Activity P

Teaching Ideas and Evidence through 'Electricity' in Year 7

Developed by Tom de Trafford with Jon Dunning and Linsey Cushion
Fearnhill School, Letchworth

Rationale

This project examined how practical work and the use of models and analogies affected the way that the pupils constructed their own understanding of the concepts that they were studying. The impact of different teaching methods on the pupils' learning was analysed, and attention was paid to how the use of physical evidence was combined with external ideas to give the pupils the means to form their own personal models of science.

This classroom research was based on a series of lessons on electricity for year 7. Pupils were asked a number of questions about the topics they were studying before and after the main teaching sequence. The questions focused on pupils' understanding and, more importantly, how they constructed their ideas.

Teaching sequence:

The following section provides a brief summary of the lesson plans.

Lesson 1

In the first lesson, focused on magnetism and the forces that are experienced by magnets and how these relate to their field lines. The main pupil activity was the drawing of the field lines from a bar magnet.

Lesson 2

In the second lesson the objective was to learn about electromagnets and why they are so useful in society. The starter required pupils to think about how they could make use of a magnet that could be turned on and off. It was at the point when it was planned to actually build electromagnets that the major problems in the pupils' knowledge of graphs became apparent. Time had to be spent on improving these key skills.

Lesson 3

In this lesson pupils looked at the key components of a circuit and revised the idea that a complete circuit is needed for a current to flow. The lesson also looked at what makes a good conductor. This subject was pulled together with a plenary that looked at the need for free electrons for current to flow.

Lesson 4

This lesson began by reviewing the idea that electrons moving within the circuit are the carriers of the energy in the circuit. The lesson then moved on to focus in more detail on the difference between parallel and series circuits. This was done in three main stages; the first was a relatively pure description of how the electrons would

flow in the two types of circuit. The next stage was for the pupils to build the circuits for themselves and report on the effects on the brightness of the bulbs. The third stage was with the use of some more complex analogies with water and soldiers.

Lesson 5
Although the pupils had been introduced to the idea of devices taking the electrical energy from the circuit this lesson was the first in which resistance was introduced as an idea in its own right. This lesson also used the structure of combining demonstration of the effects of resistance with the building up of an expressed model of what it is about a wire that leads to it having resistance. During this lesson the pupils were asked to specifically describe the way a circuit works in terms of the experience of a particular electron (to which they gave a name).

Lesson 6
In this lesson the pupils were introduced to the workings of a battery and the part it plays in a circuit. The practical part of this lesson was based on the building of fruit batteries and measuring the voltage that they gave for different metals. This was a fun activity, although there was a danger that pupils would not really understand what they were measuring with the voltmeters. The teaching was based around providing the pupils with the idea that the battery was giving the electrons a push, an amount of energy, and that voltage is the measurement of this energy or push.

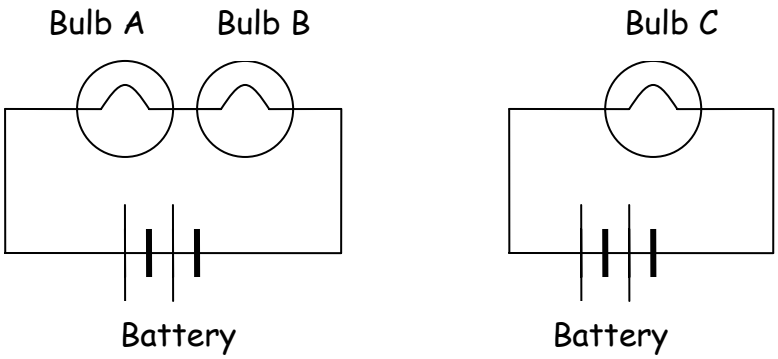
Lesson 7
This lesson was used to give the pupils the opportunity to build electromagnets. With hindsight it was probably a better time (cf. lesson 2) to look at the links between electricity and magnetism once the pupils had a better understanding of electricity. In addition to this, the pupils were introduced to the concept of fuses.

Lesson 8
In this lesson the whole topic was reviewed and the different ideas were pulled together ahead of giving the pupils my questionnaire on their understanding of the topic.

Lesson 9
This was an additional lesson to the topic in which the pupils were given a number of exercises to improve their ability to accurately read results from different types of meter. It was not directly linked to the more conceptual teaching of the ideas of electricity but focused on the skills that they would need.

Analysis
The main analysis of the teaching sequence took the form of a questionnaire (Appendix 1) which was aimed at analysing both the understanding of the group of pupils and trying to gain some insight into the personal constructs behind that understanding. The answers to the understanding questions either took the form of a simple right or wrong answer or a description of the concept. The more difficult part of the test was the “how?” questions, which tried to analyse the way the pupil had answered the simple knowledge questions.

Bulbs in series
The second question in the test showed two circuits, one with a single bulb and one with two bulbs in series. The pupils were then asked to identify which bulb was the brightest.



This simple question proved relatively easy for the pupils with 92% of them picking the correct answer. Below is a selection of the reasons given by the pupils for their answers:

“Bulb C has one battery to itself.”

“I worked it out because it does not bump into as much things.”

“The electrons will only have to go through one bulb so they won’t be as tired as they would be if they were going through two bulbs, so the one bulb is brighter.”

“I know because if there are 2 bulbs they share the brightness but one bulb can have all of it.”

“It only has to go through one bulb and back to the battery, it will take less so it will be brighter.”

In most of these answers the pupils are looking at the way that electrons have to flow around the circuit. The concept of the different energy levels is being taken as how ‘tired’ an electron is and the amount of work it needs to do. This model involves personalising the electrons and then focusing on the experience they have in completing the circuit.

One of the pupils who got it wrong was not able to visualise the idea of current flowing around a single circuit and passing all of the components. This pupil selected the answer that bulbs A & B would be brightest, using the explanation:

“Because they have too different currents flowing to them and C has only 1.”

Batteries
Question four in the questionnaire required the pupils to give some indication of how they saw the operation of a battery and what it does. The pupils had been given the analogy of the battery as the pump in the circuit that pushes the electrons around and

gives them the energy. Many of them had taken on this idea and gave descriptions such as:

“A battery is like a pump, like a heart in the body that pumps the electricity.”

“A battery pushes electrons around the circuit like a pump.”

The second of these ideas has the advantage of incorporating the idea of the electrons flowing and therefore coming around the circuit. The first has the more dangerous idea of electricity as a substance, and this gives some insight into why this pupil got question number two wrong.

A significant number of pupils focused on the battery as the source of the electrons in the circuit and the store of energy:

“A battery is the start of a circuit, everything comes in or out of a battery. It stores all the energy at the beginning and then it is realised.”

“In a circuit a battery gives out electrons that travel around the circuit.”

“It keeps the circuit running. The electrons start off at the battery and keep flowing until it reaches the battery again.”

These pupils are showing a reasonable understanding of the impact of the battery on the circuit and the way that it is giving out electrons, without needing to fully understand the relationships of electricity.

Resistance

Question five specifically looked at the pupils’ understanding of how resistance works in a series circuit. The pupils were asked to describe why a bulb or resistor slows the current, and the way this process works.

“The electrons have to squeeze through the thin wire.”

“The electrons in the circuit has to overcome obstacles that wear them down.”

“Because resister makes them slow because on the way threw it keeps hitting the sides and the electron get tired and slows down.”

“It is slowed because most of the electricity goes into the bulb.”

Most of these ideas allow for the concept that electrons lose energy or have to do some work in moving through the resistance. The last response however shows the danger of pupils thinking about a substance called *electricity*, which somehow goes into the bulb. This model is likely to lead to problems and is unlikely to be much help with answering even the simplest of questions.

Outcomes from the work

The work carried out for this project has allowed me to examine in more detail at the way in which pupils interpret their science lessons and not just at what they are being

told. Asking pupils why they give a particular answer to a question provided useful information about the way in which they learn and the range of misconceptions they have picked up in the process.

This formative assessment of pupils' understanding makes it is possible to select additional teaching activities that will counter misconceptions and help the pupils to build an effective personal model.

Recommendations

In testing pupils it is useful to give them the opportunity to tell you more about their understanding of a phenomenon than they can by answering a simple closed question. Allowing pupils to develop their ideas and describe them is useful for them in formulating these ideas and for the teacher in understanding them.

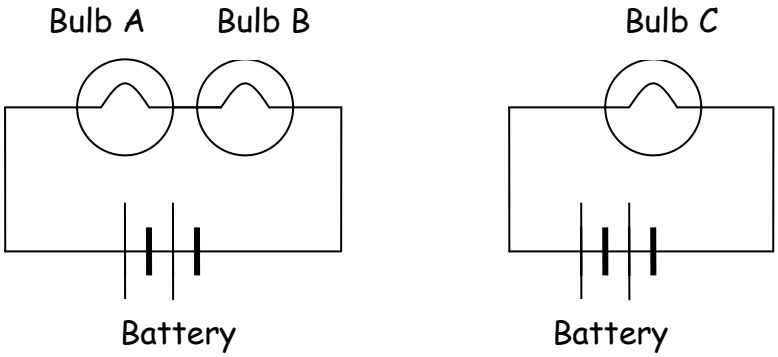
The use of carefully constructed analogies is a powerful tool in developing understanding, but it is critical to assess the understanding and be careful to avoid developing any new misconceptions.

What do you understand about electricity and magnetism?

1) Why do you need a circuit for current flow?

How do you remember this? (Think of experiments, teacher explanations, and visual models.)

2) Which bulb is brightest?



Underline your answer: i) Bulb A ii) Bulb B iii) Bulbs A & B iv) Bulb C

How did you work this out?

3) How does a fuse work?

How do you remember this? (Think of experiments, teacher explanations, visual models)

4) What does a battery do in a circuit?

5) Why is the current slowed down when it goes through a bulb in a series circuit?

6) What is you favourite type of work?