supplies the same current, regardless of the circuit in which it is used. [Link](https://spark.iop.org/many-pupils-think-battery-supplies-same-current-regardless-circuit-which-it-used)  Misconceptions research on IOP Spark: Some students have differing ideas about what is happening in the wires of an electric circuit when it is working. [Link](https://spark.iop.org/some-students-have-differing-ideas-about-what-happening-wires-electric-circuit-when-it-working)  Misconceptions research on IOP Spark: Many students think that electric current or electric charge (or ‘electricity’), rather than energy, is stored in a battery. [Link](https://spark.iop.org/many-students-think-electric-current-or-electric-charge-or-electricity-rather-energy-stored-battery) | |
| 00:35 – 00:55  Understand what a battery is  Demo equipment:   * Fruit battery   PowerPoint  Worksheet | **Slide 16**: Fruit battery demonstration. Key learning: a battery does not contain or emit electric current, but pushes it around a circuit if it is a complete loop.  **Question:** Is there electricity in a piece of fruit?  **Answer:** this is a meaningless question, as electricity is not a substance. However, the juice in a citrus fruit can react with a pair of metals in a way that pushes an electric current from one to the other, as long as the circuit is a complete loop.  Take a citrus fruit (lemons or limes work best). Gently squash the fruit to break the flesh structure without damaging the outer skin. Insert one clean piece of copper and one clean piece of zinc (each about 5mmx40mm) into the fruit, close together but not touching.  Complete the circuit: connect the fruit battery to a microammeter and LED using wires and crocodile clips.  Add additional fruits batteries (extra cells technically, but see the notes in the ‘Research’ column on the right) into the circuit. Use normal lab wires with crocodile clips to connect the fruits, copper to zinc each time.  As extra batteries are added, the push increases, and the current flowing around the circuit increases - we can see this from the microammeter reading or brightness of the LED (students don’t know what an ammeter is yet – just say “this reading represents the size of the electric current i.e. how much current is flowing: the rate at which the charge is moving”).  (If the LED does not light up, switch it around, as the direction of the electric current in the LED is important. If you do not have a microammeter and the LED is still not lighting (as the current is very low), you should be able to get a reading on a voltmeter (connected across the fruits) to show that the citrus fruits are providing a push [that makes electric current flow around a circuit] just like an ordinary battery does.)  “The batteries we put in devices (show example) do exactly the same thing – they do not contain ‘electricity’ or electric current! A battery pushes electric current as a result of a chemical reaction: a battery contains chemicals that react to make one end positive and one end negative. This can push an electric current around a complete circuit. As the chemicals are used up (which here will take quite a while!) the push gets weaker and eventually will stop. So a battery has a fixed amount of energy it can transfer to a circuit.”  (NB make sure the pupils do not think that the battery is a store of electrons and that these are getting used up).  When a battery has run out of energy we say it has gone flat or run down.  Demonstration: <https://spark.iop.org/batteries-cells-and-energy-stores#gref>  **Slide 17:**  Teacher explanation: A battery is a source of energy.  Students to copy definition of *battery* and carefully copy the labelled diagram– **this would ideally be done on the whiteboard, outlining your expectations for diagrams** (large, using pencil & ruler etc, labelled neatly etc.).  **Task 2:** Students look at pictures of incomplete circuits and decide which work. For those that won’t work they ‘fix’ them by drawing wires. **Adapted from** [www.bestevidencescienceteaching.org](http://www.bestevidencescienceteaching.org)  **Best Evidence Science Teaching project resources**  NB 1: in SLIDE SHOW mode, slide 18 explains that the battery and bulb each have two contact points.  NB 2: it may be helpful for pupils to examine a bulb and see the filament’s connections – one to the base and one to the side. This should help them appreciate how a complete circuit forms. | | | 4a. Memory: Pay attention to cognitive load – structure tasks to limit the amount of new information pupils need to process – as per IOP resources ([Link](https://spark.iop.org/two-jobs-battery)), we only refer to ‘batteries’, as the technical distinction between cells and batteries adds nothing essential to the understandings of the workings of electric circuits. [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=33)  Misconceptions research on IOP Spark: Many students think that electric current or electric charge (or ‘electricity’), rather than energy, is stored in a battery. [Link](https://spark.iop.org/many-students-think-electric-current-or-electric-charge-or-electricity-rather-energy-stored-battery)  Misconceptions research on IOP Spark: Most pupils see the battery as the source of electrical effects in a circuit. [Link](https://spark.iop.org/most-pupils-see-battery-source-electrical-effects-circuit)  Misconceptions research on IOP Spark: When explaining electrical effects observed in the classroom, students may opt for explanations in terms of 'energy' or the ambiguous word 'electricity', instead of referring to electric current. [Link](https://spark.iop.org/many-pupils-offer-explanations-electrical-effects-terms-energy-rather-electric-current)  Misconceptions research on IOP Spark: Some younger pupils hold a ‘consumer-source’ model of the simple circuit. **They may think, therefore, that a single wire from a battery terminal to a bulb terminal will be sufficient to light the bulb.** [Link](https://spark.iop.org/some-younger-pupils-hold-consumer-source-model-simple-circuit) | |
| 00:55 – 01:00  Plenary | **Slide 21:**  Thinking time then cold-call for why connecting a battery backwards means a circuit won’t work. Correct statements given in slide notes.  AfL: Bounce explanation around room to gauge understanding of as many students as possible (see slide notes).  ‘Hands up if you recognised that one battery is the wrong way round’  ‘Hands up if you knew this was the reason, but couldn’t explain why that means the circuit won’t work’ | | | 2b. Self-regulation: Model your own thinking to help pupils develop their metacognitive and cognitive knowledge – you can provide a useful example for pupils by making your thinking processes explicit ... by working through problems in front of a class [Link](https://educationendowmentfoundation.org.uk/public/files/Publications/Science/EEF_improving_secondary_science.pdf#page=13) | |