Values and ethics in science education [secondary]

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Some teachers may consider that values and ethics are not really a part of science education[1]. Yet every classroom, including the science classroom, is value-laden. If a teacher presents science as a value-free pursuit of objective truth, that in itself is a value position (Layton, 1986) and conveys a particular view of science to pupils. This chapter examines whether science education should include issues of values and ethics and how teachers of science might explore values and ethics in their lessons.

The meaning of values

In this chapter we adopt a standard working definition of values used by many in the field of values education:

> principles, fundamental convictions, ideals, standards or life stances which act as general guides to behaviour or as reference points in decision-making or the evaluation of beliefs or action. (Halstead, 1996, p.5)

In a science classroom, there are at least three such guides to behaviour that might be present (Figure 1):

1. How teachers are guided by the values embedded in the science curriculum
2. How teachers are guided by the values of science and how these are conveyed, explicitly or otherwise, and interpreted by pupils
3. How teachers are guided by the values of individuals and society when considering the implications of science.

Figure 1 about here

[1] In a survey of secondary science teachers "Almost half of the science teachers interviewed feel that their teaching of science should be 'value-free', that it does not yield issues that have social or ethical implications" Levinson and Turner (2001, p.7).

Science teachers have values that relate to their general role as teachers as well as ones that are important in the context of teaching science. There are values embedded in the science curriculum itself. For example, at key stage 3 the current science National Curriculum says of pupils that:

> They think about the positive and negative effects of scientific and technological developments on the environment and in other contexts.

However, we do not intend to use this chapter to explore the nature of the science curriculum. We focus on teachers' actions and the implications for pupils.

Values of science

We start by looking at the range of values that could be presented about science and how they relate to contemporary views of the nature of science. There are some aspects of terminology related to the nature of science which are worth exploring here. Nott and Wellington (1993) developed a useful exercise for teachers to allow them to reflect on their view of the nature of science. In this exercise, agreeing or disagreeing with such statements as 'There is such a thing as a true scientific theory' and 'Human emotion plays no part in the creation of scientific knowledge' allows teachers to draw a profile of their own views and compare these with others. Underpinning this exercise are a number of dimensions along which teachers position themselves, reflecting some of the terminologies and concepts relevant to the nature of science and its teaching (Figure 2).

Figure 2 about here

In reading these dimensions, a teacher may reflect on their own position and understanding of the nature of science. Some of the terminology may be very well-known; other aspects may be unfamiliar. Although there is no one correct view of the nature of science, some views are widely regarded as having greater validity than others.

For example, a mature understanding of the nature of science recognises that while some scientific knowledge is extremely secure, other is more tentative. [2]

A near consensual view of the nature of science can be summarised thus: Science is a creative, collaborative and culturally-bound activity in which reliable knowledge is generated through diverse but rigorous methods, albeit knowledge which could be subject to change depending on the collection of further evidence or reinterpretation of evidence (McComas, 1998; Osborne *et al.*, 2003).

What is more contentious is the extent to which what is accepted as valid scientific knowledge varies from culture to culture. At its simplest, cultures vary in what they spend their scientific efforts on. For example, in the early days of genetic engineering, relatively little research was done into the possible harmful ecological consequences of genetically modified (GM) crops. The common assertion from companies involved in these technologies that GM crops had no harmful effects on the environment was therefore of little scientific value since the hypothesis 'GM crops have no harmful effects on the environment' had not been tested. It is worth emphasising that, in this sense, scientific knowledge is *produced*: it does not simply sit around waiting to be discovered in an unproblematic manner.

Although the science curriculum has a strong influence on what is taught and how it is taught, the science teacher's views on the nature of science and the importance, or otherwise, of ethical aspects will bear on the detail of classroom interactions. We give in Box 1 an example here of a teacher's efforts to focus on the nature of science – in this case an experienced teacher, Judith , who participated in a research project to look at the barriers and opportunities in teaching 'ideas-about-science' (Bartholomew *et al*., 2004).

[2] Research into teachers' understanding of the nature of science has concluded that most have rather inconsistent and naïve views of the nature of science (Abd-El-Khalick and Lederman, 2000).

Box1

Judith set up a lesson in which the learning outcomes were to “know that scientists often work collaboratively and make hypotheses and predictions”. She presented pupils with a cube, five sides of which were shown with BAT, CAT, FAT, HAT and MAT on them. Pupils were then asked to work out what they thought was on the sixth (covered) side. (This task was developed by Lederman and Abd-El-Khalick (1998) to support teaching of scientific creativity and pattern seeking.) The pupils were initially perplexed but once they understood that they had to reason for themselves they engaged in the activity with growing confidence, each group making predictions based on what to them was logical reasoning. The nub of the lesson came when Judith asked about their predictions:

> When they report back Judith calls on each group in turn to give their answer and reasoning – though most groups are still discussing and haven’t reached consensus. Some groups who were beginning to think about patterns in the alphabet revert to their earlier ideas when reporting back. One pupil explains to the class that she thinks the word is PAT and gives an explanation based on the fact that B and C (bat and cat) are next to each other, F and H have one letter between (fat and hat), and M and P have 2 letters between. Judith says that this is the right answer and she goes over again, explaining that bat and cat are opposite each other, fat and hat are opposite each other and there is nothing opposite mat (from field notes).

This vignette conveys a crucial point in science teachers’ normal pedagogy, seen many times in the research project but illustrated here succinctly. The pupils had been encouraged to consider their reasoning, but the teacher and class were dominated by the imperative to get ‘the right answer’. Judith embraced the research project’s aims of explicit teaching of ‘ideas-about-science’, through evaluation of evidence, and showed a reasonably sophisticated understanding of the nature of science. However, her actions show how strong was her need, whether through long-engrained habit or her underlying values, to arrive at fixed scientific knowledge. This lesson would have conveyed very different messages to pupils about the nature of science if the reporting back stage had allowed for:

- pupils to develop their own and challenge each others' ideas
- the possibility of there being more that one right answer
- a much greater acknowledgement of the ways in which theories are generated, tested, rejected, and refined.

Ethical aspects of science

Whereas science can tell us what we can do, ethics, as a discipline, helps us decide what we ought to do. Just as teachers may have different views on the nature of science, they may also hold views as to whether social and ethical aspects of science should be pursued within the science curriculum (Reiss, 1999). Whatever stance one takes, to ignore the ethical dimension of the pursuit and applications of science is to sell pupils short in their appreciation of the issues of contemporary science.

There are ethics involved in the *conduct* of science as well as in considering the *implications* of scientific advancements. So, for example, when pupils at KS3 and KS4 ensure that the data they collect are accurate and impartial, objectively report findings that contradict what they expected to find and strive to be open-minded, for instance by considering alternative explanations for their findings, they are developing the habits that good scientists have and that help ensure that scientific knowledge is reliable.

Many advances in science raise ethical issues in their implications. Ethical issues in genetics, for example, are increasingly recognised within the science curriculum. But how can ethical issues be addressed by science teachers with little or no training in ethics? One response is to leave these issues to the RE or PSHE classroom. While this response solves certain problems, we should be aware of the messages it can convey about school science – does it reinforce a view that school science is remote and irrelevant to everyday life?

Lack of discussion of socio-scientific issues in science classrooms could lead pupils to ignore the scientific evidence behind a problem and see science as a sterile pursuit unconnected with modern societal issues. Many societal issues arise precisely because of advances in scientific knowledge. If pupils were the ones who determined the content of the science curriculum, social and ethical issues would definitely be included as they are seen to be important for their future and very motivating (Cerini *et al.*, 2003; Haste, 2004).

However, consideration of socio-scientific problems can raise issues for the teacher. From a year-long study of classroom discussions of socio-scientific issues (Ratcliffe and Grace, 2003), we recount in Box 2 one particular interaction which shows the dilemmas for teachers.

Box 2

The lesson was about what material you would use for replacement window frames – and it could just be done from the point of view of examining the advantages and disadvantages of the properties of softwood, aluminium, hardwood and uPVC as materials. However, the teacher, encouraged by the "issues" nature of the course and a decision-making framework that was provided, gave the pupils opportunities to clarify their views on the issue. This extract is from his summary at the end of the lesson

> Liam: Well, we thought we'd go for uPVC cos it's quality and if you buy the softwood you've got to keep up the maintenance. It would cost more and you'd probably end up paying as much as you'd pay for the uPVC anyway – so you might as well buy that.
> Teacher: Did the environmental effects have any bearing on your decision?
> Mike: A little bit
> Keith: Yeh, a little bit, (very quiet) just a tad.
> Teacher: So that helped sway you away from hardwood?
> Keith: Oh yeh, but we still think just cutting down one more tree for our bedroom window's not going to make that much difference.
> Teacher: OK, do you all agree with that?
> Liam: Yeh.

At this point the teacher does not pursue the conversation further. The exchange shows, perhaps unsurprisingly, that these 15 year-old boys are very ego-centric. It also illustrates the dilemma in which science teachers can find themselves. Should this teacher persist with exploring the environmental impact arising from consumer choice? Should he try to impose his own views? Should he act as devil's advocate or a neutral chair? Should he spent time clarifying the individual and societal values that impact on such decision-making?

Of course, a humanities teacher might be asking what all the fuss is about. Social science classrooms thrive on discussion, exchange of opinion and evaluation of evidence – clarification of values being a strong feature. And here's the paradox; despite science being an evidence-based discipline, at its frontiers full of controversy about competing theories and models, many pupils in science classrooms do not normally engage in discussion and argumentation, either of scientific controversies or of socio-scientific issues. This seems mainly because for so long school science has been seen as a body of accepted knowledge – which of course most of it is; but a body of accepted knowledge to be learnt and regurgitated in exams, not to be interrogated for its evidence base. If you see your role entirely as helping pupils understand the way the natural world works – mastering explanations of scientific concepts that are often counterintuitive – then you may not wish to engage in value-laden discussions. Such teachers are understandably often less confident and skilful in dealing with controversy in the classroom.

Given the dilemmas science teachers may face in dealing with socio-scientific issues in the classroom, what is there to guide them in their role? The Crick Report (Advisory Group on Citizenship, 1998, p.59) acknowledges three general approaches adopted by teachers in handling controversial issues: the 'neutral chair', the 'balanced' and the 'stated commitment' approach.

- In the role of 'neutral chair' the teacher acts as facilitator in encouraging pupils to explore the issue and express their opinions fully. Teachers do not declare their own views.

- The ‘balanced’ approach assumes that teachers will ensure that all different aspects and views are covered. They will discourage discussions which only concentrate on one particular viewpoint, acting as ‘devil’s advocate’, if necessary, to counter one-sided arguments.
- In the ‘stated commitment’ approach the teacher declares his or her own views at the outset, encouraging pupils to disagree or agree on the basis of their own reasoning.

Each of these three perspectives has advantages and disadvantages. The ‘stated commitment’ approach allows pupils to recognise teachers as authentic beings with their own perspectives on an issue, yet “carries the risk that teachers who use it may well be accused of bias and attempting to indoctrinate those whom they are teaching” (Advisory Group on Citizenship, 1998, p.59). The reality that individual teachers hold views is ignored in the ‘neutral chair’ and ‘balanced’ approach, though these approaches have the advantage of encouraging open discussion. However, the plurality of views encouraged by both these approaches may prevent pupils from developing critical skills to judge the worth and validity of different solutions. The teacher in the extract above is, to a certain extent, combining elements of these three perspectives in a common sense approach – a stance that is encouraged by the Crick Report to dispel fears of indoctrination and insensitivity.

Whichever approach is taken, a great deal can be achieved by teachers encouraging pupils to reflect on the reasons for the ethical views they hold. At its simplest, gently asking ‘Why do you think that?’ can be effective. Furthermore, encouraging pupils to think about the implications of their views for others as well as for themselves is productive. And remember that ‘others’ doesn’t just mean ‘other humans’; it can mean other animals and even the environment.

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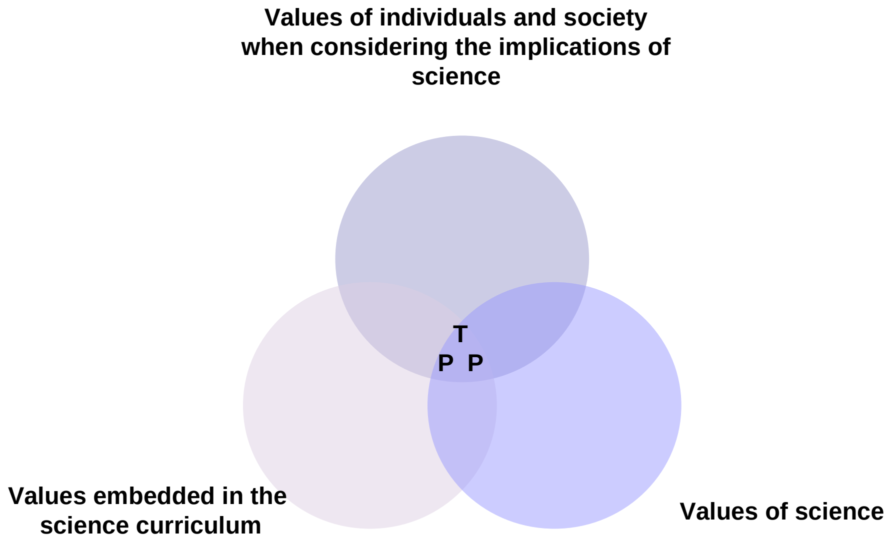

Figure 1: Interpretation of values influencing science classrooms.

Positivist

Holds that science is the primary source of truth. The laws and theories generated by experiments are descriptions of patterns in a real, external *objective* world.

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Relativist

Holds that judgements as to the truth of scientific theories vary from individual to individual and from one culture to another, i.e. truth is *relative* not absolute.

Inductivist

Holds that scientists generalise from a set of observations to a universal law, inferring from the particular to the general. Scientific knowledge is built by induction from a secure set of observations.

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Deductivist

Holds that scientists form hypotheses that are not determined by the empirical data but may be suggested by them. Science then proceeds by testing the observable consequences of these hypotheses, so that observations are theory-laden.

Decontextualist

Holds that scientific knowledge is *independent* of its cultural location and sociological structure.

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Contextualist

Holds that the truth of scientific knowledge and processes is *interdependent* with the culture in which the scientists live and in which the science takes place.

Realist

Believes that scientific theories are statements about a world that exists in space and time *independent* of the scientists' perceptions. Correct theories describe things that are really there, independent of the scientists, e.g. atoms.

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Instrumentalist

Believes that scientific theories are fine if they work, that is they allow correct predictions to be made. These theories are instruments which we can use but they say nothing about an independent reality or their own truth.

Content is important

You think that science is characterised by the *facts and ideas* it has and that the

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Process is important

You see science as a characteristic set of identifiable *methods/processes*. The essential part of science education is the acquisition and mastery of this ‘body of knowledge’.

learning of these is the essential part of science education.

Figure 2 Some dimensions and terminology relating to the nature of science (summary from Nott and Wellington, 1993)