Electricity and Magnetism: Teaching and Learning Issues 06

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This is the 'Teaching and Learning Issues' that explains the particular challenges. To develop your expertise in the episode, work with the 'Physics Narrative' and the 'Teaching Approaches'. Navigate to any part of the topic using the Topic Menu, or use the tabs below to stay within this episode. .

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These challenges reflect research carried out into alternative conceptions.

Challenge 1: Which are magnetic?

Wrong track: All metals are magnetic, magnets will stick to any metal!

Right lines: Most metals are not magnetic. The most common magnetic metals are iron, steels with a high iron content, nickel and cobalt.

Challenge 1: Which are magnetic?

Thinking about the learning

The classification of materials into electrical conductors and insulators in primary school suggests to pupils that metals are special when it comes to electricity. It is not therefore surprising that the same classification is transferred in pupils' thinking to the topic of magnetism. Metals are expected to be magnetic and non metals are expected to be non-magnetic.

Challenge 2: Magnetism and gravity

Wrong track: We are pulled down onto the Earth’s surface by gravity. Gravity works because the Earth is like a giant magnet which attracts things to the surface.

Right lines: Gravity is not related to magnetism.

Challenge 2: Magnetism and gravity

Thinking about the learning

This is a common misconception. Pupils know that magnets are associated with a magnetic force and that there is magnetism associated with the Earth. When a mechanism is sought to explain gravity, magnetism therefore becomes an obvious candidate.

The gravitational force and magnetic force are different in nature. Suppose you have two magnets and two non-magnetic bars of iron. The forces acting are as follows:

Objects	Magnetic force	Gravity force
2 magnets	Attracting and repelling (depending on the poles)	Attracting
2 bars of iron	None	Attracting

Challenge 3: Magnetism and air

Challenge 3: Magnetism and air

Thinking about the learning

Some pupils will argue that air is needed to enable magnets to attract and repel each other. This line of argument is certainly incorrect, but it is also understandable in that it suggests a medium through which the magnets can act at a distance.

Thinking about the teaching

You might want to challenge this “wrong track” thinking directly in your teaching by setting up a demonstration. This might involve placing a piece of iron in a bell jar, removing all of the air from the jar with a vacuum pump and seeing whether the iron is still attracted to a powerful magnet held outside the jar. Ask for pupil predictions before you start removing the air.

Challenge 4: Magnetic fields

Right lines: The magnetic field is the space around the magnet where it will attract or repel other magnets.

Wrong track: The magnetic field is those iron filings around it.

Challenge 4: Magnetic fields

The very idea of a magnetic field is a demanding one to get hold of. The fact of the matter is that the magnetic field is a theoretical idea invented by physicists to allow us to describe the action of magnets as they attract and repel. It is possible to maintain that it is not anything real, there is nothing to see or touch around the magnet. When pupils first come across this idea of the magnetic field, it is not surprising that they sometimes go off down the "wrong track" in their thinking!

Thinking about the teaching

Magnetic fields cannot be seen

It is important to keep coming back to the basic idea that the magnetic field is the space around the magnet where it exerts a force. You might explore that space with iron filings and plotting compasses, but these simply tell us about the direction and strength of the force acting, they do not make the field any more real.

Magnetic fields exist in 3D spaces

If you look in a science text book at a magnetic field diagram for a bar magnet it will almost certainly show a 2D representation. It is worth emphasising however, that the magnetic field exists in the space all around the magnet.

Ask the pupils!

You might introduce the idea of magnetic fields, carefully making all of the key points set out above, but even then it is worth asking your pupils what they understand by the idea of magnetic field. Ask them to jot down a sentence or two. You might be surprised by what they write!

Challenge 5: Drawing magnetic field patterns

Thinking about the teaching

Our experience over many years of directing pupils to scatter iron filings around bar magnets has shown that the magnetic field patterns which seem so clear to us are far from obvious to the vast majority of pupils. Indeed how else could it be? This is one of those situations where:

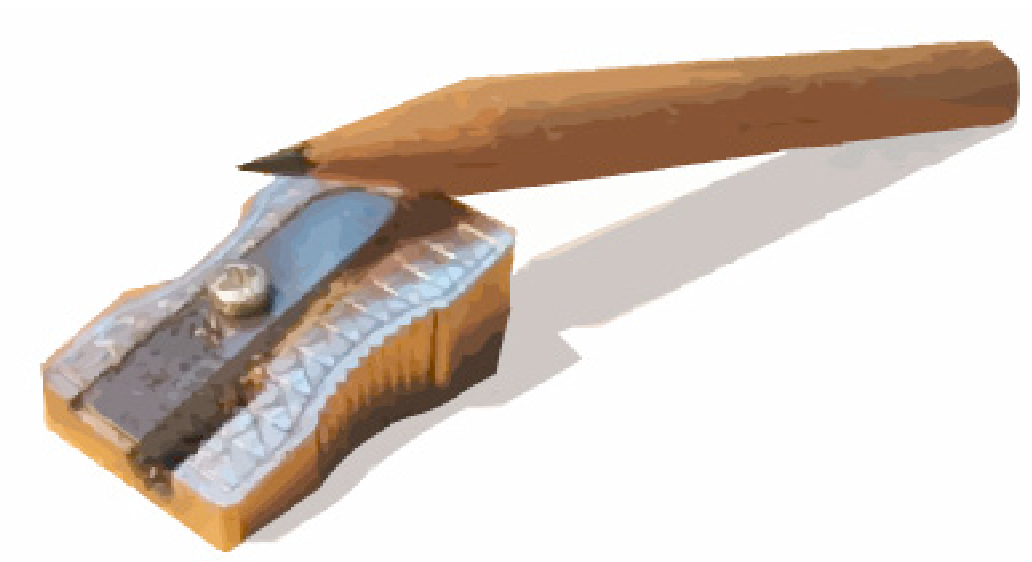
> …if you know what you are looking for, it's obvious
> …if you don't know what you are looking for, it's hopeless

We have a physics teacher friend who remembers teaching a year 8 class about magnetic fields. The pupils were drawing the magnetic field pattern around a bar magnet, using iron filings, and our friend looked over the shoulder of one of the pupils. The boy was producing a drawing that was heavy with shading and, in some ways, captured what was in front of him, but that displayed nothing of the magnetic field pattern which the teacher actually wanted. The teacher pointed at the boy's drawing and then at the actual pattern of iron filings, and said:

> "John, just look at the iron filings and look at your drawing! Does it look anything like that? Are you looking at the same thing as me?"

As soon as he had said this, our teacher friend smiled to himself. The point could not have been more clear. The teacher and pupil were looking at different things. The teacher saw a magnetic field pattern, the pupil saw clumps of iron filings. Before the pupil could draw the field pattern he needed more instruction in what it was that he was looking out for.

There is an important message for teaching here.



Challenge 6: Magnets wearing out

In real life, "permanent" magnets do wear out and lose their magnetism. Pupils sometimes associate this with the magnet "giving something out" to make it attract and repel.

Wrong track: The magnet sends out electricity to make it attract and repel. That's why it loses its strength.

Right lines: Magnets wear out as their internal mini-magnets become disordered, pointing in all directions.

This idea of the magnet sending out electricity is incorrect, but the question as to why magnets wear out is a good one. It's best thought of in terms of the mini-magnet model introduced in the Physics Narrative.

Challenge 7: Magnetic north and south

Thinking about the teaching

The point was made in the Physics Narrative, that the Earth's magnetic pole in the Northern hemisphere is, in fact, a south pole. This follows directly from defining the end of a compass needle which points north as the north seeking pole.

In truth, this is not an important point in terms of developing your pupils' understanding of basic magnetism. Furthermore, it is not something which you need refer to since a compass needle is all you need to find the North and South poles of a magnet.

Nevertheless if a pupils does ask the question:

> "So does that mean the magnetic north is a south pole?"

...you can reply with absolute confidence:

> "What an excellent question! Yes it does!"