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Teaching Ideas and Evidence through 'Electricity' in Year 9

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The Project

This classroom research is based on a sequence of lessons given to year nine pupils on electricity. Their ideas on how an electron travels in a circuit and how different models describe electricity were analysed. The '*imagine you are an electron'* written activity focused on what the pupils understood, and the model answer provided an opportunity for them to evaluate and modify their work, as well enabling teacher analysis of their level of understanding and how they constructed their ideas. The ability of the pupils in the class was very varied and included pupils with English as additional language (EAL), deafness, behavioural difficulties, as well as gifted and talented pupils.

This project examined how teaching strategies (practical work, the use of models and analogies) can identify and correct pupils' misconceptions through considering how they construct their knowledge relating to everyday experiences and prior teaching.

The Lessons

The lessons were structured using Bloom's taxonomy of cognitive processes so as to challenge the ability of all pupils. The aim of each lesson was to include different classroom strategies/learning tasks, including abstract, complex, open-ended tasks with an independent focus. The following strategies were used:

- Challenging, inventive tasks;
- Open questions and open-ended tasks e.g. 'imagine you are a…?';
- Giving the pupils opportunities to develop thinking skills: observation, exploration, comparison, classification, imagination, prediction, critical thinking, interpretation, summarising, reflection and evaluation;
- Giving the pupils a chance to plan, select, analyse and discuss their own work;
- Use a wider range of curriculum materials from later key stages as an extension to develop deeper understanding.

The following section forms a brief summary of the lesson plans:

<u>Lesson 1</u>
In the first lesson the topic of electrostatics was reviewed and the movement of electrons was used to link to current electricity. Pupils predicted what current readings would be observed in their practical work. To consolidate the link, the homework set was to imagine the journey of an electron in a circuit. This was an open-ended written

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activity with the purpose of further clarifying the pupils' understanding, identifying their level of scientific language and allowing the more able pupils to illustrate their understanding without any limitations. This exercise facilitated the elicitation of pupil understanding at this stage, to make their ideas explicit so that they could actively use and evaluate their mental model in the following lessons.

Lesson 2

The purpose of the second lesson was to relate their understanding to observations from the practical activity and use visual aids to develop their concepts of current and energy transfer.

Lesson 3

This lesson was introduced with a discussion to review what is needed for current to flow. This led to introducing the idea of 'voltage' and what it means in terms of the energy carried by each electron, so linking to the idea of energy transfers in a circuit. The use of analogies of pupils running around different tracks on a training circuit consolidated the ideas of current, voltage and energy transfer. The discussion was extended to the analogy of hurdles and hills to resistance, in preparation for the next lesson. The idea of why a light bulb actually lights up was discussed. The analogy of pupils running around the field representing the flow of charge, their energy transfer as the transfers in the circuit and the cups of water being the energy given from the battery was used. This allowed understanding at a level within the grasp of all pupils and in particular the EAL pupils. However the discussion of how the light bulb lights allowed the more able pupils to explain their ideas and provided an element of peer education.

Lesson 4

This lesson included a numeracy activity, which had the additional purpose of introducing the more able pupils to the idea of 'Coulombs' and the definition of current as 'the amount of charge passing a point per second. The second homework issued to the group was for them to re-evaluate their work using a model answer to the 'journey of an electron' exercise, to identify if they had originally held any misconceptions. Misconceptions and the problems they can cause were explained to the pupils. The topic of resistance was discussed again, using the idea of why a light bulb filament glows and an extract from the 'Horrible Scientists: Simply Shocking' book was read to engage pupils in active listening, and aid them in identifying and explaining the relationship between current, voltage and resistance.

All the pupils gained experience working with the equation, but for the more able pupils, this task also introduced the concept of the Coulomb as the unit of charge. During later lessons in this module the pupils were given homework to summarise the topic of electricity. The homework entailed pupils' describing and explaining the concepts that the different models/analogies used to help understand the science were actually portraying.

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Analysis

The current prediction

This activity highlighted the fact that some of the pupils held the misconception that current is ‘used’ up in a series circuit, as they predicted the current would be different at different points in a series circuit. This supports the research suggesting that pupils believe that the current is used up.

The journey

In some ways this homework may have seemed unfair as the pupils were describing a concept without any formal Year 9 teaching. However, this topic has been taught since year 5 and it allowed me a further opportunity to explore the prior understanding of the pupils. A pupil who was not among the designated ‘gifted and talented’ pupils produced an excellent piece of work, which showed either an understanding of the topic or the ability to research information for a challenging task (a characteristic of the more able). One of the gifted pupils in the class produced an extensive piece of work, which also showed extensive research, but contained some misconceptions. Some may argue that allowing pupils to write an account of a journey of an electron as if it were alive may instil or even create more misconceptions. However, I felt that if pupils were given the choice to describe their work in this manner, the sense of ownership might help scaffold their understanding in later study of this topic.

The identification of misconceptions

Most pupils showed understanding of the possible misconceptions identified in the model answer. However, the gifted pupils still showed that they were maintaining the ‘wrong’ understanding of ideas despite formal teaching e.g. 'that all electrons start in the battery. Pupils tended to indicate in their work that they conceptualised current in terms of individual electron movement rather than as a ‘flow’ of charged particles.

The models

This homework was not as well answered as I had hoped. However the more able pupils did make an attempt to answer the questions. Pupils could not grasp the concepts behind all of the models. However one pupil showed an understanding of potential difference rather than simply using the term ‘voltage’ in her description of one model (a key stage 4 concept) and this should help her when this module is expanded for GCSE. In the homework about models there was confusion about which part of the model represented the resistance and the source. The extension exercise, to design their own model, and the misinterpretation, indicates that they were still working with the concept that one charge travels round the circuit.

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Conclusion

The biggest barrier that has not been overcome completely by all pupils, including the most able, is the use of language within the topic of electricity. Despite ensuring that the term ‘electricity’ was only used in the title of the module, pupils still used it in their homework descriptions e.g. “electricity travelling in the wire”. The initial homework highlights the big confusion with everyday language and common misconceptions.

After reviewing the pupils’ work and assessing their contributions in class, I believe that the lessons, underpinned with Bloom’s theory of higher order skills, e.g. analysing and evaluating their own work, has benefited all the pupils in the topic of electricity. Although no pupil produced a perfect answer, they appeared to have progressed and created a foundation on which they can build.

A major barrier that affects all pupils, but particularly noticed here among the more able, relates to the identification and amendment of misconceptions. Unfortunately the electricity topic provides a vast number of potential misconceptions due to the abstract nature of the concepts. Advanced conceptual understanding is required to understand electricity fully and the pupils themselves have many conflicting sources of information, from the everyday use of language of electricity to prior teaching experiences at year 5, that are filtered by their own limited conceptual understanding.

Evaluation

In using the pupils’ work to reflect on the teaching sequence, I question what I can really expect a year 9 pupil to understand about electricity within four lessons when it appears that prior teaching and their own conceptual understanding has led to the development of the ‘wrong’ ideas. A problem lies within the question ‘What is electricity?’ Adults and children alike often have confused ideas about electricity. The word is used in everyday life to describe the mains electricity supply, but what does it really mean? What does it really mean in the minds of year 9 pupils? The predictions pupils made in the practical activity indicated that some were thinking that ‘electricity’ comes from the source and gradually gets used up as it goes round the circuit. This is understandable when you consider that appliances seen in the home have a single lead taking the ‘electricity’ from the source to the device, where it is ‘used’ up (hence the bills!). It is much harder to understand the concept of current, needing for a complete circuit, transferring energy.

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