

Electricity

STEM: Electric Transport

Teacher's Notes

Early, First & Second Level



In recent years the move to reduce demand on fossil fuels and reduce carbon emissions has grown in popularity. The Scottish Government is committed to reducing carbon emissions and has set a number of targets for reducing greenhouse gas emissions. The Climate Change (Scotland) Act 2009 creates a statutory framework for greenhouse gas emissions reductions in Scotland by setting an interim target of at least a 42 per cent reduction by 2020, and at least an 80 per cent reduction by 2050.

Electric Transport is considered one way in which carbon emissions can be reduced.

Early Level : Electric Transport

The aim of the early level learning experiences is to give learners the opportunity to **investigate** toys and robots that use electricity, then use what they know to solve a problem within a real life context.

Introduce subject by listening to and discussing books such as:

- 'When Charlie McButton Lost Power' by Suzanne Collins
- 'Oscar and the Bird - A Story about Electricity' by Geoff Waring
- 'Which Switch is Which?' By Sam Godwin
- 'Charging About: The story of electricity' by Jacqui Bailey and 'Switch on, Switch Off' by Melvin Berger.

Explaining the concepts about which they have been learning can help learners to demonstrate their understanding.

This can be supported through listening to and discussing books:

- 'Maisy Drives the Bus' by Lucy Cousins
- 'The Seals on the Bus' by Lenny Hort
- 'Don't Let the Pigeon Drive the Bus' by Mo Willems
- 'The Wheels on the Bus' by Paul O. Zelinsky

Bee-Bop practical investigation:

Learners sit around the Bee-Bop which is moving on the floor.

Elicit existing knowledge from children about computers being used for control.

Introduce the idea of the bus – use a picture/ video of a bus with passengers. [Journeys-bus, car, train](#) song [Wheels on the Bus](#)

Learners identify common features of the toys they investigate.

They will begin to explore ways of attaching the wheels;

- the axle and wheels can be fixed. Both then turn together.
- the wheels are free to turn on the axle. The axle is still and only the wheels turn. **Use ideas for the challenge.**

The Challenge

Scenario:

‘The old school bus has failed its test at the garage. It has dirty exhaust fumes and so and we need a new one. The Head Teacher wants us to come up with ideas for a cleaner bus...’

We want this one to be cleaner and quieter than the last one and be able to carry a given number of ‘passengers’.

We are going to try and use the Bee Bot to make a new bus.

The passengers can be Lego characters, Compare Bears or similar.

Groups will collaborate and work through the tasks that will be involved in the challenge, such as thinking of the Bee Bot as the ‘engine’ of the bus.

As a team, evaluate and combine the best of the group’s ideas, justifying decisions, thinking about what it should look like, who it is for and what it will do;

Evaluation: testing the ‘bus’ against the criteria:

Is it clean?

Does it carry the passengers safely?

Can it move in different directions?

How could it be made better?

Learners present their test journey to a group, telling the story of its journey

First level: Electric Transport

Resources to support exploring circuits through practical investigations:

- [BP online circuit activities](#) provides interactive circuits and related activities
- [BBC learning zone 1](#) related to circuits, batteries and power sources
- <http://www.energyquest.ca.gov/story/chapter02.html>

The Challenge

This challenge will allow learners to apply knowledge, understanding and skills gained in sciences and technologies to design and make a controllable, battery-powered toy bus using card, wood, found materials and a variety of mechanical and basic electrical components. They will be given opportunities to devise tests for their working model in order to suggest or make improvements to it.

Aims

Design a suitable shape for the body of the bus incorporating a circuit and switch like the ones they have explored.

Groups will collaborate and work through the tasks that will be involved in the challenge:

- investigating the important/common features of different toy vehicles
- researching, investigating and exploring possible shapes for the chassis and frame of the bus. This research should incorporate data gathered in the explore stage when building a construction model and simple frame chassis;
- sketching up possible ideas and adding notes to explain what each part does;
- evaluating and combining the best of the group's ideas, justifying decisions thinking about what it should look like, who it is for and what it will do;
- building and testing different chassis possibly using the 'Jinks' frame '[Mechanicals' Jinks frame information sheet](#);
- evaluating: assessing the model with reference to plan. Did it do what it was meant to? Did it look like it should? Did it fit the purpose? Make any necessary adjustments.

Resources

One company, 'Alexander Dennis of Falkirk' has come back from the brink in Scotland after developing hybrid buses. This [Alexander Dennis Promotion Movie](#) could be used as a stimulus for pupils to create their own advert for their electric bus.

Lothian buses use Dennis' hybrid buses. Learners could send letters or emails to these companies or similar ones to ask questions about their work environments and some of the skills they use.

Glossary of terms

Electricity: the transfer of energy using electric charge. It provides power for lighting, appliances, and other electric devices in our homes and businesses

Energy: the ability to do work. People get energy from food, but things like an i-pod, a video game player and a mobile phone get their energy from electricity

Energy efficiency: using energy wisely and not wasting it

Cell: a device that stores energy and makes it available as electricity

Circuit: an electric device that provides a complete path for electric current to flow

Switch: a mechanical device used to turn current on or off in an electrical circuit

Renewable energy: natural energy which does not have a limited supply. Renewable energy can be used again and again, and will never run out.

A list of renewable energy sources: Biomass, Hydro, Geothermal, Solar, Tidal, Wave, Wind, Wood

Hybrid vehicle: a vehicle that uses an on-board rechargeable energy storage system (RESS) and a fuel based power source for vehicle propulsion. These vehicles use much less fuel than their counterparts and produce fewer emissions. Hybrid vehicles recharge their batteries by capturing kinetic energy through regenerative braking. Some hybrids use the combustion engine to generate electricity by spinning a generator to either recharge the battery or directly feed power to an electric motor that drives the vehicle. This takes place when cruising or in other situations where just light thrust is needed.

Axle: the **shaft** on which wheels are carried. The wheels are either fixed so that they turn with the axle or able to spin freely on the axle.

Chassis: the frame of a vehicle

A more detailed glossary is available from the [Nuffield Foundation](#)

Additional background information:

- BBC Class Clips:
[Dangers of Electricity](#)
[Circuits](#)
- [National STEM Centre](#): register for free. Use the e-Library to access 'Nuffield Primary Science and Technology for Ages 5-7 and 7-19: 'Circuits' and 'Vehicles'.

Potential Interdisciplinary Links

This challenge could be extended and linked to investigating citizenship issues locally and nationally. Learners can explore the impact of electric transport & sustainable energy sources on people's lives, weather and climate change as well as the different ways it is used in their local environment and Scotland.

Second Level: Electric Transport

When involved in inquiry-based science, learners need opportunities to discuss scientific phenomena and concepts.

When learners' relate simple circuits to electricity being used in the home e.g. appliances are often operated because switches are connected in series – they should know the socket switch and appliance switch must both be on for the appliance to operate whereas the sockets and house lighting are arranged in parallel as different sockets and lights can be operated independently.

Possible tasks for exploring circuits through practical investigation

Design and build simple circuits to meet basic design requirements:

- switching on and off a simple bulb or LED;
- switching on and off a simple buzzer;
- switching on and off a simple electric motor
- a circuit which switches on a bulb when either of two switches is used.

Learners could also think of other ideas to explore, and devise ways of investigating these. Ideas could include: cost of journey per passenger compared to other modes of transport; how will the electric vehicles be re-charged?; what is the possible impact on the local and wider environment?

Resources

A range of switches

An appropriate number of cells

An appropriate number of MES bulbs (3V to avoid 'blowing' the bulbs)

A range of bulb holders

Buzzers

Motors and motor holders

Motor pulley wheels

LEDs, various colours

Wire

Wire strippers/cutters

Battery testers

Various 'junk' items to help make 3D models

Investigate ways to reduce drag

- Learners should have carried out work on forces, air resistance and streamlining and this could be used to make the electric transport models move more efficiently. This could be linked to aspects of SSERC's 'Pimp my trolley' activities.
- Learners' explore friction/air resistance by carrying out an investigation to explore factors which seem to affect the resistance of their electric transport vehicles. It should not be very challenging for learners to work out whether or not square shapes objects are more or less streamlined than pointed ones so to add to the difficulty and cognitive challenge, learners could test a range of different objects which are pointed at the front but have subtle shape differences, devising their own ways to investigate this to gather information from which to draw conclusions.
- Learners could report back on their observations and conclusions relating to objects moving more easily and relate this to energy efficiency and impact on the environment.
- Learners could research examples of streamlining in nature or in technologies. They could gather examples of images of streamlining for a particular category e.g. sharks, seals, submarines, competitive diving, and annotate the pictures with explanations of use of streamlining. This links directly to the STEM Central Second Level Rescue Vehicles Learning Journeys available on the National Improvement Hub.

Investigate buoyancy and water resistance

Groups will identify some of the tasks that they will be involved in with the challenge:

- Is the vehicle moving over land or water?
- How does one transport system link to another?
- As a team, evaluating and combining the best of the group's ideas and justifying decisions;
- Building and testing prototypes;
- Reflection: assessing the models and making any necessary adjustments.

Groups should be given the chance to test models and make any necessary modifications.

Prototypes of model vehicles have to meet design briefs and learners have to describe and explain how the electric vehicles reduce the demand for fossil fuels.

Extend and link challenge to:

- the geography of different areas e.g. how would people be transported over water? What if part of the town is higher than other parts? Is the geography suited to rail transport?

- citizenship issues locally, nationally and internationally. Learners could explore the impact of reducing demand on fossil fuels, the impact of developing new power stations or alternative power generators e.g. wind farms

This second level learning journey builds upon learners' prior experiences of SCN 1-09a and possibly SCN 0-09a and is dependent upon several science concepts which are not necessarily intuitive to learners.

The concept of electric current and voltage often prove to be difficult for young learners. Current and voltage are considered in greater depth at third level. There is, however, merit in allowing learners to construct series and parallel circuits so they can describe the connections between their learning and their everyday experiences of using electricity.

Parallel circuits can be developed as an extension to learners' work on series circuits which helps progression between second and third Level outcomes.

The words 'cell', 'battery', 'current' and 'voltage' are regularly used when explaining how circuits operate. At second level the following approximate definitions will be sufficient as the concept of electricity is developed further at third level:

Cell: commonly a chemical unit which transfers energy to an electric circuit. Cells are often incorrectly referred to as batteries.

Battery: is a combination of cells usually added together in **series** e.g. two 1.5V cells connected in series will provide 3V.

Current: is an indication of the amount of electric charge flowing past a point in the circuit in 1 second.

Voltage: is an indication of how much energy a cell or battery can transfer to the circuit components e.g. a 3V battery provides more energy per charge than a 1.5V cell

There are several basic rules with series and parallel circuits:

1. Series:
 - a. The current has the same value **through** all components connected in series;
 - b. In a series circuit, all the components are either switched **on** or **off together**;

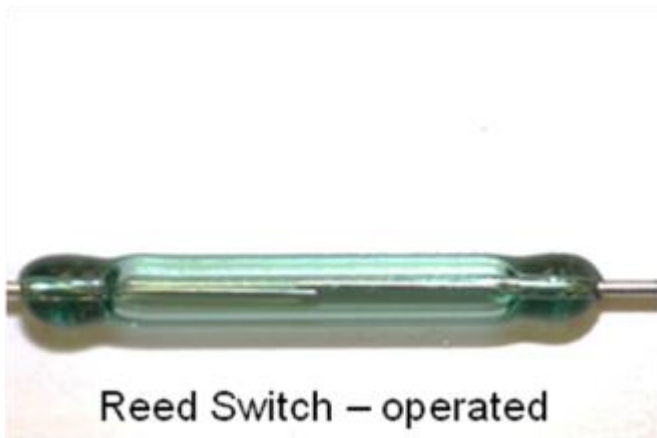
- c. A fault in the circuit switches off the whole circuit (sometimes referred to as an 'open circuit' or a 'break' in the circuit).

2. Parallel:

- a. The voltage is the same **across** all components connected in parallel;
- b. In a parallel circuit, different 'branches' of the circuit can be operated independently of other parts of the circuit;
- c. A fault in one part of the circuit does not necessarily switch off the whole circuit.

Points to consider when constructing simple circuits:

1. Switches



Reed Switch – operated by a magnet



'Toggle Switch' (SPST)



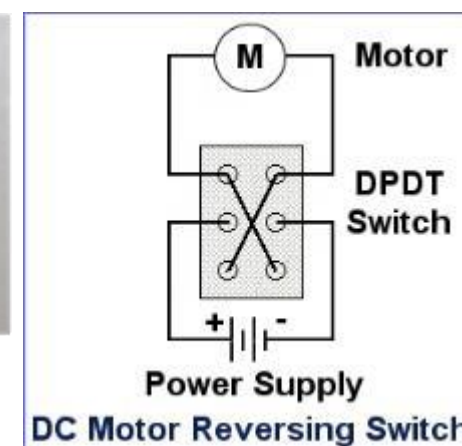
'Push to Make' Switch



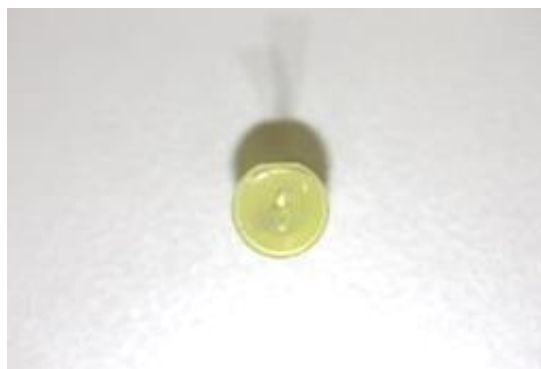
'Push to Break' Switch



'Reversing' Switch (DPDT)



2 .The common types of LEDs used in primary science and technology are designed to be operated by 3V batteries. The LED must be connected into the circuit the correct way around as the LED only lights when current is flowing in the correct direction (the LED acts as a n electrical turnstile) or [polarity](#). To do this, connect the longer leg of the LED to the positive of the battery. If the legs look similar in length then look at the cover of the LED from below and you should observe a flat edge – connect the flat edge to the negative of the battery. LEDs use less electrical power than bulbs and tend to be less bright than bulbs therefore do not 'drain' cells or batteries as quickly. LEDs can be bought from several standard suppliers of science and technology equipment to schools.



3. Standard MES bulbs are relatively cheap to buy. The bulbs have a voltage and current rating stamped on to the side of the threaded metal casing. 3V bulbs are suitable for most work in the primary classroom.

**Typical MES Lamp
(ideally 3V)**



Flashing MES Lamp



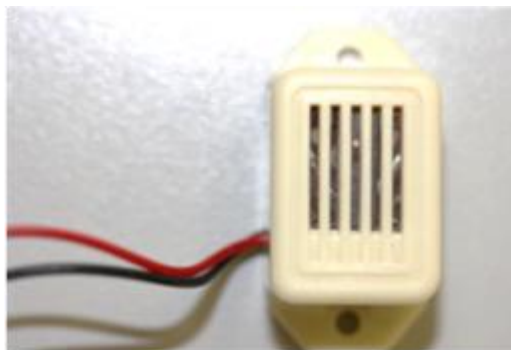
This bulb has a piece of bi-metallic strip in the centre. As the bulb lights, the bi-metallic strip warms and begins to bend away from the contact so switching the bulb off. The bi-metallic strip then cools and returns to its original position and switches the bulb back on and so the process repeats making the light flash – ideal for an indicator, emergency vehicle or lighthouse.



Lamp holders

This lamp holder to the top right has a slot for a lollipop stick so the bulb can be mounted vertically.

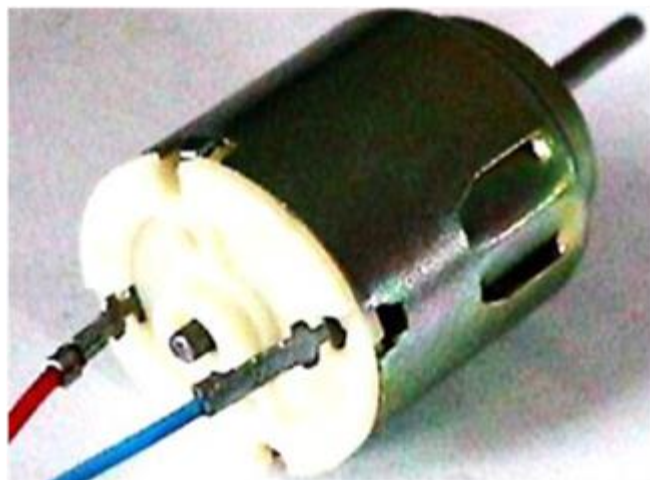
4 . The common types of buzzers used in primary science and technology are designed to be operated by 3V-6V batteries. The buzzer must be connected into the circuit the correct way around as the buzzer only sounds when current is flowing in the correct direction. Most buzzers are fitted with a black and a red wire. Connect the red wire of the buzzer to the positive of the battery and the buzzer will sound.



Red to +ve
Black to -ve

5. Movement – the electric motor. The direction the motor spins depends upon how it is connected in the circuit. The basic motors can be made to drive simple vehicles by means of an elastic band wrapped around the axle of the vehicle and a pulley wheel attached to the motor. If the motor spins too quickly, the speed of rotation can be changed using a cog and simple gearbox thus introducing another element of technology and numeracy in terms of ratio of the number of teeth on the cog and gear. To slow the motor down use a small diameter cog to turn a large diameter gear and vice versa for speeding up the motor.

Movement – the motor



Pulley wheel



Gear/Cog

6. An Electrical Connecting Block can be used to connect several simple series circuits to one cell or battery. In this way individual simple series circuits are in effect connected in parallel to one power source.



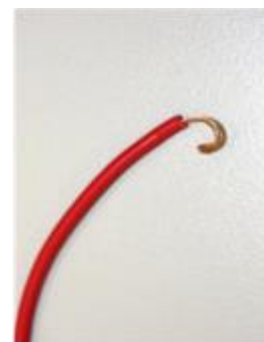
Useful accessories.



Cell/Battery tester



Wire Cutters
and strippers



Hook wire for
Connecting to lamp
holders



PP3 Battery snaps