Ideas, evidence and argument in science education

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What has argument got to do with science you might ask? Science is about incontrovertible facts; argument is for the humanities where they never seem to be able to agree about anything. For those of us who were attracted to science because it seemed to deal in absolutes, the lesson of the past 30 years has been that we were deluded. Ever since Thomas Kuhn (1962) wrote his seminal book – *The Structure of Scientific Revolutions* – and opened the doors to those sociologists who wished to study how science works, it has become increasingly evident that the 'facts' are only established when the scientists finish arguing. Any new scientific finding is almost always controversial, questioned and often refuted (see, for example, Yearley, 2004).

Examples are legion: Wegener had an extremely hard time initially with his idea advanced in 1912 that all the continents had once been part of the same continent. Few scientists believed him and many produced good reasons why he must be wrong – principally the lack of any force that could literally make the Earth move. Toricelli's argument that there was a vacuum at the top of his barometer was disputed for over 30 years, as everybody knew that nature abhors a vacuum. And anyway, if there was a vacuum, it would have destroyed the whole of Aristotelian physics which had served the world well to that point in time.

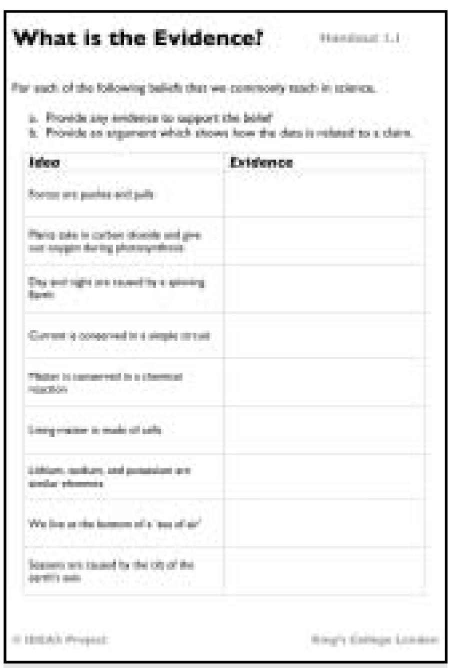

Figure 1 An activity from the INSET pack.

Another good example is just the simple idea that day and night are caused by a spinning Earth. Why should any primary age pupil believe this? Any observation tells you that it is the Sun that appears to move. Surely, if it was spinning, then when you jumped up you would not land in the same spot? Moreover, if it was spinning, it must be going at over 1,000 mph at the equator which would be enough to fling anybody off. In short, wherever you look in science, what is commonly accepted today, and now the bread and butter of school science, was, at one time, controversial and disputed. Understanding that this is how knowledge is produced in science is, we would argue, an essential part of learning science for two reasons.

First, it is important that students understand that science is a process of rational belief and that observations do not lead inexorably to self-evident conclusions. Commonsense, for instance, would suggest that vision is an active process. Science, in contrast, argues that it is a passive process where light enters the eye. How has science come to this belief? Not to explore some of the reasons why we believe what we do is both an injustice to science, and an injustice to our students. For students have a right to expect, from their teachers, reasons for what we wish them to believe. To achieve that, school science needs to spend more time explaining how we come to know or, as philosophers would say, answering the epistemic question. Moreover, we think it is as important that students know why the wrong answer is wrong, as much as they do why the right answer is right. Indeed, there is research evidence (Hynd and Alvermann, 1986, for instance) that shows that such students have a better understanding of the standard scientific view.

Second, talk in science classrooms is dominated by a form of dialogue where the teacher asks the questions (even though they know the answers), the student responds with a short phrase, and the teacher then provides an evaluative response or, alternatively, asks for further elaboration. This mode of interacting is both unusual – in that it is monologic rather than dialogic (the normal form of talk), and it gives very little opportunity for students actually to use the language of science. Providing some space for students to work in small groups discussing and evaluating the evidence both for, and against, a scientific idea will not only give them an opportunity to talk science but will also add some much needed variety. Some recognition for such arguments is now apparent in the new key stage 4 programme of study where it states that '*pupils should be taught to present information, **develop an argument*** (emphasis added) *and draw a conclusion…*'.

However, this is a challenge. Most science lessons place a premium on developing conceptual understanding, seeing teaching as a process of information transmission where rote learning, recitation, and exposition predominate. As Robin Alexander (2005) argues: *'Rote, recitation and expository teaching give us security. They enable us to remain firmly in control, not just of classroom events but also of the ideas with which a lesson deals. They keep power firmly in our hands as teachers. They reduce the risk that the limits of our subject knowledge will be tested, still less exposed. They make it unlikely that awkward questions about evidence, truth and opinion will interrupt the flow of information from teacher to taught'*.

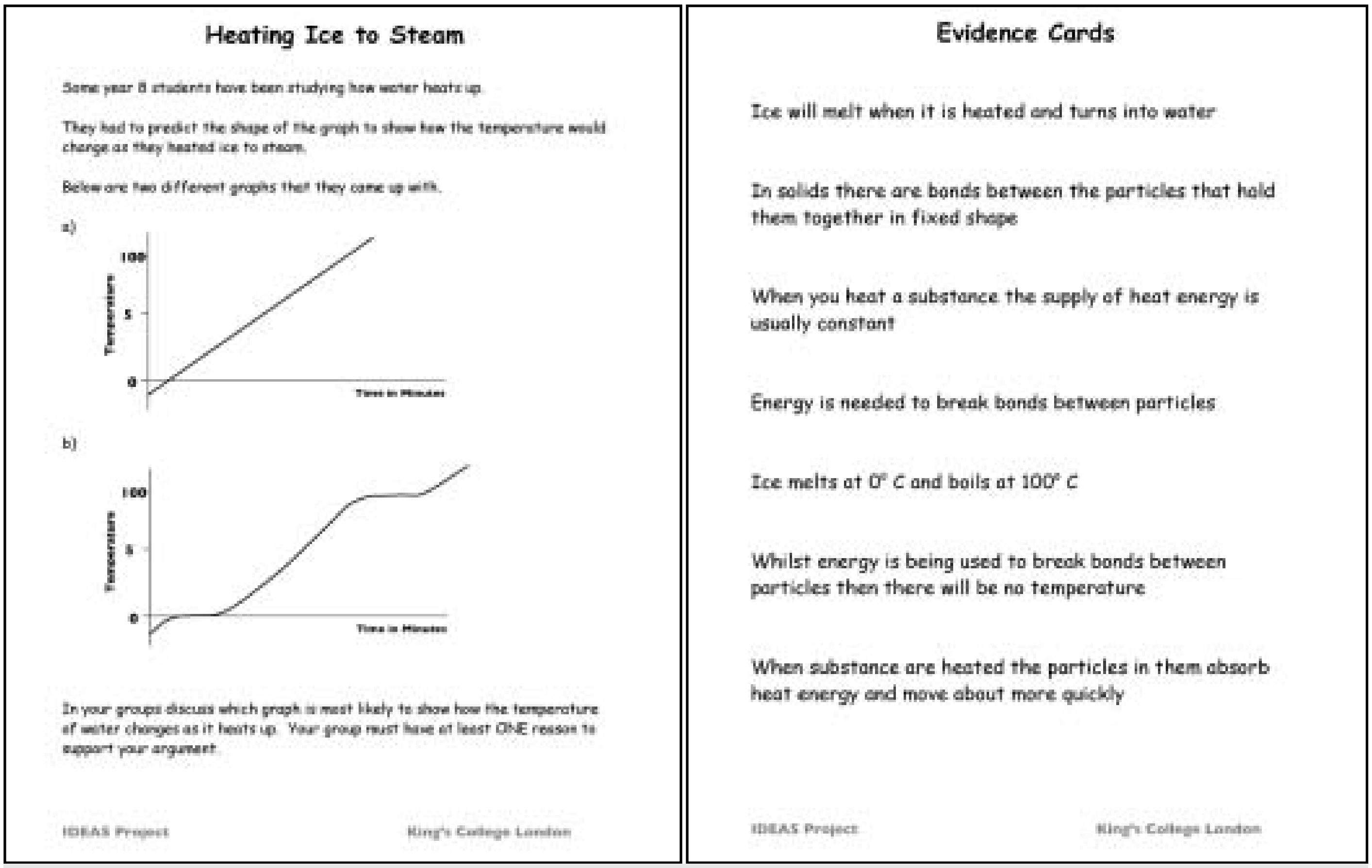

Figure 2 An example from the Resource pack.

For these reasons and others, we set out five years ago, in a project entitled Enhancing the Quality of Argument in School Science, to explore how argumentation lessons could be developed in school science (see Osborne *et al*, 2004, for details of this work). Working with a group of teachers we were able to develop resources and demonstrate that pupil skills improved. Moreover, we developed a better understanding of what was needed to make this kind of approach work – that is, how to engage the pupils and to ensure there are worthwhile learning outcomes.

We then approached the Nuffield Foundation for funding to help us to develop a set of video/DVD-based materials for professional development for teachers of science. This pack – the IDEAS pack (Ideas, Evidence and Argument in Science Education), first published in 2004 and reprinted in 2005 – consists of 28 clips of ordinary teachers dealing with how to structure and approach the teaching of ideas, evidence and argument in science. The teaching of ideas, evidence and argument is what the National Curriculum for science calls ‘How science works’. In addition, there are materials to support six half-day workshops exploring aspects of teaching argument. The materials come on CD-ROM as Word and PowerPoint files. There is also a separate set of resource materials to support the teaching of ideas, evidence and argument in school science education. This consists of 15 sample lessons that teachers can use to try out some or all of the approaches in the IDEAS CPD sessions. Each of the activities comes with an introduction that provides:

- The Aims;
- The Learning Goals of the Activity;
- Teaching Points which highlight aspects of background knowledge or the knowledge the students may need for the activity;
- A Teaching Sequence which suggests how the materials might be implemented in the classroom; and
- Background Notes for activities that require further elaboration on the science.

Further information and an order form for these materials is available at: www.kcl.ac.uk/depsta/education/publications/ideas.html

Based on our research evidence, we strongly believe that these kind of materials can make a significant contribution to improving the teaching and learning experience in science. In short, learning to argue is at the heart of learning to think.

References

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