


Progression toolkit: Paying for electricity

Learning focus	The amount of energy that an electrical appliance transfers is proportional to time; and its power is proportional to the potential difference across it <i>and</i> the current through it.				
As students' conceptual understanding progresses they can:					
As students' conceptual understanding progresses they can:	Describe the difference between energy transferred and power. P	Describe how the power of an electric circuit depends on current through it. P	Explain why the power of a component depends on the potential difference across it.	Explain the relationships $I = Q/t$ and $V = E/Q$.	Explain why power of a component can be calculated using $P = I \times V$.
Diagnostic questions	Calculating energy	Power and current	Power and p.d.	Defining current Defining p.d.	Mystery circuit
Response activities		Rope power		Dotty rope	Mains power

Key:

- P** Prior understanding from earlier stages of learning **B** Bridge to later stages of learning

<h3>Calculating energy</h3> <p>BEST STUDENT WORKSHEET</p> <p>Calculating energy</p> <p> kettle 1 is a kettle with a power rating of 2000 W. kettle 2 is a kettle with a power rating of 2000 W.</p> <p> kettle 1 is filled with two times the amount of water as kettle 2.</p> <p>1. How long do the kettles take to boil? Put a tick (✓) in the box next to the best answer.</p> <p>A kettle 2 takes twice as long to boil. <input type="checkbox"/></p> <p>B they both take the same time to boil. <input type="checkbox"/></p> <p>C kettle 1 takes a little bit longer to boil. <input type="checkbox"/></p> <p>D kettle 1 takes twice as long to boil. <input type="checkbox"/></p> <p>2. Which two equations are correct? Put a tick (✓) in the box next to the best answer.</p> <p>A Power = Energy × time (P = E × t) <input type="checkbox"/></p> <p>B Power = Energy / time (P = E / t) <input type="checkbox"/></p> <p>C Energy = Power × time (E = P × t) <input type="checkbox"/></p> <p>D Energy = Power / time (E = P / t) <input type="checkbox"/></p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>	<h3>Power and current</h3> <p>BEST STUDENT WORKSHEET</p> <p>Power and current</p> <p>An electric circuit is a device for doing work of some kind. In this circuit a bulb is transferring energy to the surroundings. The rate of energy transfer is the power of the circuit. Power is measured in watts (W). One watt is equal to one joule per second.</p> <p>Which electric circuit has the most power? Put a tick (✓) in the box next to the best answer.</p> <p>A <input type="checkbox"/> B <input type="checkbox"/> C <input type="checkbox"/> D <input type="checkbox"/></p> <p>All the same</p> <p>What is the best reason for your answer to part a)? Put a tick (✓) in the box next to the best answer.</p> <p>A Current from the battery is the same in all circuits. <input type="checkbox"/></p> <p>B Current from the battery is bigger in this circuit. <input type="checkbox"/></p> <p>C Current through each bulb is the same in all circuits. <input type="checkbox"/></p> <p>D Current through each bulb is bigger in this circuit. <input type="checkbox"/></p> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>	<h3>Power and p.d.</h3> <p>BEST STUDENT WORKSHEET</p> <p>Power and p.d.</p> <p>Each circuit contains the same type of bulb, but each one is different. The bulbs are chosen so that the current in each circuit is the same.</p> <p>The current in each circuit is the same.</p> <p>These statements are about the three different bulbs. For each statement, tick (✓) in the column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>I am sure this is right</th> <th>I think this is right</th> <th>I think this is wrong</th> <th>I am sure this is wrong</th> </tr> </thead> <tbody> <tr> <td>A The brightness of each bulb is the same.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>B The p.d. across each bulb is the same.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>C The p.d. is biggest across bulb 3.</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>		I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong	A The brightness of each bulb is the same.					B The p.d. across each bulb is the same.					C The p.d. is biggest across bulb 3.					<h3>Defining current</h3> <p>BEST STUDENT WORKSHEET</p> <p>Defining current</p> <p>Electric current is measured with an ammeter. It is measured in amps (A). An electric current flows through a complete circuit.</p> <p>Each statement is a definition of electric current. For each statement, tick (✓) in the column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>I am sure this is right</th> <th>I think this is right</th> <th>I think this is wrong</th> <th>I am sure this is wrong</th> </tr> </thead> <tbody> <tr> <td>A The amount of energy transferred in 1 s.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>B current = charge × time (I = Q × t)</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>C The rate at which charge flows in a circuit.</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>		I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong	A The amount of energy transferred in 1 s.					B current = charge × time (I = Q × t)					C The rate at which charge flows in a circuit.					<h3>Defining p.d.</h3> <p>BEST STUDENT WORKSHEET</p> <p>Defining p.d.</p> <p>Potential difference (p.d.) is measured with a voltmeter. It is measured in volts (V). In this circuit the potential difference is being measured across bulb 1.</p> <p>What happens when the potential difference across a bulb is bigger?</p> <p>Bulb 1 p.d. = 2.0 V current = 0.2 A (1 filament bulb)</p> <p>Bulb 2 p.d. = 3 V current = 0.2 A (2 filament bulb)</p> <p>The current through each bulb is the same.</p> <p>For each statement, tick (✓) in the column to show what you think.</p> <table border="1"> <thead> <tr> <th></th> <th>I am sure this is right</th> <th>I think this is right</th> <th>I think this is wrong</th> <th>I am sure this is wrong</th> </tr> </thead> <tbody> <tr> <td>A The force pushing charge through bulb 1 is bigger.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>B Bulb 1 is transferring more energy than bulb 2.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>C More charge passes through bulb 1 each second.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>D p.d. = energy transferred ÷ charge (V = E/Q)</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>		I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong	A The force pushing charge through bulb 1 is bigger.					B Bulb 1 is transferring more energy than bulb 2.					C More charge passes through bulb 1 each second.					D p.d. = energy transferred ÷ charge (V = E/Q)				
	I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong																																																																	
A The brightness of each bulb is the same.																																																																					
B The p.d. across each bulb is the same.																																																																					
C The p.d. is biggest across bulb 3.																																																																					
	I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong																																																																	
A The amount of energy transferred in 1 s.																																																																					
B current = charge × time (I = Q × t)																																																																					
C The rate at which charge flows in a circuit.																																																																					
	I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong																																																																	
A The force pushing charge through bulb 1 is bigger.																																																																					
B Bulb 1 is transferring more energy than bulb 2.																																																																					
C More charge passes through bulb 1 each second.																																																																					
D p.d. = energy transferred ÷ charge (V = E/Q)																																																																					
<p>Simple multiple choice</p>	<p>Two-tier multiple choice</p>	<p>Confidence grid</p>	<p>Confidence grid</p>	<p>Confidence grid</p>																																																																	
<h3>Mystery circuit</h3> <p>BEST STUDENT WORKSHEET</p> <p>Mystery circuit</p> <p>Two different bulbs of the same type are connected in a circuit. One bulb lights up and the other does not.</p> <p>Why does bulb 1 light up, but not bulb 2? Put a tick (✓) in the box next to the best answer.</p> <table border="1"> <thead> <tr> <th></th> <th>I am sure this is right</th> <th>I think this is right</th> <th>I think this is wrong</th> <th>I am sure this is wrong</th> </tr> </thead> <tbody> <tr> <td>A Bulb 2 is broken.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>B Bulb 2 has a much lower resistance.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>C There is more current through bulb 1.</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>D The p.d. across bulb 1 is bigger.</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>		I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong	A Bulb 2 is broken.					B Bulb 2 has a much lower resistance.					C There is more current through bulb 1.					D The p.d. across bulb 1 is bigger.					<h3>Rope power</h3> <p>BEST STUDENT WORKSHEET</p> <p>Rope power</p> <p>A group of students want to model the power of an electric circuit. They use a rope of rope.</p> <p>To answer</p> <ol style="list-style-type: none"> How could they use the model to show how energy is transferred by an electric circuit? How could they use the model to show the effect of increasing current on the power of a circuit? How could they use the model to show the effect of increasing p.d. on the power of a circuit? <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>	<h3>Dotty rope</h3> <p>BEST STUDENT WORKSHEET</p> <p>Dotty rope</p> <p>A group of students want a loop of rope with dots. The dots represent equal amounts of electric charge.</p> <p>To answer</p> <ol style="list-style-type: none"> How could they use the model to demonstrate $I = Q/t$? How could they use the model to demonstrate $V = E/Q$? <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>	<h3>Mains power</h3> <p>BEST STUDENT WORKSHEET</p> <p>Mains power</p> <p>A kettle and a lamp are plugged into the same mains circuit.</p> <p>Some students are thinking about why the kettle has more power than the lamp.</p> <p>First Each coulomb of charge transfers more energy to the kettle than the lamp.</p> <p>Second A bigger current flows through the kettle than the lamp.</p> <p>Third Charge is pushed through the kettle with a bigger force.</p> <p>Fourth The kettle has more power because it has a bigger resistance.</p> <p>To answer</p> <ol style="list-style-type: none"> Who is right about why the kettle has more power? <ul style="list-style-type: none"> Justify your answer. Who is wrong about why the kettle has more power? <ul style="list-style-type: none"> What would you say to help them on their case? <p><small>Developed by the University of York Science Education Group, the Salter's Institute and the Institute of Physics. This resource is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike license. Downloaded from www.bestevidencescienceteaching.org on 22/04/2016.</small></p>																																									
	I am sure this is right	I think this is right	I think this is wrong	I am sure this is wrong																																																																	
A Bulb 2 is broken.																																																																					
B Bulb 2 has a much lower resistance.																																																																					
C There is more current through bulb 1.																																																																					
D The p.d. across bulb 1 is bigger.																																																																					
<p>Confidence grid</p>	<p>Clarifying - demonstration/modelling</p>	<p>Clarifying - demonstration/modelling</p>	<p>Talking heads</p>																																																																		