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RESEARCH REPORT

Reconceptualizing the teaching of controversial issues

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Science has a role to play in the resolution of many of the issues deemed controversial in all societies. However, evidence of a lack of public confidence in science and scientists as effective problem-solvers continues to accumulate. This paper speculates that this lack of confidence might in part be due to the way in which science educators present controversial issues. In particular, we argue that current approaches to teaching about controversy do not sufficiently acknowledge the nature of the issues themselves. The paper proposes a set of principles as the basis for a reconceptualization of the teaching of controversial issues and gives an example of how they might be applied.

The nature of controversy

All societies have issues that can be deemed controversial. By controversial we mean that significant numbers of people argue about them without reaching a conclusion. The argument often focuses on what should be done about an issue but is usually underpinned by differences in key beliefs or understandings about the issue held by the protagonists. The basis for the controversy may stem from differences in one or more of the following factors: religious beliefs, such as abortion; cultural differences, such as links between 'race' and intelligence; and, moral issues, such as genetic engineering. For Dearden:

> a matter is controversial if contrary views can be held on it without those views being contrary to reason. This can be the case, for example, where insufficient evidence is held in order to decide the controversy, or, where the outcomes depend on future events that cannot be predicted with certainty, and where judgement about the issue depends on how to weigh or give value to the various information that is known about the issue. (1981: 38)

The key point here is that from the perspective of the individual, their stance on the issue is reasonable.

Stradling (1985: 9) defines controversial issues as:

> those issues on which our society is clearly divided and significant groups within society advocate conflicting explanations or solutions based on alternative values.

Dearden's observation that the protagonists in a controversy interpret the same information differently and Stradling's suggestion that this may be related back to different values held by the individuals warn us that recourse to reasoning based on science alone may be insufficient in resolving conflict.

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Lynch and McKenna (1990) argue that we see the world using our own particular schemata or worldview. This view is built up from birth in response to our social and cultural interactions with the world, formally and purposely through education, and erratically through experience. These interactions provide the basis for the way in which we interpret, or 'see' the world around us. Thus, a Marxist and a capitalist will interpret the same problem differently, 'seeing' different causes leading to the event and suggesting different solutions.

In our view, teaching about controversial issues in science needs to take explicit account of their nature, emphasizing in particular that:

1. Groups within society hold differing views about them.
2. Groups base their views on either different sets of information or they interpret the same information in different ways.
3. The interpretations may occur because of the different way that individuals or groups understand or 'see' the world (i.e. their worldview).
4. Differing worldviews can occur because the individuals adhere to different value systems.
5. Controversial issues cannot always be resolved by recourse to reason, logic or experiment.
6. Controversial issues may be resolved as more information becomes available.

A controversy in the UK in 2001 illustrates these six key aspects of controversial issues. The controversy emerged from the discovery of a viral disease, 'Foot and Mouth', in livestock on English farms.

> Foot and Mouth Disease (FMD) is a highly infectious viral disease in which fever is followed by the development of vesicles or blisters – chiefly in the mouth or on the feet. Cattle, sheep, pigs and goats are susceptible and some wild animals such as hedgehogs, coypu, rats, deer and zoo animals including elephants. The disease is rarely fatal, except in the case of very young animals, which may die without showing any symptoms. Affected animals lose condition and secondary bacterial infections may prolong convalescence. The disease is spread mechanically by the movement of animals, persons, vehicles and other things, which have been contaminated by the virus. Airborne spread of the disease can also take place. There is no cure. It usually runs its course in 2 or 3 weeks after which the great majority of animals recover naturally. In many parts of the world, notably Africa, Asia and South America, the disease is endemic, others such as the United Kingdom, are part of an internationally recognised FMD free zone. (Summarised from information at Department for Environment, Food and Rural Affairs 2002)

In 2001 an outbreak of FMD occurred in the North of England. The disease spread rapidly and the Government imposed a policy of restricting movements on and off farms, the slaughter of all infected animals and, eventually, the slaughter of animals, infected or not, on adjoining farms. The slaughtered animals were incinerated on large open pyres on the farms.

A controversy arose over whether the slaughter and burn policy alone should be used or in addition to the vaccination of uninfected cattle in order to stop the spread of the disease. Vaccination had been used as a control policy in other European countries. One of the problems with vaccination is that it has implications for a speedy return to FMD-free status and, arguably, subsequent unfavourable economic consequences in terms of marketing British meat outside the UK.

The controversy about whether to use vaccination was widely reported in the news, with scientists and scientific evidence being used to support both sides of the

argument. Animal welfare groups were also involved, suggesting that the slaughter of uninfected animals was unacceptable on moral grounds when they could be protected by vaccination – effectively valuing animal welfare issues above economics. In the end, the Government adhered to the slaughter and burn policy. However, it also set up an inquiry into the way in which the outbreak had been handled, the slaughter and burn policy and the possibility of using vaccination in the future.

The FMD outbreak provides one example of different views being held about an issue by government, farmers, scientists, animal welfare groups and by groups within the public. These differing views implied different emphases (based on a range of values) placed by individuals on the needs of society, farmers and animals. At times, the debate was emotional rather than rational. No more so than when a particular calf, much publicized by the press, was granted exemption from slaughter. Finally, the decision to conduct an inquiry illustrates the desire for increased knowledge in order to be better able to face a similar crisis in the future.

Science, science education and controversial issues

Many controversial issues have a basis in science. The issue may arise because of scientific developments or it may be that scientific endeavour is seen as a way of resolving the problem. Genetic engineering, sources of energy and animal welfare are issues of controversy in many countries. Although these issues have a basis in science, they are often intrinsically linked to social, political or economic concerns. For example, some people would recognize the development of genetically modified crops as scientists striving to help to feed the world, others as international companies trying to make money while others see it as 'mad scientists' trying to invent 'Frankenstein's monsters'.

Cross and Price draw distinctions between:

> the nature of Science as a process leading to the production of scientific theory and . . . [science] as an institution [that is] the organisations of Scientists and the major places where science is done. (1992: 23)

All three aspects of science, process, theory and institution, are subject to change over time. In describing the historical development of the relationship of science and science education, Solomon concludes that:

> Most contemporary philosophers view the construction of scientific knowledge as a much more fallible and human affair than one of strict reliance on the 'verdict of Nature' through disinterested experiment or logical argument. (1993: 15)

Scientific processes and scientific theories have the potential to help people to make sense of controversial issues and can, therefore, play a part in the resolution of the controversy and the solving of problems. However, there is gathering evidence in the UK that public misunderstanding of the nature of science, the role of scientists and the potential and limitations of science in resolving problems is leading to a worrying distrust of science and scientists, particularly those providing advice to the Government. The House of Lords Select Committee on Science and Technology, in their Third Report, commented on a perceived 'crisis of trust':

> Society's relationship with science is in a critical phase . . . On the one hand, there has never been a time when the issues involving science were more exciting, the public more interested, or the opportunities more apparent. On the other hand, public confidence in scientific advice to Government has been rocked by a series of events, culminating in the

> BSE [*Bovine Spongiform Encephalopathy*] fiasco; and many people are deeply uneasy about the huge opportunities presented by areas of science including biotechnology and information technology, which seem to be advancing far ahead of their awareness and assent. In turn, public unease, mistrust and occasional outright hostility are breeding a climate of deep anxiety among scientists themselves. (Select Committee 2000: 11)

It may be that the apparent lack of trust in scientists is linked to the unrealistic way in which science (both process and content) and scientists are sometimes presented through science education and the media (Solomon, 1993). Cross and Price (1992: 135):

> see as part of the critical scientific attitude the elucidation of the values, attitudes and interests, which are embodied in Science as an Institution.

Controversial issues appear in the school curriculum of many countries. Science teachers are thus provided with the opportunity to support pupils in developing a realistic understanding of the role of scientists and scientific endeavour in resolving those controversies. Changing the way in which teachers present science may not be an easy task. Cross and Price (1996) are concerned about teachers who present science as unproblematic and characterized by content and certainty. In their interactions with pre-service and in-service teachers, Cross and Price noted a strong loyalty in teachers to their subject discipline (to science as opposed to science education) and a lack of opportunity in the schools for discussion of the nature of science or the construction of knowledge. Camino and Calcagno, working in Italy, reach a similar conclusion:

> The most delicate matter still has to be faced, that is encouraging [science] teachers to change their ways of thinking. This implies, first, trying to persuade teachers to abandon the safety of viewing science as an objective and neutral discipline in favour of the idea that knowledge is 'a-disciplinary', transitory and loaded with values. (1995: 72)

The arguments for the inclusion of controversial issues in the curriculum are compelling.

> Education should not attempt to shelter our nation's children from even the harsher controversies of adult life, but should prepare them to deal with such controversies knowledgeably, sensibly, tolerantly and morally. (Qualifications and Curriculum Authority 1998: 56)

As Dewhurst (1992: 153) argues, students are going to meet moral dilemmas before and after they leave school. Schools therefore have 'to help their students to handle questions of value, to learn to make judgements which are truly their own as well as learning to take responsibility for their own lives'. Similarly, Leib (1998: 230) suggests that 'it is [the educators'] duty not to shy away from tackling controversial topics'.

In our view, in order to teach about such matters effectively, teachers need to be aware of the nature of controversial issues and take account of this in their teaching.

As we have already argued, controversial issues are controversial because attitudes to the issues will be based on value judgements, which in turn may be based on moral codes or related ethical principles held by the individual. Ethical in the sense that they are judgements in relation to what is 'good', 'worthwhile' or 'ought' to be done (Peters 1996: 93). In considering values it may be helpful to draw a distinction between the values we exhibit everyday when expressing a preference for one thing rather than another and more generalizable values such as a preference

for honesty (Rogers 1983). Ormell (1993) has suggested that the distinction between the two might usefully be indicated using a capital 'V' when referring to what he describes as 'Hard' values. Holding a Value, Ormell argues, means being willing to act in the service of that Value. The development of firmly held and displayed values may derive from moral codes or ethical principles that are related to religious, political or philosophical positions (Sunderland 1998).

Towards a reconceptualization of the teaching of controversial issues

So far, it may appear that we are not suggesting anything new. Throughout the last few decades of the 20th century, a range of science educators called for the science curriculum to include the social political and economic aspects of controversial topics. The Science Technology Society movement resulted in a range of curriculum innovations and materials, such as Science and Technology in Society, in the UK (see, for example, Hart 2002). However, we are not simply repeating the call for science to be set in a broader context. We are also suggesting that the *nature* of controversial issues needs to be understood by pupils and teachers, and that this should be at the heart of the educational endeavour. We need to support the development of citizens who are scientifically literate and able to engage effectively with controversial issues. Developing a generic understanding of the nature of controversy and the ability to deal with it is more important than developing pupils' understanding of a particular issue *per se*. We go on to suggest that this shift in emphasis may have significant pedagogical implications.

If knowledge is not seen as morally and politically neutral then, argues Geddis, students need to learn skills that allow them to:

> uncover how particular knowledge claims may serve the interests of different claimants. If they are to be able to take other points of view into account in developing their own positions on issues, they need to attempt to unravel the interplay of interests that underlie these other points of view. (1991: 171)

The challenge, therefore, when teaching about controversial issues is to recognize that they are often controversial *because* the protagonists from their own worldview are applying reason and thereby arriving at their different perspectives. Students need to explore how it is that individuals can apparently arrive at different perspectives on an issue. Introducing them to multiple perspectives is therefore an essential part of the methods of teaching about controversial issues.

Recent research in England (Oulton et al. 2001, in review) suggests that when asked about the teaching of controversial issues, teachers frequently suggest that they underpin their pedagogical approaches by taking stances in relation to three aspects. These are the extent to which:

- the focus should be on rationality, reasoning and sticking to the facts;
- a balanced view on the issue must be presented; and
- the teacher should remain neutral.

While teachers generally agree that a balanced view should be presented, there is widespread disagreement about whether teachers should remain neutral. These matters have been debated quite widely in the literature but we feel that they can

usefully be considered here in the light of the deeper understanding of the nature of controversial issues that we propose.

We have already argued that most controversies are not susceptible to solutions based simply on reasoned argument. Ashton and Watson (1998: 190) warn that teaching that implies that all situations can be resolved by recourse to reason is unrealistic, as 'real life situations will not wait for a calm philosophical . . . approach'.

Similarly, Kibble expresses concerns about an:

> over-simplistic presentation of moral dilemmas, as this ignores the reality of real situations which he sees as complex . . . and frequently involving an element of 'guilt' on all sides. (1998: 54)

Dewhurst (1992: 159) also considers that rationality does not provide an appropriate basis for discussion because it lacks 'social connotations, and it can also have associations with proof and deduction mediated by general principles. It is just such proofs, which are lacking in areas of moral controversy'. Therefore, simply sticking to the facts is insufficient if pupils are to understand the real reasons why controversies are so hard to resolve. Therefore strategies that help pupils to distinguish between sound and unsound reasoning, facts and emotions and strong scientific evidence from weak are to be encouraged. For example, Lock and Ratcliffe (1998: 112) suggest that pupils should be helped:

> to develop a respect for evidence and encourage the kind of open-mindedness to which scientists aspire. Working in such a way can develop a tolerance to uncertainty and an appreciation of the probability limits within which particular interpretations apply.

Presenting students with a balanced view of a topic appears, initially, to be a reasonable stance to adopt. However, Carrington and Troyna (1988) point out that balance is itself a contested concept and begs the question how is balance to be achieved? The teacher will need to make subjective judgements about what constitutes the 'facts' and 'what is not relevant, important or accurate' (Stradling 1985: 10). Also, as Stradling (1985) asks, are we more concerned with balanced teaching or balanced learning? In England, the Qualification and Curriculum Authority also warn that:

> whilst aiming for balance we should remember that to be completely unbiased is impossible and in some cases undesirable. What we need to avoid is indoctrination. (1998: 56)

The need to avoid accusations of indoctrination are particularly important in England as teachers are legally required, except in the case of racism and other forms of discrimination, to ensure that they offer a 'balanced' presentation or, at least, provide opposing views when dealing with political or controversial issues (Department for Education 1996).

While supporting the need to avoid indoctrination, our concern is that the requirement to maintain balance is unhelpful as perfect balance is probably impossible to achieve. Teachers have to make subjective judgements about what information to present, and differing views may not be easily accessible or may be in a format that is more or less attractive to pupils than opposing material. Even if the teacher thinks that they have presented matters as fairly as possible, others with different worldviews may still judge the presentation to be biased. An alternative, and to our knowledge as yet untested, approach, based on the reality of controversy, is to be open about the fact that balance can never be fully achieved but counter this

by developing in pupils a critical awareness of bias and make this one of the central learning objectives of the work.

The suggestion that teachers remain neutral when discussing controversial issues is, in part, a reflection of a liberal view of education in which pupils are free to make up their own minds on issues. Such a position aims to stop teachers from using their position of authority to impose their own views on those of the pupils. However, it can also be a way of avoiding criticism, particularly where a teacher holds radical views, that may conflict with those of others, such as parents. Stenhouse (1983) proposed what he called 'procedural neutrality', in which the teacher acts as a neutral chairperson during classroom debates. However, Stradling (1985) reports that teachers found procedural neutrality difficult to sustain as it threatened the rapport they had built up with the class and seemed to cast doubt on their personal credibility. Kelly (1986) proposed 'committed impartiality' in which the teacher attempts to provide all sides of an argument but *does* share their own views with the class.

The notion of teachers maintaining neutrality through a range of pedagogical approaches continues to pervade the literature (Henderson and Lally 1988, McBee 1996, Pence 1990, Reiss 1993). In the context of a more open and realistic exploration of controversial issues, we find this position hard to justify. At the very least, our rejection of balance and acceptance that all materials and judgements about teaching and learning strategies are open to bias leads us to argue that teachers should make their position explicit at the start of the exercise so that pupils are aware of potential bias in the way the teacher has arranged the experience and in what they say and do. Also, if we really expect pupils to be open about what they feel and think, is it appropriate that teachers never give their opinion and share the basis for their thinking? This increased openness would not remove from pupils and teachers alike the right to remain silent on some matters that they do not wish to make public.

Issues of pedagogy

Rethinking the teacher's stance in the light of an understanding of controversial issues led us to reflect on some of the frequently recommended teaching approaches. Role-plays and simulations are often proposed as methods for stimulating debate about controversial issues and, it is suggested, that they can offer students the opportunity to explore other peoples' perspectives. However, Geddis (1991) notes that role-play and simulation require considerable time in preparation. Camino and Calgagno (1995), while recommending role-play, conclude that teachers need training to encourage them to move away from instructional methods and adopt new methods of teaching.

At the heart of these types of activity is the notion that debate and taking on a role will enhance an individual's understanding through exposing them to the argumentation of others. Dewhurst (1992) warns that this is not at all a straightforward process. The nature of moral dilemmas is that they have an affective component and to suggest that a person's stance may be changed by rational argument is simplistic, as we have indicated earlier. Similarly simplistic is the notion that, through role-play, students will be able to empathize with the viewpoints of others. As Lynch and McKenna (1990) argue, we see the world using our own particular schemata or worldview. It may therefore be impossible for us to put

ourselves into someone else's shoes in a role-play. However, *attempting* to do so may encourage us to accommodate new information into our schemata and thus alter our worldview. This can be difficult and may be even more problematic when emotionally charged topics are discussed; nevertheless, the emotional aspects must not be ignored.

Given the frequency with which role-play is recommended, there is surprisingly little evidence in terms of learning outcomes related to attitudes that support the approach's effectiveness. This, together with the effort required to develop and manage role-plays, leads us to question the utility of this strategy as a way of approaching the teaching of controversial issues. This is not to say that role-plays are without use. It may be useful to role-play, for example, a public enquiry, but the focus should be on pupils' understanding of the event as a process, not simply as a way to develop their understanding of the issue.

Class discussion is widely suggested as an effective way of encouraging students to explore controversial issues and of avoiding an authoritarian approach (see, for example, Ratcliffe 1997). Kelly (1989) summarizes a number of techniques for conducting discussions around the principles of 'best case' and 'fair hearing of competing views'. However, as Harwood and Hahn (1990: 7) suggest, teachers need to invest time in order to prepare themselves and the students if the discussion is to be successful. Students, and possibly teachers, need training in discussion techniques. It is also important that discussions are informed and are not simply an 'exchange of ignorance' (Clarke 1992). Clarke also warns that the models of debate presented to students in society make it increasingly difficult to organize an effective debate in the classroom:

> We also live in a time of general decline in the protocols of civil discourse. Television talk shows bristle with outrageous behaviour which teachers are understandably reluctant to see reproduced in their own classrooms. (1992: 29)

In debates, students are frequently asked to make up their minds on the issue and vote accordingly. We are concerned that this approach can be problematic if it encourages pupils to form opinions too soon. In such cases, pupils' opinions may simply be based on the personality or the ability of one of those presenting an issue, and it is unfair to ask pupils to make their mind up on something that adults continue to argue about. Solomon (2001) suggests that the emphasis should be on discussion, as opposed to argument and debate, as discussion is more likely to lead to self-reflection and a clarification of values.

Humanities teachers tend to use 'stimulus activities' more than science teachers to initiate class discussion. For example, Leat (2000) describes 'mind movies' based on materials produced for geography teachers. These are essentially stories, but pupils are asked to turn the story into a 'movie' in their minds, by imagining certain 'shots'. Like stories, they draw on and develop visual memory skills. The teacher reads a carefully selected passage to the students (taken from a newspaper, magazine, Internet article, etc.) and asks them to imagine the situation. This provides the basis for a class discussion that begins with a deeper feeling for the issue.

Thorp (1991) describes the use of photographs to stimulate discussion of issues of race and equality, these activities use photographs depicting aspects of the issue being explored. The pictures are covered by a 'cropping card', which leaves only a small area visible (i.e. giving only part of the 'story'). Students discuss in small

groups what they think is happening in the photograph. More of the photograph is then gradually revealed until it is completely uncovered. Students then discuss their original impressions and compare them with the final image as a whole class activity.

Science educators have also begun to experiment with new formats to stimulate discussion. For example, 'critical incidents' have been used with considerable success by Nott and Wellington (1995) to help science teachers convey their beliefs about the nature of science. They are descriptions of real classroom situations, which can be used as a tool for helping students appreciate and articulate their own views about controversial issues, and those of others. The students are confronted with an example of an incident and asked to respond by saying what they *would* do (a reactive perspective), what they *could* do (a pro-active perspective) and what they *should* do (an ethical/moral perspective) in this situation. The students' response is a useful indication of their views on the nature of controversial issues, which are not always so forthcoming by simply responding to abstract, context-free questions.

Our analysis, to date, suggests to us a need to reconceptualize the teaching of controversial issues in science in the light of a deeper understanding of the nature of controversy and to develop appropriate pedagogical approaches. As a way of initiating this process, we begin by outlining what we think it is reasonable to achieve in the classroom. In essence, we would expect that to be functionally literate in terms of engaging with controversy, students would have developed skills of critical inquiry such that they would, as Crick wrote, 'ask more awkward questions, hopefully in a more sensible way, and not be put off by stock answers' (2001: 34). We would also see our position as protecting teachers from being accused of bias in their teaching, something that appears to be one of the barriers to effective teaching of controversial issues today.

What are we looking for in terms of pupil outcomes?

To answer this question, one needs to consider the nature and purpose of schooling. For example, should schools be encouraging individuals to develop independently their own views and opinions, be inculcated in societal norms, or should they be encouraged to reflect critically upon the nature of controversial issues (a socially critical view)? In the case of environmental issues, but applicable more widely, Fien (1993) and Huckle (1995) see a socially critical approach as essential if a full understanding of the issues is to be achieved. That is, that the questions of power and authority behind the issues are explored. We do not see these three positions as necessarily mutually exclusive, but we do recognize that they represent for some teachers controversial standpoints (see, for example, Fien 1993, Jickling and Spork 1998).

The position that schools adopt may depend on what issue is being discussed. Making up your own mind in the case of genetically modified crops may be acceptable in all schools. However, open debate about the morality of abortion is unlikely to be encouraged in a Catholic school and an antiracist approach is required in the case of racism in all schools in England. In some societies, a socially critical approach, which raises political issues and challenges the status quo, may not be welcomed by everyone (Crick 2001).

We think society would benefit if science education encouraged pupils, who are both today's and tomorrow's citizens, to:

1. adopt a more positive and realistic view of science and its potential for resolving conflicts than is currently common;
2. develop critical skills in relation to reflection upon and critiquing argumentation;
3. less automatically accept received views;
4. recognize the tentative nature of scientific knowledge and be willing to develop their thinking over time;
5. develop their willingness and ability to find more information; and
6. offer better argumentation in support of the stance that they currently hold including as appropriate philosophical and ethical aspects.

To achieve these outcomes we need to re-think our approach to the pedagogy to be employed when teaching controversial issues.

An alternative pedagogical model

We suggest that a pedagogy is needed, which promotes approaches that:

1. focus on the nature of controversy and controversial issues; that is, that people disagree; have different worldviews, value and limitations of science, political understanding, power, and so on;
2. motivate pupils to recognize the notion that a person's stance on an issue will be affected by their worldview;
3. emphasize the importance of teachers and learners reflecting critically on their own stance and recognize the need to avoid the prejudice that comes from a lack of critical reflection;
4. give pupils the skills and abilities to identify bias for themselves, encouraging them to take a critical stance towards claims of neutrality, a lack of bias and claims to offer a balanced view;
5. promote open mindedness, a thirst for more information and more sources of information and a willingness to change one's view as appropriate, and avoid strategies that encourage pupils to actually make up their minds on an issue too hastily; and
6. motivate teachers, as much as possible, to share their views with pupils and make explicit the way in which they arrive at their own stance on an issue.

We return to the example of the controversy surrounding FMD to illustrate what teaching approaches based on this model might look like. We begin by suggesting how a teacher working with pupils in the 14–19 year age range might currently approach the topic (see Wellington 1986a, 1986b). Using an article in a newspaper as a starting point, the teacher would ask the pupils what they know about FMD. These ideas would be collected on the board and the teacher would fill in any obvious gaps so that the pupils have an understanding about the disease similar to that indicated in the summary earlier. The class would then be encouraged to discuss in small groups the pros and cons of vaccination as a way of controlling the disease. They would then have a whole class debate and vote for or against the use of vaccination. For homework they would have to write a short piece arguing for or against vaccination. The teacher would mark the homework on the basis of the accuracy of its scientific content.

In our alternative model, the teacher would again start with the newspaper article, or a stimulus activity of the kind described earlier, question the pupils about their ideas about the disease and fill in some of the gaps. He/she would then provide the class with five position statements on how the outbreak should be handled, each from a particular group (UK Government, National Farmers' Union, an organic farming organization, an animal welfare group, the Dutch government). The teacher would explain the purpose of the exercise and why he/she has chosen these particular groups to represent *a* (not *the*) range of opinion on the issue. He/she would divide the class into groups, and each group would use the documents and the Internet in order to answer the following questions.

1. Who is in the group?
2. How are they funded?
3. Who do they represent?
4. What are they trying to achieve as an organization?
5. What key values/philosophy or ethical position is explicit in the organization's publicity materials?
6. What evidence are they using in the FMD debate?
7. Do they indicate the limits to their evidence?
8. What is the source of their evidence?
9. Do they present contrary arguments?
10. How strong do you think their argument is?
11. What do they want us to believe?
12. What are the consequences of their argument?

Each group would present its findings as a poster, handout or short presentation. The teacher would lead a group discussion, which includes the teacher and pupils reflecting on the strengths and weakness of the various presentations and the arguments from the five groups. The focus would be on the quality and effectiveness of the argument and presentations rather than on a resolution of the issue. For homework, pupils would be asked to compose a critical question that they would like to ask a representative of each organization if they were interviewing them for a television news programme. In each case, the pupil would have to state (for the teacher) why they were asking the question. The teacher would mark the sophistication of each question in terms of the pupil's ability to analyse weakness in arguments and their ability to pose questions that could effectively elicit answers.

Conclusions

We recognize that what we are proposing may not appear radical to some. Such approaches do occur in some aspects of the curriculum, but in our experience they are not widely found in science education (see, for example, Jiménez Aleixandre and Pereiro Muñoz 2002).

We are also aware that there are many barriers to curriculum development in this area. Taking together those cited by Clarke (1992), McBee (1996), Werner (1998), and Thornton (2000), the list includes: the complexity of the issue; the teacher's lack of familiarity with and knowledge of the topic; concern that the complexity of the topic will make it too time consuming to deal with comprehensively; the pressure to teach other more 'accountable' aspects of the curriculum; and the fear that the teacher will be accused of bias. Some of these barriers might

be removed if radical surgery were performed on the science curriculum or if science ceased to be a compulsory subject for all. We would argue that our approach, by challenging the notion of achieving perfect balance and the focus on developing process skills, should reduce some of these tensions. Change is challenging, but the alternatives of carrying on with the current sham or abandoning the teaching of controversial issues in science altogether as too problematic are unacceptable.

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