Towards a pedagogical framework for the teaching of controversial socio-scientific issues to secondary school students in the age range 14-19

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Abstract

Teaching controversial socio-scientific issues presents a significant challenge to teachers because these issues are often based on complex but tentative scientific evidence, and differences between contending parties reflect political, socio-economic and ethical considerations. This thesis aims to develop a realisable pedagogy, underpinned by a theoretical framework, to address such controversial issues.

The framework draws on three separate but interwoven strands: McLaughlin's formulation of nine 'levels of disagreement' which conceptualises controversy in a democratic and pluralistic society, the levels ranging from differences based on evidence to differences in worldviews; the 'communicative virtues' in which participants need to be schooled to support open dialogue; and Bruner's 'modes of thought' in which protagonists in a controversy aim to convince their interlocutors through narrative and logico-scientific modes. This pedagogical framework operates through constructions of the school-society interface ranging from science as authoritative to science as negotiable.

83 teachers, from 21 different secondary schools and further education colleges in England and Wales, were interviewed about their experiences of teaching controversial socio-scientific issues. Empirical indicators drawn from the teachers' narratives were mapped onto the framework to construct a picture of current pedagogy. Findings point to a need to support teachers in focusing on specific case studies, particularly those which draw on evidence and its associated logical procedures, to encourage teachers to explicitly draw on student narratives and to educate students in the communicative virtues. Opportunities and limitations are discussed in locating the teaching of controversial socio-scientific issues in the curriculum and in further characterising pedagogy and learning for future research.

Contents

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A couple of years ago Professor Terry McLaughlin became my supervisor. Terry's first piece of advice was to ask me to define a controversial issue. This took me aback because, having thought that I had thought about controversial issues in the preceding years, the task seemed an irrelevance. But Terry was right and a huge shift took place in my thinking as a result. From that point on the core of the thesis took shape. Very sadly, Terry died last year, and I am only sorry that I could not let him know how much he had helped me. I will miss the intellectual rigour he brought to the discussions we had about my thesis.

During a chance conversation in the corridor Dr. Jane Hurry asked me how my doctorate was progressing. It was a very rash move on Jane's part who ended up co-supervising me on the empirical part of my work which I had found very difficult. I had vacillated about starting and really getting to grips with it. Having Jane as a supervisor has been an enormous pleasure and privilege and it is entirely due to her that I have managed to submit my thesis. Although Jane professes no expertise in any area of my work her perceptiveness and advice have been peerless. I am particularly grateful to Jane for taking me on, for her humour, wit, incredible patience, good nature and ability to help my ideas to take shape. Even the lessons in basic statistics and using a PC effectively have all played their part.

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Declaration

I hereby declare that, except where explicit attribution is made, the work presented in this thesis is entirely my own.

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Chapter 1: Why controversial socio-scientific issues

1.1 The personal background

My first interest in the role of controversial issues in learning in school life probably started in the sixth form and lunch time meetings in the secondary school I attended as a student in Hackney, east London, when contemporary political issues were debated. What particularly struck me was the attentiveness with which the teacher who ran the sixth form sessions listened to students' views and reflected them back for further consideration, the articulacy and insights of some relatively low academic achievers and the strength of the emerging politics of my peers. Perhaps this wasn't so surprising given that most of the students in the school came from aspiring working class families, many of whom had moved away from relative poverty in the East End of London over the last twenty years, and had a background in anti-fascist action and left wing politics. These episodes in school life were lively and distinct and stood in contrast to my ponderous slog through O-levels and A-levels. In the end it was formal examinations which dominated school life because success in these determined entry to university which was seen as an essential means to self-improvement and consistent with the aspirations of the students and their families. This was also the time of demonstrations against the Vietnam war and the student marches in London and Paris which could explain why the idea of controversy impressed me then.

My next specific involvement with controversial issues in schools was in the early 1980s. My sixth form chemistry group in a girls comprehensive school engaged in a series of lessons covering issues such as Acid Rain and Nuclear Power based on the BBC Education radio series *Make your mind up*. Presentations were made from two sides of an argument and stimulus questions then encouraged students to further debate these issues. This prompted great interest and animation among the students; some of the quieter students advanced mature, penetrating and critical arguments and for a short while this enthusiasm carried through into their A-level studies. But the students' arguments in the school classroom on these issues might not have accurately represented their views. Occasionally when I talked to them beyond the school walls

their views were more certain and less thoughtful. As an example, one of the young women who was ardently opposed to any form of development of nuclear fuels – whether for peace or defence – in the class discussions burst out with the comment 'we should nuke the reds . . . '. When this comment was challenged by one of the other students, she was at first surprised that there was any contradiction in her worldview. We live with complexity and I suspect that students often sterilise their arguments in the classroom environment. Contrasting talk within and outside the classroom reflects to some extent the role of the school classroom in framing discussion and anticipates a point I will return to in Chapter 7.

Since I have worked both as a teacher and in teacher education there have been a number of episodes and experiences which, as the incident with the gung-ho sixth former suggests, raised problems about the teaching of socio-scientific issues in schools. Recently I have attended conferences, read publications and seen activities in the classroom[1] encouraging discussion about biomedical topics such as stem cell research. Frequently the discussion revolves around issues of abortion and 'what counts as a person', excluding all other aspects of the issue. The published resources often contain rich details of the medical procedures and science behind stem cell research but rarely does any knowledge or understanding of this material come to bear on the discussion. The evidence and knowledge often provided is at variance with the kinds of topics students want to discuss. The focus on published information brings to mind an oft-used phrase connected with socio-scientific issues – 'informed decision-making' or 'informed debate' (Bhattachary & Sheppard, 2004; Lords, 2000)[2] as an important attribute that students and the populace of a democratic state generally will gain from immersion in such issues. As with apple pie and motherhood having a society of informed decision-makers is no doubt a good thing. But what precisely are the kinds of decisions that the public are likely to take? If we are expected to be informed about new biomedical technologies, why not about foreign policy towards Argentina, modern architecture, the funding of local health authorities, the state of the armed forces – when in fact will there be time to take a break from being well-informed about all those things

[1] See, for example, the lesson on stem cell research on Teachers' TV in 2005, Available online at: http://www.teachers.tv/video/2982 (last accessed 12th April 2007)
[2] Available online at: http://www.parliament.the-stationery-office.co.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm (last accessed 21st May 2007)

that impinge on our lives? And what kind of information will we/they need to inform that decision-making? And can we really talk about a ‘public’? People have a variety of interests, backgrounds and motivations and the kinds of information different people will need is likely to be as various as the number of people involved. Moreover the phrase ‘informed decision-makers’ can lead to a dangerously attenuated view of the process of decision-making, i.e. that the necessary evidence and information will lead to good decision-making, a logic which excludes other factors such as feelings, culture and worldviews.

How chunks of information might influence decision-making was brought home to me (literally) at the birth of our first child in the early 1990s. Within about 20 minutes of the birth a doctor approached us with a syringe and asked for permission to give our baby an injection to prevent Vitamin K deficiency bleeding, which occurs in about 1 in 10 000 newly born babies resulting in death or serious brain damage. Clearly this seemed to be a good procedure. I had read that the injection was controversial because babies who have it sustain an associated higher risk of childhood leukaemia than babies who do not have the injection. When I mentioned this report to the doctor he said that there was some evidence that the injection was associated with increased risk of leukaemia. It now seemed not such a good thing, more so because parents prefer not to see their neonate injected with anything at such a vulnerable stage. The doctor did say that the Vitamin K could be administered orally with no associated risk of leukaemia (now this did seem a good thing) but was not so effective at preventing Vitamin K deficiency bleeding as the injection would be (so not so great). In the end we decided that the Vitamin K should be administered orally. Some years later I learned that further trials on Vitamin K injections in other European countries did not suggest that there was an increased risk of childhood leukaemia (so a good thing after all). The point is that in this relatively straightforward issue the timing of the information, its provenance and the circumstances in which the information was given all affected the decision that was finally taken. And even then it was the wrong one. (Afternote: My daughter, fortunately, is healthy and well into her teens).

1.2 Valuable lessons

In 1999 my colleague, Sheila Turner[3] and I, were commissioned by the Wellcome Trust to write a report on 'The teaching of social and ethical issues in schools arising from developments in biomedicine and biotechnology in the age range 14-19'. The research reflected the views of teachers across the curriculum and was published in a summary form as *Valuable Lessons* (Levinson & Turner, 2001).[4] Since then some of the recommendations have been taken forward. Courses for professional development in teaching these issues have been incorporated within the new National Science Centre Learning Strategy, the findings were discussed on BBC online,[5] formed part of the evidence for the House of Commons Science & Technology report on *Science Education from 14-19*[6], prompted funding for research arising from the report (R. Harris & Ratcliffe, 2005; Ratcliffe, Harris, & McWhirter, 2004) and were taken further in the *Valuable Lessons Stakeholder Conference* in London in December 2001 (Turney, 2001). Reflecting on the thinking I did on this project prompted me to embark on this thesis.

One of the tasks of societies in modern democracies is to make ethical judgements on a range of issues, many of them now having a scientific base. This can only be achieved effectively if individual members of these societies have been educated to become sophisticated and appropriately sceptical thinkers, a piece of social engineering for which the major vehicle is the school. I note here, and will return to this point later, that most schools are intrinsically undemocratic. Until the age of 16 pupils are not voluntary attendees and in many schools have little say on how and what is studied or how the school is run. The power relations between teachers and students are unevenly distributed: the predominant discourse is that teachers teach (or to use current functionalist terminology 'deliver') the curriculum, students learn what they are taught, or imbibe what is delivered. Some schools are more democratic than others, they have for example active School Councils[7]. We should be aware, however, that where children

[3] Sadly Sheila was diagnosed with cancer shortly after the commencement of the project and died in November 2000. A tribute to Sheila appears both in the full and summary reports.
[4] The full report can be found in pdf format, available online at: www.wellcome.ac.uk/en/images/ValuableLessonsFull_4274.PDF (last accessed 21st August 2006)
[5] Available online at: http://news.bbc.co.uk/1/hi/education/1440993.stm (last accessed 14th June 2006)
[6] House of Commons Science and Technology Committee (2002) *Science Education from 14 to 19, Third Report of Session 2001-02*, London: The Stationery office Limited.
[7] Available online at: http://www.citizenshipfoundation.org.uk/main/resource.php?s11 (last accessed

and young people have no choice but to attend school, albeit willingly for most, this might limit the effectiveness of schools as a preparation for an active democratic role in society or as a citizen-in-the-making in developing political literacy (Crick, 1998). This is not to criticise the role of schools, one could also characterise parents of small children as undemocratic in ensuring the safety of their charges, it is simply to recognise the distinct nature of decision-making of school students compared with enfranchised adults.

A number of strands emerged from the *Valuable Lessons* research where I thought there was a greater need for substantial reflection.

1. When teachers were asked the question' How would they go about helping students to make a judgement on an issue?' a frequent response was that it was not the job of the teacher to tell students what to think. There was a strand of naïve cultural relativism in the responses from teachers across all subjects. While there has been a discussion about the role of the teacher and the school in teaching students about personal autonomy (Bridges, 1997), the idea that students were left to find their own way through complex social dilemmas without any instruments to help them weigh judgements against each other struck me as a concern. There was very little teaching of ethics or moral philosophy except for a few teachers of Religious Education (R.E.).
2. Teachers of English, R.E. and social science taught about socio-scientific controversial issues in greater depth and breadth than science teachers. Despite the National Curriculum advocating the teaching of ethics in science (DfES/QCA, 1999) when this was attempted it was generally done as a bolt-on if there was sufficient time. Although teachers in different curriculum areas taught these issues, and clearly brought in diverse skills and knowledge, few schools attempted any integration across the curriculum in teaching controversial issues in science. A later study of curriculum integration, the Collapsed Day, indicates that relatively few schools have the necessary mechanisms or experience to implement this practice (Ratcliffe *et al*., 2004).

13th May 2007)

3. Despite the promulgation of the teaching and learning of social and ethical issues in science there has been very little empirical research on the *teaching* of controversial socio-scientific issues in the classroom although Oulton *et al.* is a recent exception (Oulton, Dillon, & Grace, 2004). Where studies have been done these have been on an interventionist basis (S. Kolstø, 2001; Ratcliffe, 1997; Simonneaux, 2001).

All these points are explored further in my thesis, most particularly point 3 which is effectively the subject of my research. In addition to these points Jean Rudduck's study of the teaching of the Humanities Curriculum Project demonstrated how difficult it was for teachers to run discussions in the classroom (Rudduck, 1986).

As a result of writing the report I became interested in finding out what effective teaching of controversial issues in science might look like in the contemporary situation in England. Since my own school days, the tripartite secondary system only continues in small enclaves of England. The vast majority of secondary schools are comprehensive although this has not prevented considerable social differentiation both between and within schools (Lee & Burkam, 2002). But there have been other significant changes. Britain is a far more pluralistic society, certainly in the large cities; policy-making bodies have been made more accountable and seek approval for their decisions from an increasingly risk-laden and risk-aware society (Beck, 1992; Giddens, 1990); issues related to science practice are much more prevalent in the news, and people are much more ambivalent about science as a progressive instrument for good (O'Neill, 2002).

There have been countervailing tendencies within the education system, however, which have possibly hindered the teaching of controversial issues: the de-professionalisation of teachers, particularly science teachers (J. F. Donnelly & Jenkins, 2001), the autonomy that teachers have in the classroom has been circumscribed by increasing governmental intervention in the curriculum (the introduction of the National Curriculum in 1989 probably being the most significant), Section 28[8], and legislation on

[8] Although it is worth noting that no action was ever brought against any teacher from Section 28 (Local Government Act, 1986), referring to the local authority's responsibility in prohibiting the promotion of 'teaching in any maintained school of the acceptability of homosexuality as a pretended family relationship'. The act was repealed in 2003.

the teaching of politics in schools to offer 'a balanced presentation of opposing views' in Section 407 of the 1996 Education Act[9].

Since the beginning of the new millennium there have been changes to the curriculum in schools which provide more fertile ground for encouraging the teaching of socio-scientific controversial issues. These include the introduction of the Citizenship curriculum in 2002, the piloting and establishment of *Twenty First Century Science* GCSE (originally its core module was called *Science for the Citizen*), changes to the National Curriculum (Science) in 2006 particularly with the introduction of Sc1 *How Science Works* and the AS levels in England and Wales: *Science for Public Understanding*[10] and *Perspectives on Science*. All these have explicit statements on controversy in science at the core of the specifications. There have been similar trends in the United States, Canada, Australia, New Zealand, the Irish Republic, Scotland, Taiwan, Israel, The Netherlands, Norway and Brazil.

1.3 The challenges presented in teaching socio-scientific issues

It has long been an aim of Science and Technology in Society (STS) curricula (Solomon, 1993) to engage students in socio-scientific issues but there were few ideas and exemplars on which to model effective teaching. Although there is only a small amount of research on the teaching of ethical issues in science, what evidence there is shows that science teachers find it difficult (Bryce & Gray, 2004; Osborne, Duschl, & Fairbrother, 2002; Ratcliffe & Grace, 2003) and that many teachers, but particularly science teachers, within the context of the school environment, find it challenging to enact those pedagogies such as collaborative dialogue, which support ethical thinking. The purpose of this thesis is to provide a plausible but flexible framework for the teaching of controversial socio-scientific issues between the ages of 14 and 19.

Why focus on science in particular in teaching controversial issues? Is it not the case that controversy, even about scientific issues, is taught in subjects such as history, English and R.E.? There are, however, specific challenges which teachers of science encounter which are both pedagogic and epistemological. I have referred to some of the

[9] http://www.opsi.gov.uk/acts/acts1996/96056-bp.htm#407
[10] There are now moves to establish it at A2 level as *Science and Society*.

pedagogic problems earlier but how to approach the teaching of controversial issues is covered less in the scientific training and professional development of science teachers than other teachers. In addition, science teachers spend a lot of time teaching in a laboratory which is a difficult area to organise for group discussion, particular in the old style laboratories with serried ranks of benches.

There are possibly more intractable obstacles than lack of training and classroom organisation to overcome which is why there is a particular need to focus on science. First, more and more media-based issues draw on advances in science and technology such as nanotechnology, cloning, stem cell research, gene therapy, climate change and genetically modified (GM) foods. Addressing these issues poses a problem because the science is complex. Frontier science and associated emergent technologies are uncertain, often involve complex modelling (Bauer, 1997; J. Thomas, 2000) and even experts are not agreed about the science (Robin Millar, 1997). To expect young people to have the concepts to deal with such complexity might be unrealistic and in danger of presenting an over-simplified version of the dilemma.

Second and related to this, the science learned in schools and universities does not transfer easily into the kind of knowledge needed to make decisions on such matters as GM foods and cloning (Chapman, 1991; C. Dawson, 2000; Ryder, 2001). As Dawson (C. Dawson, 2000) comments on his study of Ovine Johne's Disease in a farming community in South Australia, decisions were based on 'economic and political reasoning' (p.127) and the amount of scientific content knowledge needed by citizen-participants was minimal.

Third, science has a high academic status on the curriculum: it has relatively impermeable boundaries allowing little diffusion or mix with other subjects (physics has the highest status whereas biology has a lower status and is relatively permeable, for example with health studies and even sociology) (Bernstein, 1973). Where socio-scientific issues are enmeshed in political, social, ethical and cultural issues, this presupposes an interdisciplinary framework.

Fourth, there are serious problems about the nature of scientific discourse and its relationship to values. Linked to this is the positivist argument – and there is evidence to

suggest that many science teachers take up a logico-positivist view in their teaching (van Aalsvoort, 2004) – that there is nothing meaningful to say about statements which are not factual (Ayer, 1971), i.e. capable of being verified. It may be the case that science teachers have a preference for relatively certain consensual knowledge over the tentative sources of knowledge in other subject areas (J. Donnelly, 1999).

Fifth is the argument that the entities with which science deals are ontologically distinct and removed from the considerations that humans value such as rights and emotions: the move to humanise science in order to make it more open to socio-scientific decision-making is fundamentally flawed (J. Donnelly, 2002) whereas, at the other end of the epistemological spectrum, others conceptualise science as myth (Collins & Pinch, 1993). I pick up this argument in Chapter 2 but there is an important point to make at this stage which encapsulates much that I have already said. The Deweyan vision of promoting responsible citizenship and independent critical thinking in democratic schools does not sit easily with the dominant assumptions underpinning science curricula. 'Developed mostly as providing resources for the economy and research with a set of skills acknowledged as instrumental for these aims, the educational agendas for democracy, responsibility, citizenship etc., cannot easily be grafted on present school-science curricula' (Zemplén, 2007) (p.179). My position throughout this thesis is that science is a powerful, rational and authoritative means of understanding nature and that how young people come to learn the central theories of science is to accept the authority of that knowledge. School students are not makers of science but have to learn its nature and content. By this I certainly do not want to imply that the pedagogy is transmissive and authoritarian; on the contrary, science is best learned by a whole range of active teaching methods and immersion in ideas which stimulate interest and curiosity. As I hope to show this does not invalidate the aim of teaching socio-scientific issues as a democratic process, it is to affirm that the teaching of substantive science calls upon a different type of pedagogy and purpose and that translating science into socio-scientific issues is not straightforward as curriculum-designers often assume[11].

[11] For example, the programme of Study for Sc1 in Double Science (1999) states that pupils should be taught ' to consider the power and limitations of science in addressing industrial, social and environmental questions, including the kinds of questions science can and cannot answer, uncertainties in scientific knowledge, and the ethical issues involved.' This conflates so many epistemically diverse purposes as to make the enterprise deeply problematic. There is no guidance on how this laudable aim can be achieved.

Sixth there is the problem of selection of knowledge. Socio-scientific issues have very specific contexts. Are we talking about stem cell research because we have a sick relative and need to know more about it or are we making decisions about whether to prioritise this research over something else? The knowledge we need for one type of conversation is different from the other even though the broad topic is the same, a problem I develop in Chapters 3 and 4.

Seventh, scientific knowledge is being reconfigured. Climate change is a global concern bringing together many different sciences and knowledge sources. This is also true of the biomedical sciences and complex interactions are developing with the nature of citizenship manifested by the 'scientific citizen' or biological citizen' (Michael & Brown, 2005; N. Rose & Novas, 2004). Ravetz argues that we are entering a post-normal era in which the old distinctions between science, technology and public policy are dissolving and new types of possibilities are opening up (Ravetz, 2005). And finally, to expand on the last point, so are the political and social hopes and conflicts which science has mediated. Science, for example, has had problematic relationships with religion as illuminated in Brecht's drama of Galileo's excommunication and Darwin's publication of the *Origin of Species*. Although some contemporary scientists perceive science as a beacon of progress for humankind, particularly as contrasted with religion (Atkins, 1998; Dawkins, 2006; Wolpert, 1992)[12], it is increasingly seen in contemporary western societies as an instrument of oppression, impoverishment and social degradation[13] . These are the kinds of epistemological challenges that I shall be drawing on throughout this thesis.

While there are many resources developed for the teaching of science-related controversial issues[14] they are not grounded in any theory of pedagogy. The purpose of this thesis is to:

[12] Scientists writing in the preWWII years such as Lancelot Hogben, J.D. Bernal and J.S.B. Haldane also saw science as a force for human progress and good but they also emphasized values of social justice that needed to be yoked to the scientific enterprise.

[13] In the The Relevance of Science Education (ROSE)project which canvassed the views of pupils in many countries throughout the world typically it was students in the wealthy countries that had the least optimistic view on science (Japanese students were more jejune than all others). Those who thought science most important to their lives were young people from East Africa. (Sjøberg & Schreiner, 2005)

[14] e.g. *upd8*, Citizenship, non-statutory Citizenship guidance, Twenty First Century Science support materials

- Problematise the concept of ‘controversial issue’;
- Develop a framework for the teaching of socio-scientific controversial issues based on theoretical considerations;
- Operationalise the framework pedagogically in the light of empirical evidence, namely teachers’ own constructions of what it means to teach science-related controversial issues; and
- Discuss implications for teaching.

Chapter 2 explores scientific literacy, its multifarious meanings and contexts, its role in secondary education and how different conceptualisations of socio-scientific controversial issues emerge from it; *Chapter 3* identifies some contemporary socio-scientific issues, their multi-faceted nature and discusses the problems of addressing them in the classroom; *Chapter 4* then asks the question ‘What is a controversial issue?’ and goes on to develop on philosophical grounds a pedagogic model; how teachers’ constructions of controversy map on to this model is central to its feasibility and *Chapter 5* describes the methodology to find out how this mapping can best be done; in *Chapter 6* I discuss the results of the analysis of teachers’ constructions of what it means to teach socio-scientific issues and the changes in pedagogy needed to operationalise the framework; *Chapter 7* concludes the research by reviewing the findings, identifying the limitations, presenting the implications and identifying further research questions.

Chapter 2: Curriculum, science and society

2.1 Introduction

In this chapter I describe and analyse the educational purposes which frame the teaching of socio-scientific controversial issues. How socio-scientific issues are introduced and taught depend on a range of factors: the epistemological model of the relationship between science and society; the confidence, the personal worldview and the epistemic views of the nature of science of the teacher; the receptivity of the students; the openness of the school to new knowledge and ways of knowing and broader social and global influences. These factors are always changing. In this chapter I discuss:

- where controversial socio-scientific issues are taught in the school curriculum in England;
- the emergence of socio-scientific issues in the curriculum;
- the educational purposes for the teaching of socio-scientific issues;
- different approaches and perspectives on the teaching of controversial socio-scientific issues;
- objections to the teaching of socio-scientific issues and their controversial aspects; and
- general implications for pedagogy.

2.2 Socio-scientific issues in the curriculum

In England learning about socio-scientific controversial issues is implicit in Key Stage 4 *How Science Works*[15] (DfES/QCA, 2004) and is explicit in the specification for GCSE *Twenty First Century Science*. In the core Science module of *Twenty First Century Science*, topics include 'You and your genes', 'Air quality' and 'Radiation and Life', and there are teacher support materials for teaching controversial issues and promoting discussion. The AS level *Science for Public Understanding* includes aims encouraging students 'to develop, and be able to express, an informed personal point of view on issues concerning science and technology, taking into account . . . technical, economic,

[15] For example 'Pupils should be taught to consider how and why decisions about science and technology are made, including those that raise ethical issues, and about the social, economic and environmental effects of such decisions.' Teaching *How Science Works* began in September 2006.

social and ethical constraints'[16] (R Millar, 2000) . In AS *Perspectives on Science* students devise a research question on which they write a report and give a research presentation. This gives them the opportunity 'to learn about and begin to engage in contemporary discussions about the status of scientific knowledge, the contribution of individuals and societies to its creation and the ethical questions it generates'[17].

Socio-scientific controversial issues are also present in the Citizenship curriculum where students are expected to know and understand what it is to become an informed citizen such as the 'the importance of playing an active part in democratic and electoral processes', knowing and understanding the 'wider issues and challenges of global interdependence and responsibility . . ', expressing, justifying and defending opinions about issues, problems or events, contributing to class discussions and taking part in formal debates about these issues, and developing skills of participation and responsible action where they will be taught to 'consider other people's experiences and be able to think about, express, explain and critically evaluate views that are not their own, take an active part in school and communal activities, and to reflect on the process of participating'. (DfES/QCA 1999) (p.185). Non-statutory guidance has been written specifically to support teachers in science in citizenship: 'What's in the public interest?' (DfES 2006)[18] and 'People and the Environment'[19] . Socio-scientific controversial issues are prominent in curricula in western Europe[20], North America and Australasia.

Socio-scientific issues are taught in many different parts of the world where they often have an emphasis strongly linked to local contexts. In Brazil, for example, there are burgeoning courses, resources and research in environmental aspects of science education, often with elements of communal and local action[21]. In North America, in particular, opportunities for expanded scientific literacy and engagement with socio-scientific issues have been highlighted for groups marginalised and often alienated by

[16] Available online at: at www.standards.dfes.gov.uk/pdf/secondaryschemes/citunit20.pdf (last accessed 21st May 2007)
[17] Edexcel Advanced Subsidiary GCE in History, Philosophy and Ethics of Science (Perspectives on Science) (Pilot) (July 2004).
[18] Available online at: www.standards.dfes.gov.uk/pdf/secondaryschemes/citunit20.pdf (last accessed 21st May 2007)
[19] Available online at: www.standards.dfes.gov.uk/pdf/secondaryschemes/citunit21.pdf (last accessed 21st may 2007)
[20] In the Netherlands, for example, there is a course which parallels Science for Public Understanding
[21] For example, the journal *Revista Pesquisa em Educação Ambiental* (Research in Environmental Education)

formal school curricula (Aikenhead, 1997; Atwater, 1998; Gill & Levidow, 1987; Obed, 1998; Roth & Calabrese Barton, 2004). Beyond the formal curriculum, there are many lobby groups and political parties which campaign around scientific and environmental issues, there are, and have been, public consultations on issues such as GM Crops such as *GM Nation*[22], and lay people debate socio-scientific issues in the form of Citizens' Juries (Amour, 1995; Iredale, Longley, Shaw, & Thomas, 2004; G. Smith & Wales, 2000) and consensus conferences (Joss & Durant, 1995a).

2.3 The emergence of socio-scientific issues

To understand the context in which the teaching of socio-scientific issues has emerged in England and in other industrialised countries it is necessary to characterise broadly those debates about the aims and purposes of science education which came to the fore in the 1970s but had been present in some form since the nineteenth century (E. Jenkins, 2006). Until the implementation of comprehensive secondary education in the U.K. academic science leading to GCE O-levels and A-levels and subsequent university entrance was the norm in independent and grammar schools (E. W. Jenkins, 1989). These schools were seen as providing the scientists of the future; science was taught in secondary modern and technical schools, with some excellent exemplars of everyday and applied science (Tweddle, 1950) but it was considered of lower status. With the reforms of comprehensivisation of the 1960s and 1970s questions surfaced about the purpose of secondary science education for all. There was a dichotomy of purpose between science for the future scientist and science for the lay person or citizen, and since the latter purpose was directed at over 90% of the school population it seemed anachronistic that the old academic science curriculum had transferred to comprehensive education without much change (ASE, 1981; Black, 1992).

Movements which addressed broader aims in science education for all students regardless of their career aspirations came under a number of titles and slogans: *Scientific* (or science) *literacy* (SL)[23] (Bybee, 1997; E. Jenkins, 1990; J. D. Miller, 1983) (the whole edition of the journal *Daedalus* in 1983 was devoted to the topic of Scientific Literacy); *Science for All* (Unesco, 1983); *Science, Technology and Society* (STS)

[22] Available online at: www.gmnation.org/ (last accessed 21st May 2007)

[23] There were different nuances. In France scientific culture (la culture scientifique) was the equivalent of scientific literacy (Solomon, 1997).

(Aikenhead, 1994; Ziman, 1980) and later *Science, Technology, Society and Environment* (STS(E)) (Hodson, 1999b; Pedretti, 2005); *Science for the Citizen* or *Citizen Science* (Irwin, 1995; E. Jenkins, 1999). The programmes and agenda these movements adopted were so diverse but overlapped to such an extent that it would go well beyond the remit of this thesis to disentangle them although their descriptors contain nuances and different emphases of meanings. What they all had in common, however, were opportunities to examine contemporary scientific issues and dilemmas.

These changes included many different arguments as to the purposes of science education and the justifications for the teaching of socio-scientific issues. Policy-making bodies (AAAS, 1993; National Committee on Science Education Standards and Assessment, 1996) researchers and educators (R Millar, 1996; Milner, 1986; G Thomas & Durant, 1987) have put forward various arguments for science education but most can be categorised in five different justifications (R Millar, 1996; G Thomas & Durant, 1987), economic, utility, democratic, social and cultural.

i. The *economic justification* is based on the link between a nation's economic prosperity and the public's understanding of science. For example, one of the standards from the National Science Education Standards refers to the need to keep pace with global markets (National Committee on Science Education Standards and Assessment, 1996). This argument is met with scepticism from Chapman (Chapman, 1991) who doubts if this provides sufficient grounds for justifying science education to all because only relatively few contribute directly to the economy through application of knowledge through science and technology. In a recent lecture in London the historian of science, Everett Mendelsohn, similarly suggested that high incidences of belief in creationism in the United States had not affected budgetary expenditure on scientific research[24].

ii. People need knowledge of science to help make decisions about everyday applications of science and be comfortable with modern technology is the *utility argument*. An example is the contribution an understanding of science makes towards creativity and decision-making for skilled jobs (National Committee on Science

[24] (*Scientists and Political Actors: The Depression, The Cold War, Today* , 14th September 2006, UCL)

Education Standards and Assessment, 1996). But it can also be framed in an everyday context. Again, there is not much going for this argument. Most people can successfully change plugs, garden, wire the house and make science policy with little or no knowledge of school science. Ryder (Ryder, 2001) suggests there may be some very limited areas of health care where a knowledge of related science might be helpful.

iii. The *democratic argument* supposes that 'an understanding of science is necessary if any individual is to participate in discussion, debate and decision-making about issues which have a scientific component' (R Millar, 1996) (p.9) such as intelligent engagement in public democratic discourse about science and technology (National Committee on Science Education Standards and Assessment, 1996). Decision-making at a level which has an impact on the lives of most people, however, requires local contextualised knowledge and not an understanding of science concepts (Drake, 2006; Evans & Durant, 1995; Irwin, Dale, & Smith, 1996; Layton, Jenkins, Macgill, & Davey, 1993; Roth & Désautels, 2004; Tytler, Duggan, & Gott, 2001). More pertinently, therefore, the question is what kind of understanding of science do people need to take part in such issues (C. Dawson, 2000; Irwin, 1995; Irwin et al., 1996).

At public policy levels the response to referenda and public enquiries is often pitifully small even in relation to the population who are likely to be highly educated in science. Most public policy decision-making about scientific matters resides in trust (Irwin *et al*., 1996; O'Neill, 2002) despite concerns about the level of public involvement from policy-making bodies (G. Kass, 2001). Too often the democratic argument offered by policy-making bodies can be seen as a crude attempt to influence public appreciation, rather than understanding, of science (Levinson, 1998). There is no contradiction between people appreciating the wonders and achievements of science on the one hand and maintaining a critical stance towards its applications on the other.

It is through the democratic purpose that the teaching of controversial socio-scientific issues has its most obvious justification. Although I have indicated problems with the democratic argument this does not diminish any justification for teaching socio-scientific controversial issues provided the educational grounds for teaching them are carefully made and sufficient consideration is given to the concepts and procedures for teaching a particular issue or aspect of the issue.

iv and v. The last two arguments are *social and cultural*, that science is an important part of our culture[25] whose major ideas –Evolution, astronomy, relativity, atomic theory - should be understood by all, a justification which reflects a liberal philosophy of the value of subjects with distinct and robust conceptual underpinnings (Hirst & Peters, 1970).

Scientific Literacy (SL) is probably the most embracing term of all the slogans for a broader science education. Its first mention in connection with science education appears to be in the 1950s in the United States (Hurd, 1958) when nuclear, space and medical technologies were changing rapidly and demands for a workforce which could drive and support these technological changes were being promoted (DeBoer, 2000). Hurd's concern was that the utilitarian emphasis on the expansion of the scientific and technological base would displace the liberal-humanistic rationale for studying science and appreciating its significance (DeBoer, 2000) and his meaning for scientific literacy here was predominantly cultural. By the 1970s and the early 1980s the relationship between science and society and the applications of science as technology became important goals for science education in the U.S.A and the U.K. and with it the generation of the STS movement (Aikenhead, 1994; Solomon, 1993, 1994; Ziman, 1980). Proponents of the STS movement and scientific literacy, more generally, held a range of interpretations of the links between science, society and technology which differed according to time, geography and interest group.

Contemporaneous broader movements outside the compulsory school system or formal curriculum were the public understanding of science (PUS) or scientific citizenship. (While there appeared to be relatively little interaction between PUS and school science education there were parallel responses to public policy decisions). Like the changes being enacted in science education in schools these also reflected different purposes. From the point of view of the scientific establishment, such as The Royal Society, concerns were raised about public scientific literacy. Increasing ambivalence of the public towards science (Wynne, 1993) and increasing pressure for public accountability

[25] 'our culture' is not an unproblematic term, implying monoculture rather than diversity (Aikenhead, 2000)

culminated in The Royal Society report (1985), known as the Bodmer report which called for greater efforts by scientists to reach out to the public (Bodmer, 1985).

2.4 Scientific Literacy (SL) and Socio-scientific Issues (SSI)

It is not my intention here to probe all the interpretations of scientific literacy. There are simply too many to cover. Not only are there different characterisations of this multi-dimensional concept (J. D. Miller, 1983) there are also gradings within characterisations, for example the four stages of SL from nominal literacy at the first stage, then functional, conceptual and procedural literacy with the apogee of multidimensional literacy (Bybee, 1997). But within the whole range of meanings I want to pull out a few (necessarily non-exhaustive) characterisations which span a representative range from positivistic, top-down deficit approaches to SL[26] through to communities seeking to find solutions to problems with a strong commitment to social justice from which diffuse and indeterminate conceptualisations of SL emerge [27]. Within each grouping I will construct a new description of what a controversial socio-scientific issue might look like (Table 2.1) in terms of:

a. social hierarchies of participants;
b. content;
c. epistemic view of science and society;
d. pedagogy; and
e. assessment.

These characterisations cannot be seen as discrete, the boundaries between them are fuzzy but the possibilities of controversy are realised when contextualised within epistemological and social frameworks (see Table 2.1). My purpose in constructing this typology is that context and the meaning of controversial socio-scientific issues are related. Most secondary schools have a very particular relationship to society - predominantly cultural reproduction - which in itself presupposes certain relations between science and society. To understand the possibilities of a pedagogy there needs to be a perception of the model in which the teacher is working.

[26] Put loosely, a scientifically literate person is one who understands the main concepts of academic science.
[27] The work of Roth, Barton and Desautels are the best examples of this.

Table 2.1 Models of the science and society interface

Model	Hierarchy	Source of knowledge	View of knowledge	Controversy	Pedagogy	Assessment
Deficit	Scientist – teacher - student	Corpus of science	Science to be known is correct and certain. Nature is knowable. Where there are uncertainties and tentative knowledge this resides in the domain of experts. 'Hard' science diffuses out into applied science.	Students and lay people are unlikely to have the requisite knowledge and understanding to engage in controversial issues. Nonetheless, as well as science content they can be taught about the methods of science and controversies both within the scientific and socio-scientific domains.	Authority of knowledge resides within science and the teacher as science's representative. Knowledge needed for a controversy can be brought to the attention of students.	Test knowledge/facts of science relevant to a controversy
School and social issues	Scientist/teacher - student	Corpus of science and other disciplines	Science to be known is correct but the emphasis is on the methods and procedures of science rather than facts. Science diffuses out into social applications but there is some transparency about the scientific process.	Takes place within the classroom but might involve analysing science in newspapers distinguishing rhetoric from evidence.	Teacher controls content but might be a facilitator in discussion.	Tests argumentation abilities, use of warrants to support claims
Socio-pragmatic	Scientist/teacher/student as collaborators in school context	Science as needed	Teacher/experts delineate areas of controversy but science is seen as contestable and responsive to social needs.	Participative.	Teacher as facilitator. Knowledge shared between teacher and students	Could be knowledge and skills participant brings to sorting out a problem but difficult to ascertain.
Dialogic/negotiated	Scientist/User/ Student. Trust likely to exist between consumer and expert.	Various. Academic/decontextualised and local/contextualised. Interdisciplinary.	Limitations of academic science recognised but also its possibilities. Role for anecdotal evidence and lay decontextualised knowledge. The workings of science are transparent and contestable but there are still boundaries between science and society.	All parties engage in dialogue in trying to reach a resolution. Often action-oriented or action is an outcome.	Knowledge shared,distributed and negotiated between experts and users	Complex and problematic. Identifiers in a process such as the nature of dialogue.
Collective praxis	Led by needs of participants	Emerges from needs of participants and usually draws on local 'knowledges'. Scientific knowledge is subservient to the needs of the collective and frequently challenged	Shared and distributed. Facts and theories of 'academic' science are seen as irrelevant to the needs of the community. Science is heterogeneously distributed among groups and communities.	Might be around a particular issue but it is the view of science which is contentious. Drive is to address a social injustice. 'Scientific literacy is the contingently received outcome'. Action-oriented.	Knowledge shared and distributed between participants. Authority shaped by praxis.	Problematic.

2.4.1 Deficit model

The *deficit* model specifies a difference between those who know and understand substantive science, i.e. the experts, and those who do not know. Since the term 'deficit' can have perjorative and tendentious overtones I want to make a distinction between 'deficit' as it applies to teaching science content on the one hand and socio-scientific issues on the other. In terms of the former I conceive science broadly as rational and progressive but also authoritative. In school science established scientific knowledge is seen as uncontested and consensual[28]. There are dissenters from this viewpoint which is perceived to privilege western scientific knowledge, for example, indigenous people of the modern West 'have culturally distinct belief patterns in which scientific rationality plays a central role. From an anthropological perspective, faith in scientific rationality is at least partly responsible for many Western beliefs that appear most irrational to non-Western people' (Harding, 1991) (p.3). In many areas of science education this is an important perspective to be reminded of (Aikenhead & Jegede, 1999), and it is true of a substantial number of classrooms of schools in England where there are different cultural perspectives (Gill & Levidow, 1987). I acknowledge a potentially paradoxical position but I start from the premise that it is vital to understand the central principles of modern western science such as atomic theory and evolution by the end of secondary school. This is a separate argument that I follow up in my final chapter but I am flagging up a position at this early stage which holds that an authoritative view on the teaching of substantive science is not incompatible with a view which supports an understanding of the contested nature of socio-scientific issues.

Research carried out in the 1980s which characterised this deficit model was that of Miller in the US, (J. D. Miller, 1983) and in the U.K. (G Thomas & Durant, 1987) which measured the public's knowledge of true or false responses to science questions such as 'antibiotics kill viruses as well as bacteria' and 'the earth is nearer to the sun in winter than in summer'. Curriculum reforms (2061:AAAS, 1990) and public programmes (Bodmer, 1985; Postgate, 1995) attempted to address the problems of lack of knowledge. One conception of a scientifically literate person within the *deficit* model would not only be someone who knew some science but would know about science, its

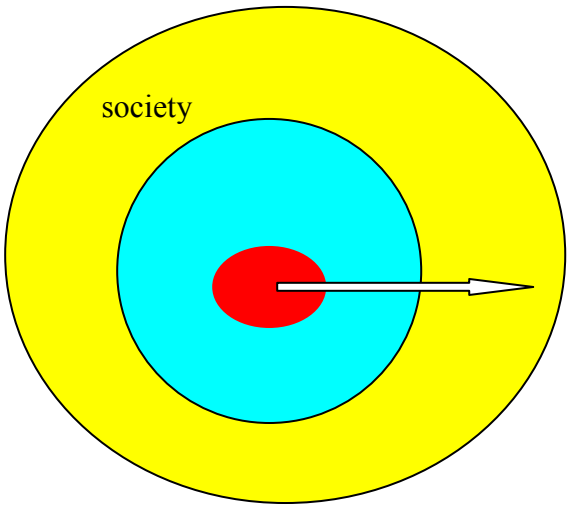
[28] I agree with Robin Millar that it makes no sense to teach atomic theory to 14 year olds as tentative and uncertain knowledge.

methods and procedures, the applications of science and its role in society. Hazen and Trefil (1991) for example, view scientific literacy as the knowledge needed 'to understand public issues . . . a mix of facts, vocabulary, concepts, history, and philosophy' (Hazen & Trefil, 1991) (p.xii).

This view of SL is broadly one which implies that any individual's scientific literacy can be measured by objective tests such as those carried out by Miller, and Thomas and Durant. Canonical science is perceived as something inaccessible to non-scientists and they need to be initiated into the basics, or given a sense of 'how the world works' (Trefil, 1997). It is unlikely that these basics will give school students or lay people the expertise to grapple with the technicalities of a contemporary socio-scientific issue but will at least give them an awareness of what is at stake in such issues. Levitt and Gross (Laugksch, 2000) doubt if a sufficiently high proportion of the populace could have the necessary expertise to make decisions on these issues. Shamos (Shamos, 1995) suggests that decision-making would involve experts working with lay people on complex decision-making processes, consistent with the *deficit* model. Teaching controversial socio-scientific issues in schools could involve scientists and teachers working with students on an issue, directing students to appropriate questions to consider, but ultimately students would be given some insight into the complexities experts have to consider in making a decision at the interface of science and society. A resource for this approach could be the SATIS materials (ASE) where students learn about a controversy having studied the related science, e.g. DNA fingerprinting (Lowrie & Wells, 1990).

In terms of the cognitive view of science in society from a *deficit* model perspective, scientific knowledge is very much at the core. 'The boundary between "science" and "society" is envisaged as a semi-permeable membrane, through which knowledge only flows outward . . ' (Ziman, 1984) (p.4). The flow is in one direction where science is applied in the form of technology and used by society more generally. (Figure 2.1)

Figure 2.1 Model of interface between science, technology and society



In figure 2.1, derived from Ziman's figure, the innermost red circle represents established scientific knowledge, the '"hard" part of modern physical theories which have universal truth (Weinberg, 1998), the middle circle represents the technological sphere in which the substantive science is applied and the outermost yellow circle represents society generally and the myriad of ways in which the technology is deployed. The arrow signifies the unidirectional flow of knowledge from the inner core to the outer domains; the epistemological core of science remains unchanged by the social changes around it. While the controversies in the outermost circle are subject to flux the decisions can be influenced by the application of science and the knowledge which resides in experts.

2.4.2 School Science and Social issues

A knowledge of science will help students as citizens-in-the making to 'hold and express a view on issues which enter the arena of public debate and, perhaps[29], to become actively involved in some of these' (R Millar & Osborne, 1998) (p.2007). The implications for a curriculum of this sort are for

> 'individuals . . .to be able to understand the methods by which science derives the evidence for the claims made by scientists; to appreciate the strengths and limits of scientific evidence; to be able to make a sensible assessment of risk; and to recognise the ethical and moral implications of the choices that science offers for action' (p.2004).

This sense of relevance to forthcoming active citizenship and a curriculum which puts more emphasis on an understanding of the methods and procedures of science is consistent with the reforms of major U.S. and U.K. curriculum bodies (AAAS, 1993; R. Yager, 1992; R. E. Yager & Lutz, 1995). Such a reformed science curriculum will address societal needs and problems but the control of the curriculum is in the hands of semi-governmental and governmental bodies and professional societies to decide what kind of knowledge has the most appropriate place in the curriculum. There is no suggestion that students will have control over what issues to study, what is learned or that they will have the skills to negotiate what they will learn. Knowledge is located in the individual and can be assessed, albeit through a framework which puts a greater emphasis on an understanding of the methods of science, gives greater weight to 'holistic understanding of the major scientific ideas and a critical understanding of science and scientific reasoning' (R Millar & Osborne, 1998) (p.2025). This framework might test skills-in-action such as students making a presentation of their findings in discussing a dilemma in the classroom.

This category has scope for student discussion and debate on socio-scientific issues. How the teacher organises the discussion might vary but there will be certain expected outcomes such as a demonstration of how evidence was used in a controversy.

There is no effective change to the model of science and society described in figure 2.1. Around the inner core the shell is a little more transparent in that the inner workings of

[29] The significance of the 'perhaps' here is to see this statement in contrast to *collective praxis* where controversy presupposes active involvement.

science are exposed to society. But the flow of knowledge is still from the inner core to the outer layers. Both the *deficit* model and this model are by and large representative of the science curricula in England.

2.4.3 Socio-pragmatic paradigm

In this category scientific literacy is developed through engagement and participation in issues such as public health and the environment (Law, Fensham, Li, & Wei, 2000). The shift from *school science and social issues* is that the content derives from general public needs rather than curricular prescription, content which is likely to be fluid, uncertain and indeterminate, as well as a programme which presupposes some form of student participation (Davies, 2004). In this approach the problems are framed by experts such as urban planning officers and doctors and, in order to participate, students and lay people will need to grasp the underlying science and technology as well as contextual factors: scientific awareness (e.g. possible impacts of GM foods on different groups in society); scientific policy and legislation (such as food labelling procedures) and scientific values and commitment (such as consumer rights) (Law *et al*., 2000). While the knowledge required is likely to be different from that of the academic school curriculum it is largely selected by experts and teachers.

Pedagogy around a discourse of collaborative planning among teachers from different disciplines would be essential (Lang, Drake, & Olson, 2006). Students would not only discuss controversial issues but possibly be involved in participating in change. Since the scientific knowledge required is likely to lie outside traditional school curricula the teacher is a learner on an equal footing with the students. Assessment is therefore problematic and is likely to focus mainly on types of procedural conceptual knowledge such as the extent of participation and new knowledge produced.

The Making Informed Decisions about Sustainability (MIDAS) project involved a sequence of collaborative fieldwork activities between primary and secondary schools, university educators and community groups (Ratcliffe & Grace, 2003), which explored the sustainability on local ponds of fishing and feeding ducks. An important outcome of this project was to develop links with local community groups. This project has the characteristics of the *socio-pragmatic paradigm* in that the authority of science is not

challenged although there is some possibility for *collective praxis* (see below) in developing opportunities for participating in change.

In terms of the science-society model the inner core and the layers remain but the boundaries between them are leakier in terms of the flow of knowledge. The arrow still flows outward from science through technology to society but there is a smaller arrow going in the opposite direction and a change in colour of the inner core, perhaps to a light pink, in which the science is less certain and academic.

2.4.4 Dialogic/negotiated

The new paradigm in the Public Understanding of Science in the 1990s was dialogue rather than deficit (Layton *et al*., 1993). Where trust and dialogue existed between expert and lay communities there was deemed to be more effective resolution of problems which related to the social contexts of people's lives. This was not so much the public understanding science but scientists beginning to understand diverse publics. The science of the problem often had to be transformed into a local context where experts and people affected could discuss the problem in local and specific terms of perceived need. What most concerned people was not a need to understand academic science or to estimate the risks but to feel that experts understood their concerns and that their voices had been listened to (Irwin *et al*., 1996). Where there was a problem or dilemma to be addressed it was not the science facts which were the crucial factors but political understanding and trust, in fact knowledge of the science for most socio-scientific problems was seen to be marginal. 'Local' does not necessarily imply geographical constraints. People have concerns about global issues such as climate change, bird flu and the impact of GM farming methods. But engagement about such issues must involve more than canvassing or scientists listening to what people have to say; experts and non-experts are joint participants.

Science knowledge through the dialogic approach is also seen as distributed, that is knowledge does not reside in one person or group to be disseminated to those who do not have that knowledge. To try and resolve a problem or issue lay people and experts will have to draw on diverse knowledges: anecdotal evidence (Tytler *et al*., 2001)[30] can provide links between local knowledge and 'expert' science. The implications for

[30] I discuss anecdotal evidence in Chapter 4

teaching socio-scientific controversial issues are complex. If socio-scientific controversial issues are to be taught in schools then the students might not need any of the science associated with GCSE or A-level syllabuses at all or the science would be so transformed, disembedded and re-contextualised that it might not be recognisable as anything approximating to the science students have been used to. Skills in dialogue, and understanding the meaning of trust in the context of public policy, will be useful attributes. Trust here is not the same as fidelity; it implies lack of certainty in a future outcome which might be controlled by others. Nonetheless this is precisely why reasonable trust is needed because we do not need trust where the outcome is certain (Sztompka, 1999). Dialogue around these issues presupposes tentativeness and uncertainty in the science. Since knowledge comes from a variety of sources an inter-disciplinary approach would seem suitable.

In this classroom context there is no one locus of authority in either scientists or teachers. Individuals engaged in finding a resolution to a dilemma will draw on multiple sources of knowledge. If, for example, a group of students were discussing whether to campaign against the use of foods in their school canteen they would take evidence from research, listen to the stories of others affected in different ways by GM foods (e.g. producers and campaigners), canvas the views of their peers and negotiate with the school authorities[31]. No one source of knowledge and information would be privileged over any other. Assessment would, again, be problematic and would have to be negotiated by all involved parties.

The boundaries in figure 2.1 start to dissolve but they are still recognisable. Dialogue between scientists and lay people is represented by arrows of similar size flowing in both directions. Expert knowledge is responsive to and is modified by informal citizen knowledge.

2.4.5 Collective praxis

A more radical critique of scientific literacy very much connected with the teaching of socio-scientific issues has come from the United States and Canada in the form of reconstructing scientific literacy in schools as *collective praxis* (Roth & Calabrese Barton, 2004). The assumptions driving this rethought scientific literacy are struggles for

[31] An example of this campaign is briefly alluded to by a teacher in Chapter 6.

social justice and an understanding of power relations (Hodson, 1999a). *Praxis*, as Habermas intends it, is a 'human engagement . . . embedded within a tradition of communally shared understandings and values, vitally connected to people's life-experiences' (Dunne, 1993) (p.176). Through the 'dialectic of interaction . . . the self emerges in a . . . process of working through conflict and struggle towards mutual recognition with others' (p.178). Central to this approach are a sense of identity and agency. As participants in community action, people are agents of change and their identities are formed and re-formed as a result of the changes in which they participate. Scientific literacy is not a property of individuals but emerges through action and is both indeterminate and under-determined. Perspectives are committed and come from members of interest groups and communities but also draw on marginal viewpoints, homeless children, women, ethnic minorities. Above all, it is citizens using science to address their own problems and, as a result of trying to find solutions, produce new knowledge.

This implies a very different use of science in a contentious issue from that described in the *deficit* model, and of *school science & social issues*. Science becomes one tool amongst many – to use Roth's analogy one fibre among others making up a thread (Roth, 2003) - which not only can be used to resolve an issue one way or the other but also becomes a means of critiquing and deconstructing the dominant, 'academic' decontextualised science. Science is a means of promoting a democracy where citizens act in socially responsible ways. Since science is so bound up with political, ethical, economic, social and communal aspects, locating and acting on contentious issues is intrinsically interdisciplinary. The location of the controversy is both on the issue – cleaning up rivers, choice over GM free foods in local outlets – but also in the tension between local science and dominant science, expert and non-expert, decontextualised science and generalised science. Schools as instruments of the state and cultural reproduction are therefore in problematic positions. As before, pedagogy is interdisciplinary but the boundaries between teachers and taught are disrupted.

The layers between academic science and society are completely broken down, the relationship between science, technology and society is heterogeneous and diffuse, science has no particular cognitive authority and science policy is played out in public spaces representing the *agora* in which science is contested and there are multiple and

differentiated interactions between interested parties and scientists (Nowotny, Scott, & Gibbons, 2001).

These five models presuppose diverse roles for the teacher/expert. In the *deficit* model the teacher/expert controls the knowledge needed for a controversy and scientific literacy can be a measure of the difference in science knowledge from before and after learning about the controversy, where the emphasis is on the science rather than the controversy. In *collective praxis* the teacher/expert is a participant whose knowledge is seen as problematic and where expertise is not only distributed between the participants but is constantly changing. Knowledge in the *deficit* model is generalised scientific concepts which can be applied to an issue, in *collective praxis* knowledge emerges from local contexts. The science teacher in the *deficit* model will draw on the forms of knowledge they have been inducted into in higher education and with which they will feel confident. In *collective praxis* this new knowledge needed might be completely strange to the teacher.

2.5 Objections to teaching controversial socio-scientific issues

In 2006 the Institute of Ideas published a book whose main thrust was to attack the thinking behind new curriculum developments in science – mainly *Twenty First Century Science* – and scientific literacy and the teaching of controversial issues in particular. The Science base in the U.K., the book argued, was being gradually eroded, prestigious science departments[32] were being closed down because the teaching of the substantive ideas of science were being diluted in schools. Instead of students mastering difficult science concepts they were being served up a watered down concoction of relevant science. Baroness Warnock warned of teaching 'more suitable for the pub than the school room' (Warnock, 2006) (p.54).

It was argued that

> 'focusing of the curriculum on controversial aspects of the implementation of science and technology, such as genetic modification or nuclear power, can no doubt provide young people with the opportunity to express themselves about issues

[32] The chemistry department at the University of Sussex, for example, which has produced Nobel Laureates such as Harry Kroto, the discovery of 'buckyballs'.

> we all face. But in the absence of a thorough grasp of science and a clear understanding of its importance in the context of a particular debate, any discussion will quickly boil down to rhetorical posturing or simply confusion. Asking teenagers to make up their minds about anything is pretty daunting. But if you try to ask them to decide if we need to replace the UK's nuclear powers stations, you are far more likely to get the obvious question: "Sir, what is nuclear power?"' (Perks, 2006)(p.17-18).

If socio-scientific controversial issues were to be taught then they should be addressed outside of science lessons. Perks' critique possibly lies outside of the *deficit* model where some insight into contemporary issues would be allowed under careful guidance. The main thesis of *What is Science Education for?* is that there is no place for socio-scientific issues in the science curriculum.

This criticism of focusing on controversial issues in science foreshadows some problems I will discuss in Chapter 4 – the science is too complex; there are many other factors such as economics and bureaucracy which influence decision-making – which suggest that the teaching of controversial issues has a dubious justification in science education. No doubt many science teachers who have faced the problem of teaching these issues in the classroom have sympathy with this viewpoint (Bryce & Gray, 2004). But this rhetoric is to take a rather limited view of science as academic (Layton, 1986; Roth & Calabrese Barton, 2004; Solomon, 1999) and of controversy as monolithic. As I shall argue in Chapters 3 and 4 there are a range of disagreements even within a recognised issue, and the fact that we might not have the knowledge or expertise to address all aspects of the issue, does not mean that we cannot think through and shed some light on important parts of the controversy. Moreover to deny students any insight into controversy is to deny them an important insight into what being a member of a democratic society entails (Dearden, 1981)

A more sophisticated critique comes from Donnelly's articulation of the key characteristics of natural science as distinguished by their ontic categories (J. Donnelly, 2002), the entities with which science deals such as electron charge clouds, thermodynamic equations and causation. Donnelly argues that unlike the humanities science is instrumental (J. Donnelly, 2004b), it enables prediction and control, which go

beyond any values we might attribute towards its procedures. The reviewing of scientific papers, the ethical constraints, the processes of the scientific community are contingent upon but not intrinsic to these ontic categories, that the 'potentialities of the material world are not to be altered by any number of social values, though of course such values may well influence which possibilities are realised' (J. Donnelly, 2002) (p.138). The implications for the science curriculum are that attempts to humanise science or place it in a social and ethical context result in the 'replacement of education in science with curricula in what might be loosely called the political sociology of science' (p.147). Kromhout and Good (1983) echo Donnelly's critique because social issues 'do not convey any real understanding of the structural integrity of science' (Kromhout & Good, 1983) (p.649).

Trenchant opposition also comes from Hall who sees a sharp distinction between the discourses of science and morality.

> 'It is widely recognised that 'is' statements in science cannot be turned into the 'ought' statements of moral discourse. For example, science can fairly accurately judge the consequences of bringing together a number of sub-critical masses of U-235 above a densely populated geographical area. It can say absolutely nothing, however, about whether such an action would be right or wrong. The answer to the latter question lies outside the domain of science but within the remit of a moral discourse. The domains of scientific and moral discourse are fundamentally different; they have different core concepts . . ., different procedural ground rules and different tests for truth. . . To apply science's empirical test for truth within the moral domain would turn morality into pragmatism'(Hall, 1999) (p.15).

The distinction made between fact and values is often derived from Hume's naturalistic fallacy in which Hume aims to demonstrate that an 'ought' statement cannot be derived from an 'is' statement although formally this can be done[33] (Hudson, 1969; Putnam, 2002), and that the way in which Hume used the term 'fact' has a very different meaning from the use of 'fact' in contemporary discourse (MacIntyre, 1988). It does not

[33] For example, 'For you to assist that elderly person in crossing the road now is good, and for you to refrain from helping that elderly person cross that road is bad, therefore you ought to help that elderly person cross the road.' Based on (Putnam, 2002).

necessarily follow from Hall's argument, or from Donnelly's, that students should not discuss controversial socio-scientific issues but that they should always be aware of the distinct nature of the scientific discourse. Hence, when investigating the science, classes could don hats marked 'science' and when addressing questions of ethics would change them to 'ethics' hats (Hall, 2004).

Both Donnelly and Hall affirm their support for Hirst and Peters' domains of education with their distinctive methods and tests for truth. (J. Donnelly, 2004a; Hall, 2004; Hirst & Peters, 1970). Donnelly, like Hall, does not see science in conflict with ethics or social values, it simply stands coldly apart from them. Science as a tool of social justice (Calabrese Barton, 2002; Roth, 2003; Solomon, 1993) is in complete opposition to this epistemic separateness of science.

Whereas Donnelly's objections are particularly pertinent to *school science & social issues* because there is an attempt to bring academic science to bear on controversial issues, the premises of *collective praxis* are completely different. From this perspective school science is inauthentic, scientific literacy emerges from praxis. Where 'expert' science does have a bearing on a problem it often has to be deconstructed and occasionally dismissed as irrelevant.

There are substantive concepts in science which are the sites of values disputes. Such a case is the 'gene', an entity that some geneticists cannot dispense with (Dawkins, 1976) and which other biologists can do without, in fact they challenge its meaning and existence as a discrete entity (Hubbard & Wald, 1997). These arguments are semi-rehearsed in Chapter 4 but it is probably fair to say that many biologists work in the field of genetics without paying undue attention to the metaphysical conflagration which surrounds this issue. It could be argued that the gene has explanatory and predictive power however it is conceptualised. But my point is that values in terms of ideological preferences go to the very core of the gene as an entity. While it might be the case that such values are contingent to the programme of the physical sciences I think the ground is fuzzier in biology and indeed goes to the heart of how genetics and evolution might be conceived and taught (Dover, 2001).

What both Hall and Donnelly are careful to qualify is that this does not mean that there is no place for the teaching of socio-scientific controversial issues in school, they do not see a place for it in science in the curriculum, or as a means of inviting interest in science (Murray & Reiss, 2005; Osborne & Collins, 2000). While this has a bearing on the implications of this thesis it does not influence my central argument and conviction that these issues should be taught and that teachers need support in teaching them in the classroom.

Throughout this thesis I will argue that socio-scientific controversies are necessarily complex so that a more realistic approach is to deal with separate aspects of any controversy. An interdisciplinary approach in genuinely collaborative well planned sessions (R. Harris & Ratcliffe, 2005; Lang et al., 2006; Ratcliffe et al., 2004), in less bounded and more openly framed contexts which allow for diffusion and mixing of different areas of knowledge (Bernstein, 1977), would be more suitable for teaching the issue than attempting to teach it through a particular subject such as science[34]. If Donnelly and Hall are stating that socio-scientific issues should be removed from science lessons which have a distinct ontic take on the material world then my position is consistent with theirs. But the teaching and learning of socio-scientific issues presupposes openness between different areas of knowledge.

2.6 Implications for pedagogy

Roth and Barton criticise the *school science & social issues* approach because the activities which might comprise part of this approach such as role play and consensus projects (Kolstø, 2000; Simonneaux, 2001) reproduce 'existing separations between school and everyday society' (Roth & Calabrese Barton, 2004) (p.176). They are based on assumptions that what is learned in school can be transferred to 'everyday knowing' (p.176). But if schools are the sites of cultural reproduction there are nonetheless instances when students become involved in transformative programmes when they discover, possibly with the help of an attentive teacher, the problems of the closed discourse of school science (Désautels & Larochelle, 2004). While there are both epistemological and social boundaries, both within subjects in schools and between

[34] Teaching socio-scientific issues through Citizenship lessons provided an interdisciplinary programme is built in and there is an assessment programme could be an alternative. It is unlikely that PSHE would be a suitable curricular locus as this is seen as low status (Whitty, Rowe, & Aggleton, 1994)

schools and the world beyond, to accept more school-based programmes as obstructions to democracy is to conceive of schools as asocial and to deny the possibility of student and teacher reflexivity. It is, in fact, to deny the transformative power of their own, i.e. Roth and Barton's, project.

Gramsci (Gramsci, 1971) has argued that the values of the dominant class, in this case, those technocratic values that drive school policy, so deeply saturate the consciousness of society that it becomes part of society's commonsense. Thus we have a functionalist approach to school governance based on league tables, an assessment-driven system and the discourse of 'delivery' and 'strategies'. But this hegemony is not static, it is in a constant state of challenge (Williams, 1973). To accept the non-possibility of any change emerging from schools is to accept a highly reductionistic and pessimistic account of praxis. I want to argue from a pragmatic position that engagement with controversial issues within schools, however slight, is better than no engagement. That discussion around disagreements even within a highly authoritarian system enables the identification of contradictions and possibilities and the consideration of alternatives[35],[36]. Where schools do engage in action, for example in support of refugee children (Carrington & Troyna, 1988) or in countering environmental problems there is the awareness of change. The *deficit* model might be a very limiting account of controversy in schools, where the parameters of authority are closely defined. But certain attitudes or dispositions can be developed which, while not necessarily transferable, do raise awareness, for example, the importance of listening to points of view with which you disagree, the respect for rational procedures such as inference and the identification of fallacious argument (D. Zeidler, 1997).

Evidence from classrooms and interviews with teachers show that science teachers in particular do not feel confident about teaching controversial issues (Bryce & Gray, 2004; Osborne *et al*., 2002) possibly as a result of their own apprenticeship in the institution of science (Cross, 1997). To attain the *collective praxis* as demonstrated by Roth and Barton is a long way from the sights, practices and expectations of many teachers. That

[35] In Chapter 1 I discussed the anti-nuclear sixth former who wanted to nuke the reds. The fact that she showed discomfiture when this contradiction was pointed out was itself a transformative act.
[36] Ellsworth is a good example of an alternative from a feminist point of view which will be discussed further in Chapter 7.

is why a framework, grounded by good educational reasons, for teaching socio-scientific controversial issues is so timely.

In Chapter 3 I will exemplify the complexity of socio-scientific issues and in Chapter 4 I will show how this complexity can be unravelled in the classroom through an analysis of the meaning of controversy.

Chapter 3: The complexity of controversial socio-scientific issues

3.1 Introduction

My aim in this chapter is to exemplify the nature of some of the dilemmas brought about by developments in biomedicine. While biomedicine forms the initial arena for my interest in controversial issues, the examples I discuss below, I believe, are consistent with the kinds of complexities which arise in other contemporary areas of science and technology such as nanotechnology and climate change.

The death of Dolly the Sheep, the first cloned mammal, on 15th February 2003, poignantly encapsulates ambivalences in biomedical technology. Dolly did not die a natural death; the decision to end her increasingly painful life from arthritis was taken by her 'creator' Professor Ian Wilmut of the Roslin Institute in Scotland[37]. Tensions between hope and failure, possibilities and constraints, corporate capitalism and human welfare, science for good and science for evil, natural causes and human intervention, have all been subsumed in the debates after Dolly was born and through developments in biomedicine and biotechnology more generally.

These developments pose dilemmas in terms of personal decision-making and public policy. To highlight the hopes and possibilities and, in particular, that of the Human Genome Project designed to map the entire human genome, ex-President Clinton, reported in *The Guardian* of June 27th 2000, said the publication of the first draft of the genome was "without a doubt, the most important, the most wondrous map ever produced by humankind, ... We are learning the language in which God created life." The Human Genome Project, then, is the hope, although God might have been a touch

[37] There is speculation that cloned mammals do not live as long as other members of the species, possibly because their cells are older. A Japanese team reported that mice they had cloned lived shorter lives, including high incidence of spontaneous abortions and abnormal births. The method of cloning the mice was different from that of Dolly. Creating Dolly involved electrofusion where the entire mammary cell was electrofused into the enucleated egg. The Japanese team micro-injected the nucleus, without the attached cytoplasm, into the enucleated egg cell. There was a suggestion that the attached cytoplasm could make a difference. Microscopic observations suggest that telomeres (the physical ends of chromosomes) in cloned cells are shortened, each time the cell divides the telomere cap becomes a little more frayed which might increase the aging process. (Reported in the Feb 11 (2002) issue of *Nature Genetics*)

less sanguine about the project than the President. But what do these dilemmas look like? And what are the implications for teaching about them? A few examples to start . . ..

3.2 Five cloned pigs

In 2003 PPL Therapeutics produced five cloned pigs which could provide replacement hearts for humans in need of a transplant. The company announced that all the technical hurdles for pig to human transplants had now been overcome[38]. Cells of the pigs had been genetically modified to knock out those genes which could provoke an unwanted response in the human immune system. The advantage of pigs for these operations is that their hearts are similar in size and morphology to human hearts and, unlike primates with their relatively slow gestation and small numbers of young, they produce a litter which would provide a ready source of available hearts. Whereas the present practice is to find a fresh heart from a healthy human who has recently died (usually in an accident), complications can arise in an emergency procedure because tests have to be carried out to check that the donor heart is compatible. Then there is the question of compliance with agreement of the donor or relatives.

But there is a fly in the ointment. This kind of xenotransplantation might result in the transmission of porcine retroviruses (Specke *et al*., 2002). Since these retroviruses are unique to pigs the human immune system would be unable to cope. The unknown virus might be transmitted in the procedure which will not only kill the recipient but could spread as an epidemic throughout the human species. How can the risk be assessed? What precautions could be taken? And what are the ethical dilemmas associated with taking the risk, however small?

Although the media response to PPL's announcement was generally euphoric, hailed as 'a potential revolution in transplant medicine[39] there were warnings. Scientific breakthroughs of this nature emerge on publication in rigorously refereed scientific journals but this was not the case this time. The scientific community was less than fulsome in their reaction to the announcement wondering why PPL had not published

[38] Available online at: http://news.bbc.co.uk/1/hi/sci/tech/2210306.stm (last accessed 21st June 2006)
[39] James Chapman (23/08/02) *The Transplant Revolution*, The Daily Mail.

their findings in a refereed journal and instead gone straight to the press. Predictions were made that PPL's stock would go through the roof as a result of the media frenzy. In fact this did not turn out to be the case because biotechnology shares had been on a downswing for some time and PPL had themselves not escaped lightly. Although share prices did rise they were by no means of the order that some had predicted.

There are other considerations. Religions differ in their approaches to xenotransplantation; for some it is permissible because the prime obligation is to save human life, which is clear in the three monotheistic religions. Within religions there are different factions with diverse views on what should be done.

In this brief summary of xenotransplantation we can begin to see that there are a range of issues within the main area of debate. All of these foreshadow areas of complexity.

- What *risks* are involved in xenotransplantation? How can we assess these risks?
- Does the *precautionary principle* apply? If an individual is desperately ill and xenotransplantation is the only technique which will save that person, what should we do? Taking the precaution of doing nothing will result in somebody's certain death.
- What rights does a sufferer have to claim a heart? What are the *rights and responsibilities* of the patient, close relatives and society more broadly?
- How can we evaluate the *scientific reliability* of the procedure given that the research was not peer-reviewed in the way cherished by the scientific community?
- What suspicions are aroused if a company is likely to make a fortune through the development of a technique that can save many lives? How far are science and technology compromised by the quest for *profit*? How can we understand this factor? Does the market play the same role in all scientific and technological breakthroughs?
- And following on from profit-loss considerations, has xenotransplantation been developed at the *expense of other health measures*, for example preventative medicine? How can we know whether there are alternative possibilities of treatment and prevention and how would their efficacy compare with xenotransplantation?

- How should members of a particular *religion* act if faced by a choice of having a pig's heart? How much credence should we give to an abhorrence in having a pig's heart inside us? Does the *myth* of the chimaera have a powerful hold on attitudes?

3.3 Embryo selection

Embryo selection through pre-implantation genetic diagnosis (PGD) can save the lives of children affected by genetic abnormalities but the technology is thought to be risky and brings with it a perception of 'designer' technology. In this technology the mother is administered a drug to stimulate ovulation and multiple egg production. The eggs are removed and fertilised *in vitro*. A couple of cells are then removed from the resulting embryos when they are at, or just past, the 8-cell stage and diagnostically tested for signs of disabling genetic conditions. Healthy embryos are then implanted into the mother's womb and other embryos are discarded.

This technique has been used legally[40] so far in two ways, first, in selecting against male embryos who will inherit a sex-linked condition such as haemophilia or Duchenne muscular dystrophy. Secondly, in a very few cases it has been used to help save the life of a child. In the first time it was used this way in the United States in 2000, Molly Nash, a little girl of six suffering from Fanconi anaemia, a virulent form of leukaemia, needed a blood transfusion from a healthy donor who had the same blood and tissue type. Given the difficulty in finding this precise fit it was decided to use embryo selection to provide the tissue, namely stem cells[41] found in the baby-to-be's umbilical cord. As a result of the birth of Molly's sibling, a baby boy as a donor of stem cells, Molly has shown good signs of recovery although it is too early for a longer term prognosis. The procedure was extremely costly, unlikely to be afforded by people on low incomes without access to substantial funds.

[40] There have been recent changes in HFEA regulations. This chapter was written before these regulations came into place but the point about complexity remains.

[41] Stem cells are so called because they possess the capability of differentiating into specialised cells such as liver cells and neurones. They can be harvested from embryos, some of which might be specially cloned for the purpose, and in the umbilical cord of newly born babies. Recent research indicates that stem cells do not act by replacing diseased cells, as first thought, but by merging with the affected cells and replacing the DNA of the latter with the stem cell DNA.

There are, however, risks associated with this procedure. Any parent who goes in for PGD is likely to have hopes and expectations, particularly if it can save the life of a loved child. But the success of *ivf* is not guaranteed (Waters, 2001), the procedure of genetic diagnosis is not one hundred per cent accurate and successful implantation might not take place. If the implantation is successful, and the baby is born, the transfusion of the stem cells may not have the desired effect. There are, then, at least four obstacles, not to mention the distress caused by failure and the stress both on the donor and receiver child.

But there are broader implications. First the technology, as we have seen in the case of haemophilia, could be used for sex selection unless it is firmly regulated. In a test case, a couple claimed the right to use the technology to select for a daughter under the Human Rights Act. Their infant daughter had died in a fireworks accident and, since they already had three sons they wanted to 'provide balance to their family', by having another baby daughter[42]. Fears over sex selection have also been raised. Males might be selected for because they are regarded as more productive in terms of family income in some groups, and are not a strain on a family's finances by having to provide a dowry[43] (Davis, 2001).

Although this technology is used to help terminally ill children, fears have been raised that it can easily be used to select for babies for broadly cosmetic reasons such as hair colour and eye colour. While there has been no known case of the technology being used in this way - and most phenotypic structures have a complex genetic make-up - nonetheless there have been calls for strong regulation, and it is not presently allowed under the rules of the Human Fertilisation and Embryology Authority (HFEA) . The prohibitive costs of embryo selection have been identified on the grounds of social justice as a means of empowering the rich who can afford such a technology, and disadvantaging less well-off people who will not be able to afford it. Yet another objection has come from ‘right to life’ groups claiming that producing an embryo only to discard it transgresses the sanctity of life principle.

[42] A UK family have already used PGD abroad to select for girls.
[43] It should be noted that other techniques have now superceded embryo selection a a means of sex selection. For example, sperm can now be sorted into 'male' and 'female' sperm in electro-magnetic fields using fluorescent dye markers. *ivf* can then be carried out. This works on the principle that the DNA content of the sex determinant chromosomes is slightly greater in females.

A case of embryo selection

Thalassaemia major is a single gene disorder which results in insufficient production of haemoglobin to enable the red blood cells to carry oxygen to the body's tissues. There are about 100 000 people with this condition world-wide. Patients are normally given regular blood transfusions (usually every three weeks or so) to make up for their own lack of red blood cells. A side effect of this treatment is that excessive iron levels build up which the body cannot deal with and, as adults, sufferers need to take medicines to regulate the iron levels. People who suffer from thalassaemia major usually have an average life span of 40 to 50 years but there is every chance this will increase. The condition can be cured by a bone marrow transplant but the donor must have an exact tissue match otherwise the donated blood cells will be rejected. Finding a matching donor is a very difficult task.

Thalassaemia is particularly prevalent in people from the eastern Mediterranean littoral and south east Asia. Some ministers of the Greek Orthodox church in London act as counsellors to Greek Cypriot couples, who intend to marry to check the history of thalassaemia in the family. Parents who are both carriers of thalassaemia major would have a one in four chance of producing a thalassaemic child.

Zain Hashmi is a little boy who suffers from thalassaemia major. His parents opted to undergo PGD to conceive an embryo which would both be free of the condition and would provide cells which were an identical match for Zain. At the donor baby's birth, cells would be harvested from the umbilical cord which would be transfused into Zain. The HFEA granted permission to a clinic to use PGD to help Zain. After a number of cycles of treatment an embryo which was free of thalassaemia and a perfect tissue match for Zain was implanted into his mother's, Rehana's, womb. But there was a miscarriage a few months later. The Hashmis are determined to continue the treatment until a baby is born to term who is a perfect match for Zain[44].

There are a number of interesting points which have emerged from the Hashmi case. Another family, the Whitakers, have a little boy Charlie who suffers from a blood

[44] Up to date (15/3/07) I am not aware that the Hashmis have been successful.

disorder called Diamond-Blackfen anaemia. The HFEA did not grant the Courtneys permission to have PGD because Diamond-Blackfen anaemia is not an inherited condition. Since Zain's father and mother are both carriers of thalassaemia there is a one in four chance that any child conceived naturally would have thalassaemia and therefore the permission for PGD was granted on the basis of welfare of the child. Testing for the gene in the embryo would help bring a child into existence who did not have the condition as opposed to a child who might. For the Whitakers the reason for testing was to select an embryo with the correct tissue match only, so any screening would be purely for the benefit of Charlie not for the embryo who would develop into a baby. As a result no clinic in the UK was licensed to use PGD with the Courtneys and they had to go to the United States. Charlie's mother has now given birth to a little boy who is a match for Charlie, and cells from the baby's umbilical cord have been collected to be transfused into Charlie[45].

The Hashmis have been criticised from various quarters, including the society representing thalassaemics, for undergoing PGD[46]. Thalassaemics, it is argued, live contented and fulfilling lives and, as treatment improves so will the quality of life and average life span. In highlighting the Hashmi case the media have tended to over-egg the unpleasantness of thalassaemia major, alarming those who have the condition and ignoring the many positive and life-affirming attributes of those who suffer from thalassaemia. To use PGD to cure Zain is to stigmatise thalassaemics, to suggest that the life of a thalassaemia sufferer is not worth living and possibly to divert attention from the need to ameliorate the condition. This argument has resonances with those from disability groups who maintain that the elimination of a genetic condition carries with it the implication that their lives are less than satisfactory and that, had the technology been available earlier, they would not have been born (Parens & Asch, 2003).

In December 2001 Comment on Reproductive Ethics, CORE, brought a high court case arguing that the HFEA had gone beyond its remit in the 1990 Act in licensing a clinic to select an embryo for the correct tissue match. While PGD can be legally used in the UK to screen prenatally for genetic disorders this did not allow licenses to be granted for

[45] Note here law has been changed

[46] UKTS (2003) *UKTS Newsletter: Thalassaemia Matters*, Issue 94, UK Thalassaemia Society, available online at: http://www.ukts.org/pages/newsletter.htm, (last accessed 31 August 2006.

tissue typing. The problem for the Hashmis is that they needed both. Although CORE won their case it was overturned by an appeal court. Nonetheless, this is a grey area and one that needs clarification through Parliament.

- Why should embryo selection be used only for genetic conditions? How can the *welfare of the child* be properly assessed?
- What is the *probability* of having a child with an inherited condition?
- Should embryo selection be available to all? Are there elements of *social injustice* in making it available only to those who can afford it?
- How can we assess the *emotional impact* on all parties involved in embryo selection for tissue typing?
- Is the use of this technology likely to lead down the *slippery slope* towards 'designer babies'?
- Is any form of genetic screening a *form of discrimination* against those disabled by genetic conditions? Does genetic screening influence our *perceptions* of disabled people as medical problems?
- What are the *rights and the responsibilities* of all parties involved in genetic screening? How do we formulate the rights of the unborn child?
- How does the media influence our perceptions of disability? How can we understand and *empathise* with those suffering from genetic and non-genetic conditions in order to provide sensitive and effective treatment?

3.4 My little cloney[47]

Finally, the possibility of human cloning also raises important dilemmas. Parents might want their child cloned because they are infertile and cloning would be the only way of producing a child that is genetically related to them. 'Frankenstein' is the term that has been used in the popular press in relation to the spectre of a human clone[48] and, historically, has deep mythic status associated with it (Hellsten, 2000). Ian Wilmut, the creator of Dolly, has clearly stated two objections to human cloning (Wilmut, Campbell, & Tudge, 2000). First, so little is known about the potential health impacts on a cloned

[47] *Sun* headline
[48] Frankenstein foods have been used frequently also in relation to GM foods.

child that it is better not to attempt the procedure [49]. Secondly, even if it were to become possible to create a clone free of any physical impediment, the psychological impact of being made identical to a parent and the expectations made should not be something a child should have to deal with and would not be in the interests of the welfare of the child (Bennett & Harris, 2003). Children may not necessarily be cloned from a parent. It has been suggested that cloning can be used to produce a genetically identical copy of a child who has died in an accident (using DNA from the deceased child), for example, so that the parents feel that their child continues to exist. A third argument, closely related to Wilmut's, is that cloning robs a child of his or her unique genetic identity and so robs them of their individuality (L. Kass, 2002).

There have been a number of voices countering objections to cloning. Harris, for example, has pointed out that the psychological impact results from the parents' motivation in producing a clone of itself. Parental motivations, however, may be less than desirable in natural ways of conceiving and does not of itself constitute an objection (J. Harris, 2004). Bennett and Harris (Bennett & Harris, 2002) deploy the argument of a worthwhile life as against an unworthwhile life, the latter being that an individual is only wronged if by being brought to birth 'they have a life so bad that it would be a cruelty rather than a kindness to bring it into existence' (p.323). Thus, a child with an illness such as Tay Sachs or acute muscular dystrophy would be deemed to have a life so harmed by suffering that it would outweigh considerably any pleasure gained by living. Such a consideration would not necessarily apply to a child produced by cloning. Although suspected parental motivation might be less than desirable, thereby making the potential life less than optimal, it would not be so bad as to make the life unworthwhile and, since it would be the clone's only chance of existing, and of existing to have a life worth living, then the production of the clone would be deemed ethically acceptable.

[49] Despite attempts at human cloning up to date it has not succeeded beyond the six cell stage. (It took 277 attempts to produce the first viable cell that eventually divided and became Dolly). Although the Raelians have announced the birth of a cloned child they have not produced any evidence that this has happened. The Italian doctor, Severino Antinori, has announced his intentions of producing a human clone but again this has not yet materialised. An interesting rider, however, is that despite the strong objections by Ian Wilmut and the Roslin Institute where Dolly was cloned, the Roslin Institute have in fact applied for a patent for human cloning Available online at: http://www.srtp.org.uk/clone102.htm (last accessed 22nd January 2006)

Objections to the genetic identity argument have been based on the fact that twins are also genetically identical although this has not necessarily harmed them as individuals. Indeed, given the interplay between genes, and between genes and their chemical environment, e.g. the factors that determine the switching on and off of genes, genetic identity is a relatively small factor in determining the course of one's life and identity (Lewontin, 1993) although the writings of some scientists appear to place the gene as the pre-eminent determinant of an individual's biology (Ridley, 1999).

A libertarian argument, strongly associated with a small group of bioethicists in the United States, based on the Universal Declaration of Human Rights, argues that people have a right to reproduce in any way they want provided they are not infringing the rights of anyone else. They further argue that a clone born and raised by a loving family is likely to be at least as well off as any other child conceived naturally (Robertson, 2002). It has been pointed out that non-interference in one's right to marry and have a family is not the same as asserting the right to access any technology in order to have a child if in doing so it violates important social goals (King, 2003).

Cloning is also perceived to be the commodification of human reproduction and to represent an industrial model of Nature (King, 2003). Unlike twins or assisted reproductive technologies such as *ivf*, the baby has been designed to resemble someone else and therefore violates the clone's person status in that they have been generated as a particular object rather than as an individual with their own interests.

- Why do we have such a *horror of cloning*? Why is this technology seen as particularly unnatural whereas other non-natural technologies are readily accepted by society?
- How can we evaluate the possibilities of *psychological impact*?
- Why do humans appear to have such a strong *instinct for genetic identity*?
- What is a *worthwhile life*?
- Should *people be free* to do whatever they liked provided it did not have an undesirable impact on others? What counts as an undesirable impact?
- How should cloning be *regulated*? And who should regulate it?

- How does post-enlightenment society perceive Nature? Is it something to be used to better the lives of people? Is it something to be valued for itself? Does modern technology *objectify* living things?

3.5 Conclusions

In describing these biomedical issues I have tried to extract pertinent questions. A summary glance through the questions would alert any teacher to the impossibility of covering any of the arguments in a short period of time or all of them in any amount of time. At this point I want to raise the possibility that these issues can be addressed from different curricular angles. There is the question of integration in the curriculum which I shall develop later but for now my point is that placing these issues wholly within the science curriculum is, at the very least, problematic.

Not only are there many different types of question within any one issue, people also see the issue in different ways. To take xenotransplantation as an example, one party might see xenotransplantation in terms of cost-benefit analysis, an efficient way of curing coronary disease minimising costs and administrative procedures in gaining consent. Another party might contend that reliance on transplantation of animal organs will distract attention from the need to prevent heart disease in the first place, that it serves the interests of capital and fails to take into account the responsibility of the health service in educating the public to be more discriminating in their diet and for the State to provide better recreational facilities to encourage physical exercise. Yet a third party might say let us gather together a group of wise people knowledgeable in the science and ethics and let them deliberate as to what might be the best way forward for the good of all. Finally, a fourth group will maintain that whether the outcomes are beneficial or not, that is not the point. This kind of operation contravenes religious doctrines, and while we would not wish to impose our beliefs on society as a whole, we will not allow xenotransplantation within our own religious community. These worldviews are by no means exhaustive and people may hold views which cut across divides. Resolving any problems thrown up by the science might be the major concern of the first group but these considerations would be irrelevant to the fourth group.

In an empirical study of residents in a town affected by the construction of a chemical factory, the significant component which led to resolution was trust and mutual dialogue

between experts and residents (Irwin *et al*., 1996). Openness in negotiations, local knowledge and the recognition of 'ignorance' by scientists as functional and defensible play a greater role in establishing trust than 'scientific thinking' which is often perceived by lay people as marginal to the issue (Layton *et al*., 1993). If these issues are going to be taught in school then it is important to identify what it is about these issues that students could be discussing. How should teachers across the curriculum contextualise and present them? At the very core of these issues is the nature of controversy. And in illuminating the meaning of controversy I wish to point to a way forward in proposing a framework which can be drawn upon in discussing controversial socio-scientific issues in the classroom.

Chapter 4: Towards a framework for teaching socio-scientific controversial issues

4.1 Introduction

My aim in this chapter is to probe the epistemological and pedagogical grounds for the teaching of socio-scientific controversial issues. I begin this chapter by challenging recent and current descriptions of controversy before developing an epistemological framework of controversial issues consisting of three interweaving strands. The core strand, adapted by McLaughlin (McLaughlin, 2003) is based on Rawls' descriptions of burdens of judgement and formulates nine levels of rational and reasonable disagreement extant in a democratic and pluralist society. These are called Levels of Disagreement (LoDs). In disagreements we seek to convince others of our perspectives. Such means of validation of our viewpoints are ensconced in Modes of Thought (MoTs) based on Bruner's characterisation of two modes of communicating ideas. Finally, discussion of disagreements presupposes certain rational commitments to dialogue such as respect for points of view, equality in participation and criticism. These commitments and dispositions are known as the Communicative Virtues (CVs). These three strands are mutually dependent although the particular configuration of this interdependence is related to content and context of the disagreement.

Discourse about socio-scientific issues is likely, although not necessarily, to be informed by evidence. A significant part of this chapter discusses how young people understand evidence and the role it plays in these issues.

4.2 Characteristics of controversy

The Advisory Group on Citizenship depict a controversial issue as one:

' . . . . . about which there is no one fixed or universally held point of view. Such issues are those which commonly divide society and for which significant groups offer conflicting explanations and solutions.'[50] (Crick, 1998) (p.56)

[50] Little emphasis was given to the teaching of citizenship through science in the Crick report. In paragraph 10.3, explications of controversy are given specifically for History, Geography, English literature and Religious Education. At the end of the paragraph we have 'And the sciences, technical subjects and the arts are not exempt from controversy, both about their theories and their applications

This description resonates strongly with others (Bailey, 1975; I.L.E.A., 1986; Oulton *et al*., 2004; Stenhouse, 1970; Stradling, 1984; Wales & Clarke, 2005; Wellington, 1986) Stenhouse (1970) and Stradling (1984) add that an issue is seen as controversial because it is not capable of being settled by appeal to evidence. As I will argue later this unnecessarily constrains the range of disagreements that might be subsumed in the term 'controversy'.

Crick's depiction tells us how to recognise a controversial issue through its social manifestations, a controversial issue can be identified when we see that society is divided about the issue and that different sides give conflicting explanations. Billig (Billig, 1987) offers psychological grounds: people have attitudes or stances towards an issue which is controversial, people do not have attitudes towards non-controversial issues. But people have strong attitudes towards rape, bullying and genocide. This does not make them either issues or controversial[51]. As I shall argue neither the social nor psychological depiction of controversy are sufficient for characterising controversy although they feature in capturing its meaning.

Such contemporary issues as the conflict in the Middle East, the privatisation of public services, the applications of stem cell research reflect the Crick description of controversy. But so could those issues which are often most prevalent in the tabloid media, for example who should be evicted from the Big Brother house, the acceptability or otherwise of the behaviour of high profile celebrities and arguments over the qualities of different football teams. There are social disagreements and conflicting attitudes about these. I am not suggesting we should not address these latter issues in school because they are 'sensationalist' and dominate the tabloid press, there may be good reasons why they should be discussed in school, I am indicating that neither Crick's nor Billig's description give sufficient selectivity to discriminate between those issues we should be teaching and those that we should not.

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in society'.

[51] I would not want to labour an obvious point but I find it difficult to conceive of any justified point of view other than rape is wrong whatever the situation. Killing is more contentious because I can see situations where killing another human being might be justified, e.g. when one's life or those of others are threatened.

Because they are characterised as social manifestations, attempts to describe controversial issues pre-suppose that differences are articulated and recognised by contending parties, and that these differences are open and visible. It is possible, however, to conceive of a situation where a significant group of people might keep their interchanges with the rest of society to a minimum[52], where there may be no forum for exchange of views or where they might feel intimidated by expressing their opinions[53]. Social consensus could be based around a point of view which is generally seen as commonsense[54], which an outsider perceives as deeply wrong and possibly offensive, but the means for articulating disagreement are not available to the outsider. The problems concern the dominant assumptions that are made. Examples of this in secondary schools might be a teacher or pupil sceptical of creationism in a creationist school (or a fundamentalist Christian in a class run by a teacher who robustly rejects creationism), a pupil who thinks xenotransplantation is wrong for religious reasons in a class where religious objections are perceived as anti-progressive or unscientific.

Inequitable distribution of power and cultural capital leads to differential access to the democratic structures which allow for the voicing of conflicting views (Apple, 1979; Ellsworth, 1989). There are many forms in which this lack of access can take place: online surveys might not be available to people with limited means; the arena of debate privileges those in power and militates against those who can find the time or wherewithal to take part in debate. e.g. women who are carers at home, immigrants working long hours, people not familiar with the language of the dominant group; groups might not be able to draw on the knowledge required to defend their rights. There are therefore inequalities in what is at stake for some putative participants in a controversy.

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[52] From my own experience, the clearest example are certain sects of Hasidic Jews, who fully recognise the secular institutions of the State but completely cut themselves off from broader inter-communal participation in social issues.

[53] I should add that groups within marginal sects might feel intimidated in expressing opinions because of adverse reaction from powerful parties within the sect, e.g. women in strongly patriarchal societies.

[54] 'Commonsense' itself is contentious. The radical 18th century campaigner, Tom Paine, regarded republicanism as commonsense ((Paine, 1976)something that would have enraged many Britons at that time. Gramsci saw commonsense as lack of critical thought (Gramsci, 1971)The contemporary understanding of commonsense is a view of the world shared by the majority of members of society and that is the sense of its use here. Nonetheless, common sense views carry the seeds of their own contradictions. Consider common contradictory dictums: 'charity begins at home' and 'love thy neighbour as thyself' (Billig 1987).

'Those whose bread is already secured, and who derive no favours from men in power . . . or from the public, have nothing to fear from the open avowal of any opinions, but to be ill-thought of and ill-spoken of, and this it ought not to require a very heroic mould to enable them to bear' (J.S. Mill, On Liberty, 1869)

This has a resonance for those most affected by an issue. Consider, for example, the position of a disabled person in a discussion on medical interventions to prevent future forms of a disability or a refugee in a discussion on immigration. Whether the tenor of the discussion is favourable or disadvantageous to the affected party the point is that they have more to lose (or gain) than other discussants who have no interest position.

To take at face value that evidence can have no effect on settling a controversial issue (Stradling 1984) would be to exclude the possibility of people or groups of people changing their minds when, for example, new facts become available, extant facts are explained in a way which makes them more amenable for reflection on an issue, or people have a new experience which influences their values fundamentally. For example people who support war without actually experiencing it may change their minds when confronted with the accounts of those who have suffered or the parlous consequences of war. These instances are manifestations of feelings, emotions, passions working in consort with reason. At a more trivial level, those opposed to speed cameras might change their minds if there was an irrefutable evidence-base to demonstrate that they saved lives and that no other instrument could.

But there is a need to be cautious in assessing the impact of evidence because:

1. Someone might change their mind temporarily;
2. It may be that people had no views before the evidence was made available or had not sufficiently reflected on the issue, or are simply indifferent to the issues, a salient factor when considering the teaching of controversial issues in schools;
3. Extreme situations may influence a belief but the situation may be so extreme that it cannot be considered to be representative or reliable evidence (Glover, 1977).
4. The effect of evidence on someone's worldview may 'just not be as simple as all that'.

There is a fuller discussion of the role of evidence in controversial issues later in this chapter.

Developments in biomedicine can be used to illustrate Crick's characterisation and possibly help to refine it. It is now legal for embryos to be screened for a form of inherited bowel cancer[55] which normally affects children in the early teens although its onset can be much later. Those embryos which do not possess or carry the genes for bowel cancer can be selected and implanted in the mother-to-be's womb. Announcements from the HFEA that this procedure would be legal met with both support and opposition (Leather, 2005). Justifications are the rights-based arguments for parents to have the choice of embryo selection and for future children to have a life free from disabling illnesses. Utilitarian arguments focus on the consequences of a healthier society, with the subsidiary rationale of lower costs to the health service. Those who oppose the legalisation of this procedure use arguments about the sanctity of life, the commodification of life and the creation of the person at conception.

What is it about embryo screening that makes it a controversial issue which 'commonly divides society'?. Embryo screening was not dividing large groups of people before the technology became available and may not do so in, say, five years time. The MMR dispute which caused public rifts in 2003 and 2004 (MMR: the facts, claims, realities and the unanswered questions; *The Independent*, Tuesday 24th February, 2004) is no longer commonly dividing society. There are clear pedagogic problems anticipated here because what might have been perceived as a controversy at one time might not be perceived as such at another. To justify the teaching of controversial issues there needs to be a more substantial and continuous thread which distinguishes controversy otherwise it becomes a disjointed teaching of one issue after another. Examples of controversial areas adopted by the Humanities Curriculum Project were war, education, the family, poverty and law and order (Stenhouse, 1970). While Stenhouse argues that values are embedded in controversies and that the values discussed in a controversy are specific - for example, not that war isn't desirable but what can be said of the desirability of a particular war - we still need a set of principles which link one

[55] Available online at: http://news.bbc.co.uk/1/hi/health/3970519.stm (last accessed 4th September 2006)

controversy to another. There are, as seen in the example of embryo screening – and this can be tested with other issues that commonly divide society - certain principles which are at stake, such as fairness and justice, rights, the sanctity of life, and the seeming incommensurability of principles held by different groups as inviolable. Abortion and euthanasia, two of the most prevalent subjects of controversy in schools, both entail arguments about rights and the sanctity of life. Rights and responsibilities, for example, were frequently invoked in the MMR dispute. What appears to be at stake then, are ethical principles, including the priority people place on these principles and the different interpretations given to them (Bridges, 1986), and therefore an account of ethical principles needs to have a place in any characterisation of controversial issues.

4.2.1 The role of reason

Controversy has been depicted through an account of reason (Dearden, 1981; Reiss, 1993). Dearden proposes an epistemic criterion of a controversial issue – 'a matter is controversial if contrary views can be held on it without these views being contrary to reason' (Dearden 1981) (p.38). Reason within this definition refers to criteria of truth, critical standards of verification which at any given time have been so far developed. 'What is controversial', argues Dearden, is 'precisely the truth, correctness or rightness of view, which presupposes that at least it makes sense to search for these things even if we do not attain them'. (Dearden 1981) (p.40).

The problem of establishing a precise and explicit language for concepts related to criteria for truth can be illustrated through cases in contemporary issues in genetics and science more generally. The term 'gene' has very different meanings and associations: for Richard Dawkins, the gene is a discrete unit of inheritance and human bodies are carriers of the eternal genome, 'robot vehicles blindly programmed to preserve the selfish molecules known as genes.' (Dawkins, 1976) (p.ix). How different is the concept of the gene for Evelyn Fox Keller's critique of the dominant discourse of gene action in which 'the very glow of the geneticists' spotlight . . . . . allowed neither time nor space in which the rest of the organism, the surplus economy of the soma, could exert its effects' (Fox Keller, 1995) (p.xv). These differences are important because they point to ideologies and ways of knowing which draw distinct and opposing pictures of humanity and life in general. To quote Dawkins' eloquent lines on seeing willow seeds fall outside

of his window: 'It is raining DNA . . . It is raining instructions out there; it's raining tree-growing, fluff-spreading algorithms. That is not a metaphor, it is the plain truth. It couldn't be any plainer if it were raining floppy discs' (Dawkins, 1986) (p.111). Sociobiologists and evolutionary psychologists employ a deterministic genetic discourse to make analogies between animal behaviour and human psychology, thus the 'ring-dove's rejection of already-inseminated females has a strong parallel in the frequent human insistence on virgin brides' (Barash, 1980) (p.84). This reductionist language ('raining floppy discs') about the role of genes leads us to think that it makes sense to locate genes that might be responsible for mental health problems or criminality (Herrnstein & Murray, 1996). But to a developmental biologist the role a gene plays in the system is very different, where the gene is a switching mechanism, part of a complex biochemical pathway 'in constant dynamic exchange with their cellular environment' rather than an entity determining and programming the body which carries it (S. Rose, 1998).

In discussing contemporary controversial issues, then, we are often dealing with concepts which are contentious, indeterminate and unstable – democracy, citizen, gene, disease, property (theft for a Marxist; legitimate for a capitalist), controversy – and therefore using contemporary critical standards of verification is, at the very least, problematic. Reasoning in a controversy *could* itself be a way of tentatively testing possible criteria which can be used to assess the truth of a statement but that holds only if we have a grasp of the role that reason plays in a controversy.

What Dearden's epistemic criteria fail to explain is why one might be committed to one point of view over another. If we have reasoned from a premise to a conclusion from the same evidence source then it is contradictory to suppose that another can reason to a different conclusion and be equally correct. There would be no justification for claiming our point of view in preference to another's (Gardner, 1984). If reason cannot arbitrate between different viewpoints then the consequences might be exactly as Dearden feared, a fall into a sociological carnival of 'subjective preferences' and 'epistemic relativism' (Dearden, 1981) . But Gardner's critique of Dearden is the failure to articulate what might help us weigh judgements in a controversy (Gardner, 1984).

4.2.2 Ways forward?

If we hold on to Dearden's identification of epistemic criteria for defining controversy we can attempt to extend the analysis and address Gardner's criticism by exploring the motives and attitudes of those participants who employ reason in discourse. It is not sufficient solely for an agent to be rational in a controversy there must be *commitment* to a point of view. What might commitment involve? At an everyday level we recognise people as being committed to a point of view by the strength of belief in their programme and the action they are willing to take on its behalf. Polanyi symbolises commitment as a meeting of the personal and the impersonal (Polanyi, 1973)

[personal passion ⟶ confident utterance ⟶ accredited facts] (p.303)

This model of commitment refers to the work of the scientist but it applies when discussing the social aspects of scientific controversy. The 'personal' is contrasted with the 'subjective' in that the 'personal submits to requirements acknowledged by itself as independent of itself' (p.300), the passionate search for the truth is driven by the belief of the individual but the process and outcome of that search is both constrained and scrutinised by others, and therefore accredited. All assertions of fact which stem from trying to say something that is true about a reality believed to be existing independently of our knowing it carries 'universal intent' (p.311). But having a personal belief means taking risks, it is not rational in the sense of finding 'strict criteria of truth and strict procedures for arriving at the truth' although in the end the belief will have to conform to those criteria of truth accepted as valid. Scientific discovery stems from a belief which can no longer accept conventional rationality. There are many different ways of revealing reality and the validity of that way has eventually to be universally recognised.

I think there are two levels at which we can discuss Polanyi's model in terms of controversy. At one level commitment to a point of view incorporates personal belief which eventually has to meet the criteria of rationality and communicability. It has for example to be self-consistent and truthful, commitment cannot be otherwise. But at another level it may take time for a point of view to gain credence because it is 'ahead of its time'.

Commitment introduces the element of belief and the personal and differentiates it from the subjective assertion. The nature of the belief is reflected in its universalisability and acceptance, distinguishing it from a point of view that can be rational but ultimately solipsistic. But we can say more about reason. There are values which accompany the rational being for such a being cannot be indifferent to the fate of others (Midgley, 2003). A valid reason is one which is recognised by others and which is recognised as such from a range of possible positions. Reason is not dislocated from feeling or at the very least, a sensitivity to the views of others. (Later I discuss Rawls's concept of the reasonable person where Rawls distinguishes between the rational agent and the reasonable person. For Midgley the rational person incorporates the reasonable). The reasoning person is not someone who is slave to the passions (or desires as Hume would have it) but one who feels, thinks and acts thereby refusing the dislocation of act from motive. What Midgley is questioning is the meaning of Kant's statement that the will is nothing but practical reason (p.105), and she goes on to show that Kant's conception of goodwill and its relationship to action cannot be divorced from the feelings which inform it, in other words that there is 'a special logical or epistemological connection between beliefs and feeling in the field of moral, social and political values' (Bridges, 1986).

In describing controversy, then, we can expand reason to recognise that people will enter the controversy with beliefs which are self-consistent and universalisable and that there is a motivation to act towards the participants in a controversy in a way which promotes a recognition for others based on goodwill. Such qualities might inform a commitment to dispositions such as reasonableness, reciprocity, truthfulness, equality and respect, a willingness to learn from each other and an openness to another point of view such that one might be affected by it (Bridges, 1979). The nature of commitment as expressed by Polanyi seems an extraordinarily high hurdle to jump for people to be seen to be engaged in a controversial issue but if we take the first level of self-consistency this could constitute a necessary condition. It follows from this characterisation that taking part in a controversy is a deliberative act and the participants, in this case we are referring to secondary school students but it would be true of everyone, might need to be educated to fulfil those basic requirements.

It may well be unproductive to attempt an overarching definition of a controversial issue; insights into the constituents of any controversy could be gained by examining a range of conflicts or disagreements. Identifying different levels of disagreement will locate more specifically those concepts, procedures and pedagogic approaches which are entailed when discussing socio-scientific issues and 'controversial issues' more generally. If controversy and controversial issues are to be justified and taught in schools an epistemological framework can make explicit to students those structures which are both common to and underpin all controversies.

4.3 Epistemological frameworks

There are three main interconnecting strands which I have drawn on to characterise controversy based on a liberal perspective of pluralist democracies. These are:

1. Levels of reasonable disagreement (LoDs),
2. the communicative virtues (CVs) or dispositions necessary to engage in reasonable disagreement and,
3. the modes of thought (MoTs) and experience which can best illuminate those disagreements.

4.3.1 Levels of disagreement

In developing a description of 'reasonable disagreement' in a pluralist democracy Rawls draws on the complementary nature of rationality and reasonableness. It is entirely possible, argues Rawls, that an agent can be rational but unreasonable. For example, an employer might summarily dismiss a loyal and long-serving workforce on the rational grounds of immediate profitability. Although rational agents may weigh evidence and make logical inferences from the available data they 'lack . . . . the particular form of moral sensibility that underlies the desire to engage in fair co-operation . . . ' (Rawls, 1993) (p.51) and it is this moral sensibility that we encounter in reasonable people. This view is consistent with Midgley's conceptualisation of the rational person in section 4.2.2

A functioning liberal society depends on an 'overlapping consensus' (Rawls, 1999) where reasonable comprehensive doctrines are affirmed by its citizens. Nonetheless, it is in the nature of a democratic pluralist society that disagreements regularly occur

within and despite this consensus[56]. The idea of a reasonable disagreement, as opposed to disagreements based on prejudice or *ad hominem* accounts, involves 'an account of the sources, or causes, of disagreement between reasonable persons' (Rawls, 1993) which Rawls calls 'burdens of judgement' – the hazards in the correct exercise of our powers of reason and judgement in the course of political life. Drawing on Rawls' burdens of judgements, and levels of controversy from Dearden and Bridges (Dearden 1981; Bridges 1986), McLaughlin has formulated nine non-exhaustive levels of reasonable disagreement (McLaughlin, 2003). Using McLaughlin's descriptions I have added to examples of these levels, the role of evidence and social dimensions. (See Table 4.1).

[56] It is also within the nature of a pluralist society that that there might be disagreement as to whether such a society is desirable, and ultimately, whether it should exist.

Table 4.1 Levels of disagreement
[57]

Level	Formulation	Examples	Role of evidence	Social dimensions
1	Where insufficient evidence is as yet available to settle a matter, but where such evidence could in principle be forthcoming at some point	• Explanation for death of the dinosaurs • Is X likely to develop Huntington's disease? • Is xenotransplantation free from retroviral infection? • Has there been a global rise in temperature since the Industrial Revolution? • Predicting the change in the size of a current when the configuration of a circuit is changed.	Criteria for evidence to be met are set out beforehand and agreed by all parties. Evidence is usually unambiguous and is consistent with the terms of the criteria. The likelihood of developing Huntington's can be confirmed by an unambiguous genetic test. Principles of verification and falsification can be applied.	Differences between parties beforehand about their judgements relating to the matters at stake but evidence should settle differences. Ethical principles are involved in aspects of the matters at stake, eg in the decision to inform someone that they are likely to develop Huntington's, but there is agreement about how the matter can be settled.
2	Where evidence relevant to settling a matter is conflicting, complex and difficult to assess.	• What is the acceptable risk of the transmission of disease as a result of the after effects of xenotransplantation? • Which factors are responsible for the pollution of a local river? • Which is the best drug for reducing the risk of heart disease? • Does the use of 'green' fuels reduce carbon dioxide emissions?	Criteria can be agreed but it is difficult to assess whether evidence meets the criteria because of the nature of the evidence and the problem. For example, acceptable risk may be estimated differently in different countries depending on cultural and economic factors. One drug might be effective for a certain group of people while another might be better for other groups. The evidence might also be too complex to be understood by non-specialists.	Differences between parties beforehand about both their judgements about the matters at stake and about their view about the status of different kinds of evidence. There could be consensus that evidence has not resolved the problem but acceptance that one might have to wait for better quality evidence or a willingness to re-frame the problem to meet the requirements of the available evidence.
3	Where the range of criteria relevant for judging a matter are agreed, but the relevant weight to be given to	• It is agreed that both the future health of the patient and the risk of infection are both matters to be taken into account for a xenotransplantation but there are	All parties might agree that the evidence is the best available but the evidence cannot necessarily influence the decision because of different weightings influenced by	Differences between parties before availability of evidence. Only likely to be consensus if contending parties agree that the evidence eventually produced is convincing in prioritising one form of

	different criteria in a given decision is disputed	differences as to whether the patient's health takes priority over the risk of infection. This influences the decision as to whether the operation should be carried out. • A local government authority agrees it must take action to reduce pollution but there are differences as to whether the emphasis should be put on energy conservation or encouraging residents to set up solar cells.	such factors as costs, culture, interest group. There is a possibility that better quality evidence might influence a decision but this cannot be guaranteed.	action over another, e.g. evidence shows that risk of infection from a xenotransplantation, under properly monitored conditions, is negligible.
4[58]	Where a range of cherished goods cannot simultaneously be realised, and where there is a lack of a clear answer about the grounds on which priorities can be set and adjustments made	• The separation of conjoined twins where the parents objected to the operation on grounds of religious and personal conviction even if it meant the death of both children. The decision of the judiciary was that the operation must be carried out to safeguard the life of one of the twins. The operation resulted in the death of one of the babies but almost certainly extended the life of the other. Although the judgement was made the precedents and guidelines were not without ambiguity[59]. • Pre-implantation genetic diagnosis (PGID)is not acceptable to certain groups because of the necessary destruction of embryos even where a child's life is at stake.	The evidence is often irrelevant because of fundamental ethical differences in the premises. Some cases may be susceptible to change through evidence.	Issue might be resolved by a legal judgement but the disagreement itself is not resolved by that judgement. Parties may simply refuse to talk to each other although all might recognise the tragic nature of a case. Proponents of PGID, for example, might recognise that an embryo must be treated with respect when it has been destroyed. Equally, those opposed to PGID might recognise the consequences of refusing this treatment. What might have united contending parties re-the conjoined twins was the realisation that one or both twins would die.
5	Where the range of	• It might be broadly agreed that	Evidence can have only a limited,	There is usually a conversation

[59] Available online at: http://www.guardian.co.uk/uk_news/story/0,3604,372028,00.html (last accessed 28th June 2006)

	criteria relevant for judging a matter are broadly agreed, but there is dispute about the proper interpretation of a criterion or criteria, given the indeterminacy of many concepts	immigration should be controlled but there are disputes about what constitutes a legal or illegal immigrant, or disagreements about what constitutes a liberal society. • Differences of interpretation over the term 'rights' where some claim PGID gives children the right to a life free from pain while others argue that embryos destroyed in the process are being refused the right to life.	if any, bearing on resolving the disagreement. Until the concepts are clarified or agreed upon viewpoints cannot be vindicated by the evidence.	between the parties but the disagreement is unlikely to be resolved quickly if at all, especially if the clarificatory terms are avoided.
6	Where there are different kinds of normative consideration of different force on both sides of an issue, and it is hard to make an overall judgement.	• Employees at a nuclear power station see their jobs at risk even though there is evidence for a cluster of leukaemia in young children. It is difficult to make a judgement on reasonable grounds whether it is right to close down the power station	As in category 2 the evidence is complex and difficult to assess and could be interpreted differently by both sides.	Both parties feel there is a lot at stake. There is likely to be a conversation between contending parties but resolution of the disagreement is unlikely.
7	Where there is disagreement about the criteria relevant for judgement.	• This could be subsumed by category 9 below.		
8[60]	Where the differing 'total experiences' of people in the course of their lives shapes their judgements in divergent ways	• Someone who has seen a sibling die from a genetic disease might be more likely to draw on that experience in supporting pre-implantation genetic diagnosis than someone who opposes this technique. This divergence is illustrated in the video 'The Gift' produced by ytouring[61].	Where evidence is available parties incorporate the evidence into the worldviews which stem from their experiences.	Parties might be asserting prejudices based on their own contexts of living but there might also be a telling of stories which illuminate the judgements people make.

[61] Available online at: www.ytouring.org (last accessed January 22nd 2007)

		• Someone who has suffered from flooding attributed to climate change brought about by carbon emissions differs in their interpretation of climate change from an oil company executive who might point out the complexity and unreliability of the climate change models used (see also category 2).		
9	Where there is no agreement about whole frameworks of understanding relevant for judgement	• Fundamentalist creationists work from different premises and use different truth criteria from evolutionists to establish their claims; • 16th century adherents to the Earth-centred universe confronting Galileo's heliocentric model.	Evidence is either completely irrelevant, or in a Kuhnian sense so linked to the theoretical framework that it cannot be translated to another framework or paradigm.	Parties are unlikely to find any common ground to pursue dialogue. This might result in further conflict, agreements to differ, complete absence of communication or a combination of all three. Parties could make an effort to at least listen to each other but they might find the discourses used incompatible and uncomprehended by contending parties.

The nine levels represent a broad gradation in level of disagreement; level 1 lends itself to processes of verification or falsification through the use of evidence (Popper, 1972) whereas in level 9 the premises for contending beliefs or arguments are incommensurate and evidence is linked to incompatible theoretical frameworks or distinct paradigms (Kuhn, 1962). These levels reflect whether people are attached to the same or different values; differences in priorities about the same values (xenotransplantation may be the only method to cure a patient's heart disease but should the patient's life take precedence over an unknown risk of infection; consensus in a local community about the deployment of wind farms as a means of reducing burning of fossil fuels but differences arise over location and cost; agreement about the disposal of nuclear waste but is vitrification the safest means of disposal?); different interpretations about an issue (people might agree about a xenotransplantation but interpret risk factors in different ways), different perspectives from interest positions (sufferers from a genetic condition have more at stake when a treatment becomes available than disinterested parties) and different frameworks of understanding.

4.3.1.1 The nature of evidence

I will focus on evidence as incorporated within the first two levels of table 1 because empirical evidence is central to science. As a very rough rule of thumb evidence is the information needed to help answer a question, whether in the form of a speculation or established theory, based on gathering data and making measurements. But the collection, analysis and evaluation of evidence rests on deeper understandings of the nature of science. How can the data be interpreted to distinguish between causation and correlation? Men with moustaches appear to record significantly higher levels of anxiety than men without moustaches. Is the relationship between men with moustaches and levels of anxiety correlative or causative? (Dunbar, 1995) We use evidence in school teaching for illustrative and investigative purposes: to illustrate theoretical concepts, for example, Newton's Laws of Cooling, the oxygen theory of combustion or the structure and organisation of cells. I will start with illustrative purposes to demonstrate the inherent complexity in understanding the concepts of evidence.

In attempting to verify the Law of Cooling[62], students might be given identical containers with equal volumes of water at different temperatures and measure the temperature drop against time comparing the rate of fall of temperatures of the containers. In so doing students are making a number of assumptions:

- one of the instruments used to make the measurements assumes that the change in volume of mercury is directly proportional to the rise or fall of temperature and that change of volume in turn is directly proportional to the change in length of mercury in a capillary tube on the thermometer;
- that the two instruments, the thermometer and the timepiece, are accurately calibrated;
- that taking more than one reading increases the accuracy of the data;
- that no two readings can be the same (there can never be exact repeatability);
- that the measurements can be recorded on to a graph in which time is the independent variable and rate of fall of temperature is the dependent variable;
- to understand that a straight line of rate of fall of temperature against difference of temperature between the body and its surroundings illustrates Newton's Law;
- to ignore outliers or anomalous data on the graph.

It would also be possible to consider how the evidence which gives support to the theory is built up in much more detail from the data by considering fair tests, sampling, range of measurements and so forth. The point is that there are many aspects to be learned about the nature of evidence before students can understand the relationship between evidence and theory.

The gain in mass of the solid when magnesium burns in air is explained within the framework of the oxygen theory of combustion. As many chemistry teachers will know to their cost this is a notoriously unreliable experiment where the product of the burning often has a smaller mass than the reactants. Unless the experiment is very carefully carried out so that none of the ash of the product is lost, the evidence in the hands of school students can provide a refutation of the theory. Because the means of gathering evidence for experiments in schools is often so prone to error teachers often resort to 'rigging' or 'conjuring', adjusting the evidence to fit the theory (Nott & Wellington, 1997;

[62] For a body cooling in a draft the rate of heat loss is proportional to the difference in temperatures between the body and its surroundings

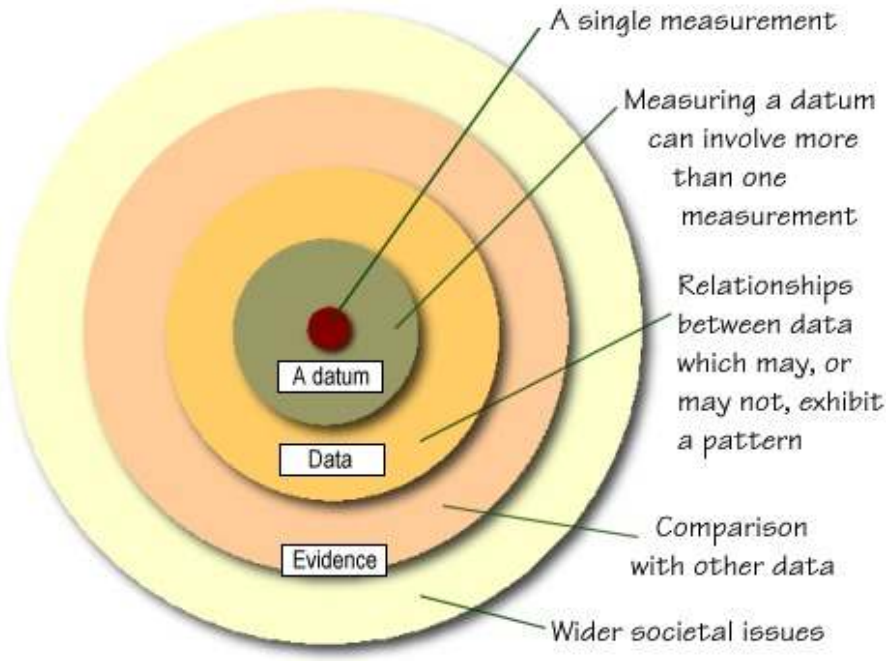
R. Smith & Nott, 1995; Wellington & Nott, 1995). The evidence therefore only has meaning in terms of the theory. This is even more convincingly the case when students are asked to draw the cells of an onion under a light microscope. If students have not been taught the structure of the cells beforehand they simply do not see them and draw blobs and artefacts (Kress, Ogborn, Tsatsarelis, & Jewitt, 2001).

But the interpretive tasks confronting school students in making sense of evidence for investigative purposes, for example whether organic foods are healthier than non-organic foods, which do not fit pre-defined models or theories is more complicated because the "solution" is 'not obvious' (Gott & Duggan, 1995; Tytler *et al*., 2001); evidence is stretched beyond warrants for substantive science, for example it is deployed in weighing judgements which draw on competing interests (Ryder, 2001). Where science is accepted and part of the canonical body data is used as a tool to illustrate the theory; where investigations are being carried out in a local context to find the solution to a problem, e.g. what appears to be the source of pollution of a watercourse, these are data-led, theory following the data (Tytler *et al*., 2001).

What has been discussed so far points to a 'body of knowledge' in the understanding of scientific evidence which has been incorporated into Concepts of Evidence where the comparison of data sets in a specific scientific and social context constitutes evidence (Gott, Duggan, Roberts, & Hussain, 2006)

Figure 4.1: Concepts of evidence

(fromhttp://www.dur.ac.uk/richard.gott/Evidence/cofev.htm)



Some of these concepts I have already referred to above such as underlying relationships between variables and measurements, calibration and accuracy. But they also include concepts relating to *societal issues*, those factors which assist us in arriving at a judgement once we have considered the available evidence and have particular significance for teaching socioscientific controversial issues. These include: *practicality* which might help us to prioritise one course of action over another such as whether the costs of a treatment can justify the number of people who might benefit (an interaction with level 3 in Table 4.1); *bias*, such as inspecting the motives behind interest groups promulgating a particular source of evidence (an interaction with level 6 in table 4.1); *power structures*, where evidence might be accorded undue significance because of the influence of bodies supporting the evidence; *acceptability*, where public and media prejudice can interfere with the acceptance – or possible refusal - of evidence in the public domain (for example the dispute over MMR and its link to autism, the environmental costs of air travel) and *status* which is related to power where scientific authority 'may influence the weight which is placed on the evidence' (Gott *et al*., 2006).

4.3.1.2 Young people's models of evidence

In listing the concepts necessary to gain a full understanding of the role of evidence we also need to understand how young people model evidence. Kuhn *et al*'s work suggests that the deployment of evidence in making decisions can be generalised from specific contexts, conceived as a transferable thinking skill, and that young people are not very good at it. They also found that the ability to represent and evaluate evidence increases with age (D. Kuhn, Amsel, & O'Loughlin, 1988). The contexts of the questions in which young people were asked to link data to theory were based on everyday experiences such as what kind of food makes it more likely that people will catch a cold. But these are cases in which children are likely to draw on the kinds of knowledge with which they were familiar from their everyday experiences rather than the data with which they were presented (Brickhouse, Dagher, Shipman, & Letts IV, 2000; Driver, Leach, Millar, & Scott, 1996). Conclusions about the ability of young people to use evidence in a range of contexts needs to draw on cases where they have to use given data to examine a new problem rather than where they can draw on data from informal everyday experience.

That thinking about evidence is domain-general and age specific has been challenged by a number of researchers (Samarapungavan, 1992; Vosniadou & Brewer, 1992). Samarapungavan's work (Samarapungavan, 1992) demonstrates that young children's (aged 6-11 years) range of explanatory power, non-adhocness of explanation, empirical consistency and logical consistency in making theory choices are sound but that children's reasoning can be accounted for by their 'developing understanding of concepts in distinct contexts' (Driver *et al*., 1996); the way they co-ordinate evidence with theory is domain-specific.

Domain-specificity in the ways students provide warrants in the form of evidence for beliefs in particular theories is consistent with other research. In a study of students on a university astronomy course Brickhouse *et al* (2000) found that the nature of the warrants provided was embedded in the specific science content. Thus when talking about gravity students tended to talk about gravity as the phenomenon – 'gravity . . .isn't a theory. It's a measurement . . . ' (p.16) rather than the theory and its supporting evidence. On the other hand natural selection was conceptualised as a theory and

students were able to separate the explanation from the evidence that supported the theory.

Driver *et al* (1996) found that consistent use of evidence with theory and explanation increases with age but young people's views on the nature of scientific knowledge range from little distinction made between evidence and explanation to a view of scientific knowledge consisting of theoretical models which can be evaluated in light of the available evidence. The research found, however, that students tended to have a naïve inductivist view of the link between evidence and theory, that 'facts' could be put together through scientists working in isolation to find the truth. 'Evidence seems to be regarded as "information" or "facts", which tell us "how things are", rather than as raw material for conjecture about "how things might be" (p.132). As I will discuss in Chapter 6 teachers' views of data or facts in teaching socio-scientific issues mirrors students' views to some extent.

How evidence validates knowledge claims is central to the strength of an argument in any disagreement and must comprise part of the process in the use of evidence in level 2. Research based on Toulmin's argumentation pattern (Toulmin, 1964) has drawn on empirical studies to examine the link between data and claim and how warrants and rebuttals can strengthen an argument (Simon, Erduran, & Osborne, 2006). These studies look at how effective young people are in providing plausible evidence and reasons for concepts taught in the school curriculum (Osborne, Erduran, Simon, & Monk, 2001) including socio-scientific issues (D. L. Zeidler, Osborne, Erduran, Simon, & Monk, 2003). But the focus of this research is on the structure of the argument rather than people as arguers, a socio-cultural concept of dialogical rationality which I shall develop. How people use arguments in everyday conversation is socially situated, some parts of the conversation may seem meaningless when read, or even heard by an outsider, but might involve social positioning and signs developing from the relationship between the actors in the conversation (Wertsch, 1991), and therefore defy categorising in an analytic model[63]. Where the emphasis is on relating argument to a model there is

[63] A possibly trivial example was on a project on healthy foods I was working on a few years ago. When asked about school meals a few children said 'School meals are rubbish'. The teacher asked them to give facts not opinions but the children thought that statement was a fact from which no other pupils dissented. They all knew what was meant by 'School meals are rubbish'. Any qualification or rebuttal would have simply seemed absurd in that context.

also a danger of under-estimating truth claims and rationality at the expense of a range of warrants and rebuttals (Erduran, Simon, & Osborne, 2004).

To summarise, the ability to use evidence effectively involves an understanding of the concepts of evidence, evidence is theory-linked and young people generally model evidence unevenly. Age and context of the task is related to the ability to model evidence. But what role does evidence play in contemporary socio-scientific issues?

4.3.1.3 Evidence and contemporary socio-scientific issues

One of the problems in understanding evidence in relation to contemporary socio-scientific issues is that understanding evidence involves complex statistics, assessment and evaluation of evidence – validity, reliability, accuracy, precision, empirical consistency – as well as the logical processes in which inferences are made from the available data. In addition to this theories are in the process of formulation and much of the evidence available is uncertain and tentative, it is science-in–the making (Shapin, 1992). Millar identifies common features associated with contemporary scientific issues: there is disagreement amongst experts; incomplete data; the data is often drawn from a range of technologies; the data in the field is often messy, that is, it is sometimes impossible to control variables as can be controlled in laboratory conditions; the data is often localised and cannot necessarily be generalised to other contexts; sophisticated computer modelling is commonly used which involve probability factors and assumptions which are a matter of expert judgement (Robin Millar, 1997). But in science-in-the-making the developing concepts often go well beyond, and contradict, the consensual science which appears in school texts. Thomas (2000) discusses how the 'prion hypothesis', favoured in explaining the role of the infectious agent in BSE and nvCJD, reverses the central dogma of information transfer in the direction from DNA to protein whereas school textbook knowledge has information going in one direction from the DNA in the nucleus[64].

In a wide-ranging literature review Ryder (2001) also shows how school science is inert in providing the necessary evidence to support personal decision-making. Despite this

[64] This situation has now changed from when I first wrote this sentence, for example the Salters Nuffield Advanced Biology course

the need for scientific knowledge of some kind for all to help in decision-making and to sustain democracy has been prominent in scientific literacy discourse. Statements emanating from policy or scholars link science content knowledge in some form to decision-making. Hence the need for ‘a healthy and vibrant democracy . . . (which) can engage critically with issues and arguments which involve scientific knowledge’ (R Millar & Osborne, 1998) (p.2004). Hurd's list of attributes for a scientifically literate person includes the use of 'science knowledge where appropriate in making life and social decisions, forming judgements, resolving problems, and taking action.' (Hurd, 1998) (p.413). For Fourez people could be considered scientifically and technologically literate when they possess the proper knowledge and skills to have a 'certain degree of control and responsibility in dealing with specific (technical but also emotional, social, ethical and cultural) problems.' (Fourez, 1997).(p.51)

Debate about the problematic role of science in the curriculum has stemmed from its perceived authoritarian role in society[65], the certainty that scientific evidence is deemed to provide, the privileged status of science as a subject in the school curriculum (Bernstein, 1977; Koulaidis & Tsatsaroni, 1996) and the logico-positivist stance of science teachers (van Aalsvoort, 2004). Scientific knowledge, therefore, carries with it a received credibility and authority although contemporary scientific evidence most closely linked to socio-scientific issues is tentative, uncertain, ambivalent, contentious and subject to multiple interpretations.

Even where relevant knowledge can be drawn from the school science curriculum it does not follow that the science learned in school can be transferred unproblematically to a context in which it appears to be relevant. Socially situated knowledge is mediated by factors which transform the way in which the knowledge is used (Aikenhead, 2005; Irwin *et al*., 1996; Layton *et al*., 1993). This does not mean that canonical knowledge is unimportant in terms of personal or social decision-making but that it is one component of a process of transformation.

A range of studies supports the view that there is no necessary link between knowledge of school science and understanding the nature of evidence in socio-scientific issues (C.

[65] From a memorandum submitted by Dr Jerry Ravetz to The House of Commons Science & Technology Committee, *Science Education from 14-19*, Third Report of Session, Volume II, Ev 109

Dawson, 2000; Dori & Tal, 2000; Kolstø, 2000; Kolstoe, 2000; Roth & Désautels, 2004) although others have demonstrated that people with a sophisticated and deep knowledge of science do use their knowledge in providing evidential warrants for scientific claims (T. Sadler & Zeidler, 2005; Tytler et al., 2001).

4.3.1.4 How people use evidence in decision-making on socio-scientific issues

While it may be difficult for young people and lay people to interpret evidence in complex science-related issues this does not make their evaluation of evidence redundant in controversial issues. Kolstø (S. Kolstø, 2001) draws the distinction between scientific evidence – public, intersubjective and open to validation - compared with local, lay, informal or anecdotal evidence. Anecdotal evidence, however, can be vitally important in bringing to light local and intractable data which the formal generalised models of scientists cannot account for (Irwin *et al*., 1996; Layton *et al*., 1993; Wynne, 1991); it has the capacity to act as 'bridging' evidence between technical assertions and personal, social and political understandings (Tytler *et al*., 2001). Anecdotal evidence can be conveyed in the forms of stories and experiences told by lay people. Imagine that new equipment has been constructed in a park for children where testing and logistics have been taken into account. After a few months the parents and children report that their children do not seem happy with the equipment. Technical experts might find nothing wrong with the equipment in terms of physical measurements but there may be other aspects such as where parents sit in relation to the equipment or the 'fun' of equipment going wrong which affects children's enjoyment.

Affect such as emotion, happiness, feelings constitutes a data source as Aikenhead (2005) found out in his study of the way nurses use evidence to make judgements. He has identified four factors: a datum collaborated by other data, perceived trends in data, consistency or inconsistency between data and its context and emotion-related observations as evidence (Aikenhead, 2005). These last include nurses' interactions with patients when establishing a relationship, such as knowing the circumstances when a patient feels uncomfortable. Identifying affective factors as a component of context-based evidence means that aspects such as sensitivity to others can be used to evaluate the quality of evidence. As I shall discuss in Chapter 6, sensitivity and respect are dispositions or communicative virtues which teachers value in lessons on

controversial topics and opens up an opportunity to yoke dispositions and feelings to more formal scientific evidence in supporting knowledge claims.

Science-in-the making is more vulnerable to a range of competing pressures and therefore more explicitly value-laden (Bauer, 1997; Longino, 1983). Bell and Lederman (Bell & Lederman, 2003) found that while highly educated adults with strong scientific backgrounds considered the evidence in socio-scientific decision-making they foregrounded personal and social concerns. People might be emotionally resistant to change even when the evidence is compelling (Cooper 1983; Claxton 1991). A range of research suggests that there is a tendency to incorporate evidence which is consistent with prior beliefs and ignore evidence which is inconsistent (Claxton, 1991; Cooper, 1983; Kinsey & Wheatley, 1984; Phillips & Norris, 1999; T. D. Sadler, Zeidler, & Chambers, 2004; J. Thomas, 1997; Yang, 2003; Yount & Horton, 1992; D. Zeidler, 1997). Students who had enrolled for an Open University second level course, *Science Matters*, were asked to complete a questionnaire outlining their views on the issues. After they had studied the course they were again asked for their views. Scientific evidence had done little, if anything to change people's minds (Thomas 1997). On the contrary, students had incorporated evidence selectively to bolster their views (Kinsey & Wheatley, 1984; Yount & Horton, 1992).

Evidence can be epistemologically oriented in the light of different interest positions (Geddis, 1991). In the acid rain controversy between the United States and Canada, the Canadian view was that the main source of acid rain came from the Ohio Valley; however the Americans demanded greater certainty before being convinced that their power plants were the source of acid rain. Established 'facts' for the Canadians were not perceived as such by the Americans, 'epistemology interacts with the interests of the stakeholders' (p.180). Evidence in socio-scientific issues is value drenched. Using the same facts Linus Pauling and Edward Teller gave different accounts of the predicted deaths from radioactive fallout from the testing of an atomic bomb. Pauling gave the absolute number of deaths likely to occur whereas Teller expressed the shortening of average life expectancy compared to that caused by smoking (Layton, 1986). Consideration of the role of evidence in a controversy cannot be divorced from other levels of disagreement where experiences 'shape judgements' and where groups differ in their priorities which are underpinned by value considerations.

Trust in experts also features in the evaluation of evidence (Bell & Lederman, 2003; Yang, 2004) in young people and adults. While high school students show 'little interest in empirical evidence underpinning knowledge claims' (S. D. Kolstø, 2001) they expressed trust in figures and agreement amongst researchers. Trust has also featured strongly in the relations between lay people and experts in the management of risk in technology (Earle & Siegrist, 2006; Siegrist & Cvetkovich, 2000) and when dialogue between science experts and lay people has underpinned attempts at resolving a dilemma. Trust presupposes dialogue which emerges in a more robust form as a result (Irwin *et al*., 1996; Layton *et al*., 1993; Wynne, 1991).

4.3.1.5 Implications for pedagogy and levels of disagreement

What should then be taught about evidence to young people to help illuminate dilemmas, disagreements and differences in science-related issues? In view of the way young people use evidence a number of authors and authorities have focused on 'explicit teaching of procedural understanding related to data and evidence' (Duggan & Gott, 2002). To make room for this will mean a reduction in conceptual content.

One of the strengths of the levels of disagreement is that it makes particular dimensions of a controversy explicit. (Although I point to focusing on a particular level of reasonable disagreement we can still see its interrelationships with the controversy as a whole). In light of the research I have discussed, use and evaluation of complex evidence such as that which is likely to feature in all socio-scientific controversial issues, will draw in other levels such as prioritisation and interest groups (table 4.1), as well as emotion. There are two qualifications I would consider necessary for the framework if it is to prove amenable to any analysis of, and support for, classroom pedagogy. The first is to support the understanding of procedural concepts in science by identifying those concepts of evidence linked to the context of a particular issue. For example in an analysis of case studies, the concepts of evidence used in deciding on the location of a mobile phone base station were measurements, significant difference, risk and validity whereas in personal decision-making about immunisation, 'incidence of disease, efficiency of the vaccine in preventing disease, validity of reports about risk' were prevalent (Duggan & Gott, 2002) (p.672). This selection of the relevant concepts of

evidence will be a complex process in itself because it will be difficult to anticipate in advance what procedural concepts and evidence will need to be highlighted. Perceptions and the local contexts of stake-holders as decision-makers will influence those factors which are most important. In a case study of the attitudes and beliefs of a protest group around the siting of a mobile phone mast, members of the local community were concerned less about the health risks posed by the mobile phone masts than about who is responsible for controlling that risk (Drake, 2006). Societal concepts predominated over other concepts such as the validity of the measurements of the microwave radiation from the base line transmitting stations. It would be a case of overkill to amass a database which identifies all the concepts of evidence to evaluate in different contexts but selective studies which provide rich background contexts and data for studying particular issues would help teachers highlight those procedures which are used both in illuminating an issue and in decision-making.

The second qualification is that focusing on evidence as a separate level contradicts research on how parties evaluate factors such as the impact of personal and group interests, or how contending parties draw selectively on evidence to support their arguments. This is not to dismiss the utility of the levels. Evidence is the explicit focus of study. This would be true when discussing the other levels of disagreement; focus on separate levels does not mean that other levels are excluded but understanding how they interplay with the explicit level being considered.

4.4 Communicative virtues

Reasonable disagreements presuppose personal dispositions, for example, being amenable to reason and respect for the point of view of others (Bridges, 1979). Where people or groups do understand each other as having rationally justifiable but competing modes of enquiry this is in itself an indication that at some level the contending parties agree on more than they disagree about (Billig, 1991; MacIntyre, 1988), that they are willing to engage in dialogue and recognise the proprieties of reasonable engagement, the agreed content of the disagreement and that the nature of the differences can be enacted best through dialogue.

4.4.1 Dialogic rationality

Dialogue is central to the operationalisation of reasonable disagreements. As a working definition dialogue is a reciprocal conversation between two or more people, a 'verbal interchange of thought' (Shorter Oxford English Dictionary) although the meaning of dialogue is historically located; the origin of the word is from the Greek *dialogos* meaning 'conversation'. Plato's Socratic dialogues aim to reveal absolute and timeless truth through example and counter example in disputatious arguments (Billig, 1987; Burbules, 1993). As a means of revealing contradictions and understandings the Socratic method is used in schools both in teaching and for parliamentary style debates.

As sites of cultural reproduction schools perform an important role in initiating and developing talk in children (Barnes, Britton, & Torbe, 1986). Our ability to think is dependent on talk and dialogue. Participation within the classroom forms the democratic bridge between the private and public spheres (Dewey, 1916). The reciprocal nature of talk in the classroom in the development of children's thinking is the basis of 'dialogic teaching' and the work done in the Oracy project (Alexander, 2006; Mercer, 1995).

Dialogic rationalism is 'interaction between people' (Myerson, 1994), reason is the criterion where 'people relate to others in a worthwhile way, particularly to those with *different views'* (p.31, my italics). There are differences in theoretical approaches to dialogic rationalism, and I shall briefly summarise contrasting theories although these are overlapping.

In linking rationality to dialogue Habermas intends rescuing rationality from the negative instrumentalist connotations of modernity where reason based on ends-means premises reflects the economic functionalism of modern industrialist societies (Dunne, 1993). Where reason has served the ends of capitalist production, rationality can become transformed through human interactions. The driving purpose of communicative interaction for Habermas is consensus where reasonable people strive to reach agreement. The truth of claims emerges from the argumentative drive towards consensus, the engagement and re-evaluation of one's viewpoints. The achieved consensus is the 'foundation of a good society' (Myerson, 1994) (p.9). Engaging in rational dialogue presupposes that people have knowledge, but argument is more about how 'speaking and acting subjects acquire and use knowledge' (Myerson 1994) (p.2). In

acquiring information or evidence relevant to a disagreement participants will have to act reasonably and co-operatively; possession of facts does not necessarily translate into rational action. Rational people hold their views open to criticism and are prepared to justify their views (Myerson, 1994).

There are two problems with Habermas's position which I wish to highlight: the drive towards consensus and the marginalisation of emotion. Where Habermas conceptualises dialogic rationality as the transformation from argument to agreement, Putnam holds from a pragmatist perspective that differences cannot necessarily be resolved through argument (Myerson, 1994). Different contexts of dialogue will have different criteria of rationality so there cannot be an ideal rationality. But there are basic virtues of conduct which participants will have to demonstrate in rational dialogue, namely that one's basic assumptions have wide appeal, the ability to withstand rational criticism and a morality that should be liveable, that is the rational is never divorced from human experience, values of justice and consideration for others. (Putnam, 1981).

Emotion and trust are the preconditions for dialogic rationality in Giddens' scheme. ' . . .Sensitivity and tact . . . balance of openness, vulnerability' (Giddens, 1992) (p.94) encourage dialogue. Dialogue, trust and autonomy underpin democracy. It seems strange to include autonomy where romantic love, the intimacy between partners, is the ideal relationship for Giddens, but true autonomy is expressed through self-awareness which can only come about through good inter-relationships. 'How individuals might best determine and regulate the conditions of their association is characteristic of virtually all interpretations of modern democracy' (Myerson, 1994) (p.67) (citing Giddens).

The dispositions which support the kinds of dialogues addressing reasonable disagreements have been termed 'communicative virtues' (Burbules & Rice, 1991) and are those dispositions necessary to attempt 'dialogue across differences'. These can be seen as 'a cluster of intellectual and affective dispositions that together promote open, inclusive and undistorted communication' (Rice & Burbules, 1992) (p.37). Bridges has similarly described necessary dispositions to communicate across differences. Examples are:

1 *Procedural actions*: there is agreement about rules of conduct, for example allowing people to speak in turn,
2 *Moral obligations*: there are expectations that people will speak the truth reflecting what they mean and that discussants are held to an obligation to speak the truth,
3 *Freedom*: participants are not subject to any constraint which prevent them from stating their opinions,
4 *Equality*: people believe they have something to learn from everybody,
5 *Respect*: there is respect for persons where any discussion is underpinned by certain moral values so that participants will be engaged in the protection of those values. Such a discussion, for example, will not involve respect for persons if a participant is abused because of ethnic origin, physical appearance and so forth[66], and
6 *Openness*: participants are open in that they are prepared to be swayed by the other's point of view if it is sufficiently persuasive (Bridges 1979).

These communicative virtues range from cognitive features such as the obligation to be critical (and respectful) of one's interlocutor to more affective ones such as sensitivity to feelings. Communicative virtues such as the necessity of peer review, criticism encouraged by competition among scientists and organised scepticism are embedded in the academic science community (Ziman, 1980).

Which communicative virtues are deployed depends on the context of the discussion but there will be certain situations when the freedom to say what one wants might not be appropriate, for example, when making racist or sexist comments. An opinion of this nature would contradict the principle of respect. There might also be situations where the requirement for patience is no longer an attribute when, for example, someone persists in advancing a point of view when others have agreed to move on. Moreover, the principle of respect presupposes a willingness 'to recognise calls for justice from those both differently situated and whose speaking styles are different too' (Enslin &

[66] It would follow that although race in society would constitute a controversial topic someone with a racist viewpoint could not take part in a controversy. However I think the point is that someone intending to articulate a viewpoint which could be interpreted as racist would have to enter the controversy with the will (and its constitutive internal feeling) to have their viewpoint contested and to be open to being affected by alternative viewpoints.

White, 2003) (p.117). These virtues are not, therefore, a set of rules, but 'other things being equal, relations that are expressive of these virtues will be supportive of the numerous and varied goods we can achieve communicatively' (Rice & Burbules, 1992) (p.38).

In section 4.2.2 I raised the idea of commitment as essential to taking part in a controversial issue. A class of students can superficially take part in a controversial issue without having any particular commitment to the issue itself, let alone a point of view. Unless students have an interest in an issue which they are committed to illuminating or resolving together in a climate of goodwill then the process is cosmetic and will not satisfy the conditions for taking part in the controversy. Students need to be intrinsically motivated to take part which will invoke the teachers' knowledge and understanding of the kinds of issues that the class will want to discuss. Taking decisions about issues to discuss does presuppose values of autonomy, trust and respect between student and student and student and teacher. But it also has to meet the criteria of the epistemic characteristics of rationality as raised by Dearden, Habermas and Putnam.

Alternatively the teacher could suggest a topic. Where students lack interest in a topic there is the problem of lack of engagement which militates against deployment of the communicative virtues, or the arrival at an easy consensus when dialogue on the issue is staunched, one of the recurrent problems in the Humanities Curriculum Project (Rudduck, 1986). Sustaining discussion depends on the teacher's skill in opening up difference or in provoking a position so that argumentation can progress (Billig, 1987). When any view is justified it assumes an unfavourable evaluation of that view (Perelman, 1979). Locating the conditions for justification are the points which can disrupt consensus and motivate and sustain dialogue on an issue. Motivating students, sensitivity to and judicious critiquing of choices for discussion are also communicative virtues.

4.4.2 Empathetic conceptual imagination

If communicative virtues such as openness are to be encouraged when discussing a controversy where is the knowledge and experience rooted to judge one claim against another? The concept of tradition as an ongoing rational enquiry within a particular

system of belief is one that recognises there have been arguments and conflicts within that tradition which foreshadow change (MacIntyre, 1988). Individuals coming from within a tradition such as a religion, or an established secular philosophy, are likely to employ the dominant arguments within that tradition. But it is far more likely that most individuals do not see themselves as part of one tradition. In reasonable disagreement individuals might be encouraged to position themselves in the tradition that they see themselves as most closely aligned to and evaluate their relationship to the tradition by engaging with the ongoing arguments within that tradition, for example liberalism, and the conflicts it has with other systems of thought. As an illustration someone from within the Islamic tradition might seek to find rational justifications within their tradition for not using the procedure of xenotransplantation even when it can save someone else's life and no other form of intervention is possible, or to find exceptions that might challenge the doctrine, or to find diverse forms of authoritative guidance which are contradictory, and therefore recognise the need for new ways of thinking about the issue..

MacIntyre employs the idea of 'acts of empathetic conceptual imagination' (1988) to depict cross-cultural dialogue in controversy. Once individuals have found the voice of their enquiry or tradition they need to place themselves imaginatively within the arguments of the tradition adopted by those from a rival system. They need to learn the language, to become involved in the conversations between the traditions, to begin to learn how to evaluate the arguments of the opposing viewpoints. The qualities for this hermeneutic approach in appreciating the difference between the individual's own context and that of her interlocutor is to follow the Platonic mode and try and understand the latter better than they understand themselves (Gadamer, 1979). The communicative virtues are indispensable instruments in this quest. By arguing respectfully from within traditions the participants will have the capacity to illuminate the arguments in the enquiry; there is also the possibility that having exhausted the argumentative resources within a particular tradition a participant may find she or he does not have the necessary concepts to uphold her particular point of view.

Of the nine levels of reasonable disagreement only one lends itself to incontrovertible resolution through evidence. Deploying evidence within argumentation models to make a claim (D. Kuhn, 1991; Toulmin, 1964), there has to be agreement between contending parties that the theoretical meaning of the evidence is consistent and contiguous with

the data and the claims that are being made from the evidence. The criteria of application would have to be closely and precisely defined. For the other levels of disagreement there are clear differences of values, preferences and premises in which evidence has some play. Drawing on Quine's model of a 'fabric' of connected knowledge and beliefs it might then be helpful to think of diverse groups in a dispute as having an interconnected system of beliefs where appeals can be made to parts of the belief system of another (Dewhurst, 1992). Different parties in a controversy will therefore have to negotiate a point or points on which they can agree. Using embryo selection as an example, those proceeding from a rights-based premise might agree with those who recognise the sanctity of life from conception, that respect for the embryo is of *prima facie* importance. This could then be the starting point for further discussion.

The preceding discussion has particular bearing on level 9 where parties have different frameworks of understanding.

4.4.3 Different frameworks of understanding

Consideration of evidence would be at best marginal to help settle a disagreement where people have different frameworks of understanding. I am taking a framework of understanding as a *weltanschauung* or world view which is the framework or belief system through which individuals interpret the world and act on it. In this sense it has a similar meaning to McIntyre's concept of tradition. Work on empirical anthropology derives a world view as relating to fundamental unconscious assumptions which influence meanings of the world (Geertz, 1973). That a worldview is an 'unconscious' assumption suggests that it is unexamined.

Cobern (Cobern, 1996) compares the worldview of science teachers to those of many of their students. Where scientists and science teachers assume that the world is materialistic and knowable through experiments that yield explanations for mechanistic causal relationships, their science students often have views of the world which are mythic or emotive. One example of this is a concept of nature evolving through processes such as natural selection as against the work of an omnipotent intelligent designer.

Frameworks of understanding can also refer to distinct paradigms (T. Kuhn, 1962). This helps to explain the role of evidence because, as Kuhn points out, people thinking in different paradigms employ completely different concepts to explain the same phenomenon. Different concepts mean that people see the same phenomenon through different lenses. For a supporter of the eighteenth century concept of phlogiston, materials burn because they lose an inner burning essence called phlogiston. Hence, coal possesses the invisible, immaterial phlogiston but the ash after burning lacks phlogiston. Evidence relating the differences in mass of the ash and the coal accounts for the loss of phlogiston. Contemporary chemists do not see an overall loss of mass. They 'see' the coal as combining with oxygen in the air. Without such a conceptualisation there could be no such thing as carbon dioxide influencing global warming. Evidence for this change could involve identifying carbon dioxide as a product of burning but this evidence would have no meaning for a supporter of phlogiston theory.

If people do have different concepts how is it possible to compare ideas, understandings, products across different cultures? And how can differences be resolved when people have different frameworks of understanding? For example, human sacrifices might be acceptable in one cultural context but condemned by another. The relativist position would be that there are different subjectivities and there is no way of evaluating them in terms of each other. To accept the relativist position would preclude discussion precisely because there is no inter-subjectivity. But it also could be that there are rational procedures for weighing judgements. While it might not be possible to make judgements about whole ways of life it might be perfectly rational to question 'the rightness or wrongness of a particular feature' of a way of life (Putnam, 1993) (p.20) and that judgements require context and purpose. It may not be possible to reach any final verdict in arbitrating between polarised cultures or ideologies but it does not follow that criticism is not practicable, that there are evaluative judgements such as self-consistency, clarity, balance and coherence, we can apply to the people who hold particular views and which emerge from the process of exchange (Putnam, 1981).

Where people have different interpretive frameworks and therefore literally or metaphorically 'see' different things how can such differences be resolved? McIntyre's

acts of empathetic conceptual imagination are important in a pluralist society and where many socio-scientific issues, particularly in biomedicine, involve manipulations of early forms of life, or in animal experimentation, where humans can be perceived as one among many life forms with no value greater than other animals or where animals can be perceived as instruments to be used for the benefit of humankind. For McIntyre openness is crucial in imagining a different point of view. How people's experiences are organised and communicated is discussed in the next section.

4.5 Modes of thought

There are two modes of thought, construed as distinct ways of ordering experience, which can be brought to bear on disagreements (Bruner, 1986). Where there are different kinds of equal but distinct reasons for actions and decisions by contending parties, narrative allows people to relate and listen, to tell of experiences not yet known, understood or imagined by other parties. Differences can thus be 'illuminated', to use Bridges' helpful term and, within settings which contain the mainstream and the marginalised, allows stories to be told where other means of communication – the judicial court, the committee of experts, the competitive debate – constrain what is recounted. The communicative virtue of reciprocity or mutual respect is thus presupposed in actuating narrative. Narrative is therefore one mode of thought. The logico-scientific mode deals in general causes and their establishment and tests for empirical truth. The means by which these two modes can be used to convince are different, one seeks to appeal to procedures for establishing formal proof, the other through verisimilitude, providing narrative stories of lifelikeness (Bruner 1986), the former seeking to *explain*, the latter to provide a means of *interpretation* (Bruner, 1996). But both are ways of structuring experience to explicate reasonable disagreement.

The relationship between narrative and science and socio-scientific issues is a complex and ambivalent one. There are the grand meta-narratives of Enlightenment science, with its achieved past and predictable future, which in school science have formed the stock in trade of heroic stories of individual scientists such as Pasteur and Jenner, and the impact of their discoveries on the welfare of humankind. But the rise of post-modernity represents a shift from this authoritative view of science to the fragmented and heterogeneous socio-scientific micro-narratives of contemporary science (Giddens,

1990) reflected by localised concerns and representations. Hence popular interest and concern about well-publicised new technologies have paralleled an increase in public consultations about science and technology developments such as online surveys (Oliver, Stewart, Hargreaves, & Dezateux, 2005), citizens' juries (Amour, 1995; Iredale et al., 2004; G. Smith & Wales, 2000) and consensus conferences (Joss, 1998; Joss & Durant, 1995a, 1995b). These consultations have met with an ambivalent response from the public which varies globally according to the technology: optimism and high expectations but also lack of enthusiasm, poor response rates and lack of trust in governments' abilities to manage risk (Cobb & Macoubrie, 2004). Funtowicz and Ravetz (Funtowicz & Ravetz, 1994) have coined the term 'post-normal science' for the uncertainties, high-risk states, values in dispute and urgencies in decision-making associated with modern technologies, genomics, robotics, artificial intelligence and nanotechnology, coined GRAIN. Given the unpredictability associated with such developments, expertise (as represented by the logico-scientific mode) needs to work in concert with local knowledge (in the form of local narratives) to help detect those problems that might emerge (Ravetz, 2005). If contemporary notions of 'scientific citizenship' (Michael & Brown, 2005; N. Rose & Novas, 2004) reflect the increasingly dynamic and egalitarian relationship between the production of scientific knowledge and social action then experience and local knowledge in the form of personal narratives need to be foregrounded in the teaching of controversial socio-scientific issues in schools. Conveying one's experience to another in a controversy or disagreement is particularly important because it helps others to decentre and see the 'world' as we see it, in so doing communicative virtues such as respect and openness are enacted.

Narrative story has had a prominent role in humanities subjects, for example, the history curriculum (Bage, 1999; Connelly & Clandinin, 1990; Hawkey, 2004). Its explicit use in science education has been limited although Ødergaard has developed a dramatic narrative in conveying a range of perspectives on gene technology (Ødegaard, 2002, 2004). Hipkins (Hipkins, 2004) has used a game based on children's stories in representing the sequence of events in the rock cycle and Kim and Barker have drawn on Polanyi's views of the personal commitment of the scientist as an internalised narrative 'which can promote a more enlightened student understanding of the nature of science' (Kim & Barker, 2004) (p.8) and Barker has actively espoused the role of the story in understanding the nature of science (Barker, 2002).

The link between narrative and science is nonetheless compelling both in social discourse and in literature more broadly. In *The Origin of Species* Evolution is described as a narrative (Darwin, 1972) , one which has become a source of metaphors and underlying narratives of modernity (Beer, 2000). Writers in the literary canon such as Italo Calvino (*Cosmicomics*) (Calvino, 1968), Tom Stoppard (*Arcadia*) (Stoppard, 1993), Michael Frayn (*Copenhagen*) (Frayn, 2000) and Primo Levi's story of the journey of a carbon atom (*The Periodic Table*) (Levi, 1986) produce strong narratives of and about science through drama and short stories. The opportunity for narrative as explanation is seen as a curriculum opportunity in the Nuffield 2000 project.

> Our proposal is that science education should make much greater use of one of the world's most powerful and pervasive ways of communicating ideas – the narrative form – by recognising that its central aim is to present a series of 'explanatory stories'. By this we mean that science has an account to offer in response to such questions as 'How did we catch diseases?', 'How old is the Earth and how did it come to be?' . . . . we want to emphasise the value of the narrative in communicating ideas and in making ideas coherent, memorable and meaningful. (R Millar & Osborne, 1998) (p.2013)

Typical 'explanatory' stories exemplified by Millar and Osborne are the 'Particle model of chemical reactions' and 'The Earth and Beyond'. These stories reflect a series of sequenced events in which macro-phenomena such as the dissolving of salt in water are caused by the interaction between charged ions from the salt and water molecules.

However, there is a need to distinguish between those narrative forms, on the one hand, where non-human or anthropomorphic protagonists act as instruments to convey declarative knowledge, and on the other hand where the protagonists are human with human consciousness and motivations, agents of their own destinies. Thus the Nuffield 2000 programme would come under the first category and Frayn and Stoppard under the second. *Cosmicomics* is ambivalent in this respect for the protagonists have a human consciousness but are morphed into entities such as quarks and coelocanths. The protagonist's narration becomes explanation and existential cataclysm in Calvino's representation of natural selection and speciation:

> According to my great uncle, the lands that had emerged were a limited phenomenon: they were going to disappear just as they had cropped up or, in any event, they would be subject to constant

> changes: volcanoes, glaciations, earthquakes, upheavals, changes of climate and of vegetation. And our life in the midst of this would have to face constant transformations, in the course of which whole races would disappear, and the only survivors would be those who were prepared to change the bases of their existence so radically that the reasons why living was beautiful would be completely overwhelmed and forgotten (p.78)

The human voice as protagonist meshes with the explanatory and would therefore be closer to an exemplification of human consciousness and motivation. This example and those preceding it demonstrate, at the least, an uneasy epistemological relationship between science and narrative.

4.5.1 Characterising the personal narrative

The word 'narrative' has its roots in Latin and Sanskrit, *gnarus* (knowing or wisdom) and the Latin *narro* (relate or tell). In ancient Rome, and in medieval times, *joculatores*, which forms the Latin root behind the English word 'joke' and the Spanish word 'toy', were popular street storytellers. As well as wisdom there are elements of street credibility and frivolity associated with the narrative story. Narrative conveys from narrator to interpreter/interlocutor what is known, and can take various forms – drama, saga, story, picture, cartoon, tapestry, film, epic poem, song. As well as allowing people to tell and listen, to talk of experiences not understood or imagined by others, narrative is an organiser for these experiences by structuring and sequencing events. It can be seen as:

> . . . the outcome of a mental process which enables us to excise from an experience a meaningful sequence, to place it within boundaries, to set around it the frontiers of the story, to make it resonate in the contrived silences with which we may precede it and end it.' (Rosen, 1987) (p.13)

The Oxford English Dictionary definition of narrative gives 'an account of a series of events, facts, etc., given in order and with the establishing of connections between them' (OED), 'episodes collected as a focused chain . . . . linked by cause and effect. . . [A] narrative ends when its cause and effect chains are judged to be totally delineated' (Branigan, 1992) (p.20).

Traditionally narrative has been conceived as a storyline consisting of a sequence of events. Hence, an extremely simple example is '[T]he king died and then the queen

died from grief' (Forster, 1927) (p.60). In foregrounding human consciousness Fludernik (Fludernik, 1996) emphasizes 'the representation of experientiality' (p.28) as central to narrativity rather than temporal sequentiality. While experientiality can include a temporal sequence of events the latter is not crucial to a portrayal of narrative dynamics, what is central is that '(h)uman experience typically embraces goal-oriented behaviour and activity, with its reaction to obstacles encountered on the way' (p29) incorporated in a three part schema of 'situation – event (incidence) –reaction to event.' But the narrator is also a reflector of experience stored as 'emotionally charged remembrance' (p.29) and therefore the narrative becomes self-evaluative and 'accountable for the actions and experiences which compose a narratable life' (MacIntyre, 1981).

Through an analysis of narrative in historical accounts White (White, 1981) suggests that narrative endows a succession of events with moral meaning. Whereas the annals and chronicle sequence events the fully realised historical account presupposes closure which give the events significance 'as elements of a moral drama' (p.20).

A model of narrative can be construed as consisting of Fludernik's three part schema which is reflected on by the protagonist as purposeful agent (or the protagonist acting vicariously) from a moral and ethical, in other words a values, perspective. Thus, in the Calvino extract above, the situation is that the protagonist recalls different perspectives on nature between himself as a land-dweller and his uncle as a degenerate coelacanth; the event is the foreshadowing of change, and the reaction to the event is the evaluation of the quality of life, as encapsulated by the phrase 'why living was beautiful' between the start and the end of this change.

As mentioned earlier innovations to the science curricula have attempted to contextualise and to narrativise science. How narratives are conceptualised in one course, *Salters-Nuffield Advanced Biology (SNAB)* (Holmes, 2005), provides a useful contrast to the Calvino extract and helps to throw in relief the model of narrative which has at its centre 'human experientiality', evaluation and accountability. The philosophy of SNAB is made explicit, to 'study biology through real-life contexts' (p.v). The first real-life context, entitled 'Mark's story' (p.4), is designed to illustrate the problems of cardio-vascular disease in young people. It is an account of what happened to Mark when he

experienced a stroke, how he was rushed to hospital where he was treated and how he regained consciousness. This is an account of a sequence of events but Mark's situation is described very thinly – we know nothing about him other than that he was 15 years-old when he had the stroke - and there is no attempt to evaluate the events from any moral or ethical perspective. While the account serves to contextualise the science, has a human protagonist and consists of a sequence of events it cannot be considered a personal narrative because it lacks the evaluative component.

In section 2.4.2 the picture of the Nuffield 2000 relationship between science content and social evaluation of science is consistent with one where knowledge flows out from the inner core of uncontested science (Ziman, 1984) as in the model of *School Science & Social Issues*. Although the agenda for the curriculum is one which draws on a socio-ethical perspective, the social and cognitive hierarchy of science transmitted from expert in the form of scientist or teacher to student is intact. The science accounts of particle and planetary motion or factual medical accounts dominate the relationship between science and society, and the reflective or reactive component which is central to any consideration of socio-scientific issues, is absent.

Using personal narratives to enhance learning in science lessons, particularly those with a socio-scientific component, would appear to be a bleak prospect under the kind of reform agenda proposed by Nuffield 2000. This conclusion is tentatively endorsed in a theoretical study of narrative in explanations intrinsic to science which 'explains some natural phenomenon and is part of the body of scientific knowledge' (Norris, Guilbert, Smith, Shahram, & Phillips, 2005) (p.537) suggesting that exposition and argumentation might be more fruitful genres in reflecting science's epistemic requirements. Norris *et al.* (2005) point out that the role of narrative in explanations about science is less problematic but the knowledge that is privileged in the 'explanatory frameworks of science' is that which is intrinsic to science. Is there then scope for narratives in teaching controversial socio-scientific issues? And what might be the pedagogic link between these narratives and the general principles of the logico-scientific mode?

4.5.2 The relationship between narrative and logico-scientific modes

It is the 'local' personal context, the level of particularity (Andrews, 1989) or what Richard Rorty has termed 'solidarity', the 'personal' or 'community experience' (Rorty,

1991) which is the most significant feature of narrative in terms of addressing socio-scientific issues. Whereas argument, the logico-scientific mode, operates on the level of generalisation, narratives supply those local contexts and particularities that reinforce warrants and supply rebuttals.

Research on interactions between lay people with interests in a socio-scientific controversy and experts have frequently identified tensions rather than complementarity between the narratives of affected parties and scientific explanations. In a discussion about the contamination of a local water source what local residents experienced as

> corroding waterlines, washers and dryers that had to be replaced every other year, flowers that died off when irrigated with well water, scales on their skin after taking a shower . . . . real, objective concerns in the everyday lives of people affected by the unusable water (Roth & Calabrese Barton, 2004) (p.37)

were explained as '"unachieved aesthetical objectives"' (p.37) by the scientist investigating the problem. Tensions between the local knowledges of Cumbrian sheep farmers and radiological experts demonstrated that the farmers' accounts of the geography of their own farms conflicted with the predictions of the experts (Wynne, 1989). Parents of Downs Syndrome children found the scientific information, given by scientists and doctors whose 'long term goal is generalised understandings' (Layton *et al*.1993) (p.45), unhelpful in coming to terms with their own narratives of coping at an everyday level with their children. When aspects of science are seen and acknowledged as uncertain by experts, and there is an effort on the part of experts to work alongside lay people, the science often becomes perceived as peripheral to people's concerns (Layton *et al*. 1993). The stories of people outside expert and academic science are becoming more recognised as they challenge common scientific assumptions and offer more complex constructions, for example, the potential of oral histories for animating narratives of landscape development (Harvey & Riley, 2005), the recognition of women's narratives working inside the scientific community (H. Rose, 1994) or the narratives of the eco-feminist movement in India (Shiva, 2001).

Informal or anecdotal evidence can act in concert with formal scientific evidence. As discussed in Section 4.3.1.4 Aikenhead's research shows how nurses draw on evidence in the form of emotion-related observations to make judgements about the well-being of

their patients such as knowing the signs when a patient feels uncomfortable or in need of care (Aikenhead, 2005).

Narratives, then, particularly those that are personalised, have the potential to supply controversial socio-scientific issues with a fund of exemplars which illuminate – and attempt to resolve – differences and provide data for broader acts of argumentation. As well as being articulated, narratives are received and interpreted, they allow people to see events in the way the narrator sees them (Harré, 1980) significant also in 'acts of conceptual empathetic imagination' (MacIntyre, 1988). Narrators have an audience who need to be addressed. Experience cannot be conveyed unless the narrator has the skills to catch the attention of the addressee. This means that narratives need to be constructed in such a way that they have a resonance for the addressee or interlocutor (Kubli, 2005). This presents a pedagogic challenge: not only do teachers have to select those narratives which reflect and inform logico-scientific principles, they need to encourage students to develop their own narratives, where necessary, to make the structure of narrative explicit, to help students relate accounts which have the quality of addressivity and draw attention to the links between these personal narratives and scientific claims.

The spoken and anecdotal form of narrative has, in the words of Harold Rosen, a slippery and subversive nature which 'derives its power from being outside the legitimized operation of institutions and wriggles its way into the interstices of those same institutions' (Rosen, 1988) (p.198). Institutions in this case are those of academic science from which the substantive scientific knowledge of socio-scientific issues might be derived.

Narrative is such a fundamental part of recounting experience (Connelly & Clandinin, 1986; Rosen, 1987; White, 1981) that it has a vital and instrumental role in conveying meaning within a socio-scientific disagreement, particularly in those levels of disagreement where there is little or no appeal across systems of belief or traditions. Structuring events into the form of a story (Kubli, 2001) is a means of translating experience across cultures (White 1981), transcending differences in sex, class and ethnicity (Rosen 1987) and therefore particularly valuable in lending itself to the interpretation of difference, and drawing attention to social injustice.

> Narrative art has the power to make us see the lives of the different . . . . . with involvement and sympathetic understanding, with anger at our society's refusal of visibility. We come to see how circumstances shape the lives of those who share with us some general goals and prospects (Nussbaum, 1997) (p.88)

4.6 Summarising the model: pedagogical implications

There are three strands that comprise an epistemological model of socio-scientific disagreements, and in fact, controversy more broadly. These are the levels of disagreement, the communicative virtues, and the narrative and logico-scientific modes of thought. Levels of disagreement can be conceived as a core around which the modes of thought and communicative virtues are intertwined, rather like the model of DNA with its histone core and the strands of CVs and MoTs helically wound around the LoDs.

It is a framework for approaching the teaching of controversial issues in schools and a tool for analysing the ways in which elements of a controversial issue are deployed in the classroom. ‘Reasonable disagreements’ might be a more helpful term than controversial issues, nonetheless the latter term is widely used and I shall refer to it in the context of its use in the curriculum. Bridges (1986) has suggested that controversial issues are those reasonable disagreements which incorporate moral and social values but it would be problematic to decide to what extent there was a value-laden element in any disagreement. Controversy can be seen as a spectrum of differences as illustrated in the framework without the need to impose qualifications on its meaning.

The strands are interwoven in a socio-scientific controversy although I shall analyse them separately. If we consider the process of different conceptual frameworks (level 9), through acts of conceptual imagination we can see how an individual needs empathy, criticality and openness to situate themselves in a tradition and to become familiar with the concepts of another tradition. The concepts of a competing tradition could be conveyed through narrative (anecdotal experience/evidence) or through the logico-scientific mode or a mixture of both. However the possibilities are limited by the epistemological model of socio-scientific issues and their role in the curriculum (See Chapter 2).

Teaching controversial issues, particularly those of a socio-scientific nature, has never been easy nor particularly successful – all too often students contribute little to the discussion (Dillon, 1994; Osborne *et al*., 2002) . Although there have been consistent calls for professional development (Levinson & Turner, 2001; Osborne *et al*., 2002; Ratcliffe *et al*., 2004) there has been little guidance for a theoretically-argued position towards the kind of pedagogy envisaged.

The teaching of science in schools has been portrayed as authoritative, generalised and academic (Fensham, 1997; R. Yager, 1992), prompting Ravetz to protest to the House of Commons Select Committee that the 'inherited institution of science education is one of the last surviving authoritarian social-intellectual systems in Europe . . . . . students absorb the lesson that every real scientific problem has one and only one simple, correct answer.'[67] This has been reflected in science teachers' own epistemic views of the subject (J. Donnelly, 1999) and the difficulty that science teaching has had in dealing with ideas where there is no clear resolution. Socio-scientific issues are shrouded in uncertainty as well as a combination of political, ethical, social and personal conflicts which are not the common fare of science lessons (Layton, 1986). Despite the imprecations and government directives on the teaching and learning of controversial socio-scientific issues in schools such as ' pupils . . . .consider the power and limitations of science in addressing industrial, ethical and environmental issues, and how different groups have different views about the role of science . . . ' (DfEE/QCA, 1999) (p.122), these statements fail to problematise the background culture in which science is normally taught.

Open discussion is an essential pre-requisite of engagement in the democratic process (Bridges 1979). Where discussion does take place in the classroom it tends to express 'the authoritative social role of the teacher' (Edwards & Mercer, 1987) (p.156), often taking the form of teacher initiation of a question, pupil response followed by teacher feedback or evaluation, known as IRF (Edwards & Mercer 1987). As the teacher tends to have epistemic control of the content (Lemke, 1989) there is relatively little argumentation (Newton, Driver, & Osborne, 1999). Feldman and Wertsch (Feldman & Werstch, 1976) found that the language teachers used when talking among themselves

[67] See footnote 65

tended to be more hypothetical, open and uncertain than the authoritative discourse used with pupils in the classroom. This does not imply any necessary contradiction between authoritativeness and open discourse. There are many situations where an authoritative approach is entirely consistent with effective pedagogy, such as explaining an idea clearly to the class. In terms of classroom control an authoritative approach by the teacher might ensure that voices that do not normally get heard in classroom discussion are listened to[68], under certain circumstances it will ensure greater openness in the classroom.

Any move towards more open and dialogic exchanges in the classroom would seem to suggest a major change in the culture of science teaching but there are enough examples to suggest that appropriate support and intervention for teachers can ease this move (Mortimer & Scott, 2003; Solomon, 1992). The communicative virtues underpin any form of open discussion but they can only be enacted where pupils understand that their voice is heard, that no one's view has a greater weight because of their position of authority in the school or social status in the classroom and where patient attention to others' words are encouraged. This does have implications for the role of the teacher in the classroom. Whether the teacher should take a procedurally neutral, devil's advocate or balanced role has been debated (Bridges, 1986; Crick, 1998) but any consideration of this role will occur within the political and cultural context of the school. A school with a School Council which is equally the responsibility of students and staff is more likely to reflect critically on what both teachers and students have to say, as well as the wider community, than a school society run on highly authoritarian grounds. The concept of criticality is central to any deployment of the communicative virtues in the teaching of controversial issues; openness does not imply uncritical acceptance of another's point of view (Bridges, 1979). As discussed earlier, the concept of 'empathetic conceptual imagination' presupposes subjecting one's own views and that of interlocutors to critical scrutiny.

The communicative virtues are indispensable to the narrative voice of participants in a disagreement. In the telling of a story within a socio-scientific issue the authoritative

[68] An authoritative, respected teacher can ensure that all voices have a chance to be heard. The voices of the loudest often are the only rather chaotic voices heard in classrooms where teaching is ineffectual and there is little discipline.

expert science becomes displaced or marginalised, the context of a lived experience becomes the central focus. In the research for *Valuable Lessons* (Levinson & Turner, 2001) one teacher spoke of a student with cystic fibrosis who could recount to an attentive class what it was like to have the condition, what medical treatment he received and how he felt about it, all of which invited questions and opened dialogue. In the work reported from *Inarticulate Science* (Layton *et al*., 1993) parents could talk about the solutions they had discovered for themselves but the science from the experts was seen to be inert. Invitations to include the narrative mode within the context of reasonable disagreements leads to what Solomon has termed 'popular scientific culture' to show 'young people a science which is lighter on logic and abstraction, stronger on involvement and active evaluation, and intimately woven into the aspirations and concerns of citizens' (Solomon, 1999) (p.9).

Both communicative virtues and modes of thought are enacted within the framework of levels of reasonable disagreements (Table 4.1). While many issues will cut across and encompass a number of levels, listing the levels as in table 4.1 allows the teacher to focus on a level so that students can begin to understand the interplay of evidence, values and worldviews in a disagreement and can make explicit what is at stake in a disagreement. Such a framework can underpin an assessment framework with an explicit focus on those factors which students would need to highlight in a specific disagreement, e.g. evidence which can be drawn on in level 1, complexities of evidence to highlight and unravel in level 2, articulating distinct worldviews as in level 9. In the socio-scientific categories in table 2.1 it is likely that *collective praxis* has the scope to deploy all nine levels while the scope is more limited for the *deficit* model.

The pedagogic framework is a checklist of ideas to underpin any disagreement. For example, students might be discussing the topic of embryo selection in producing embryos as saviour siblings to donate blood from the umbilical cord to a sick older sibling. The teacher might support the students in helping to frame the discussion. Are they trying to find out whether there is sufficient evidence to demonstrate that this procedure helps the older sibling? If so, what kinds of evidence would satisfy the criteria they establish? Which would be the most reliable sources of evidence? All this might be carried out where students have assigned roles, such as tracking down particular sources, and being given the opportunity both to contribute to the discussion and to take

part in the decision-making process. It might provide an opportunity for students to talk about sick relatives or people they know who might or might not benefit from the treatment. In this case the teacher is highlighting the need for evidence, ensuring that students both contribute, listen and participate and that there are opportunities for personal inputs to expand the reasons for coming to a particular decision.

Or the discussion might centre around the Evolution-creationism debate. The teacher's role would be to help illuminate the problem by pointing out the basis for an existential choice between different values (Bridges, 1979). In what could be a heated discussion the teacher would need to emphasize the need for respecting each other's worldviews and the freedom to say what one thinks without fear of intimidation. Both logico-scientific and narrative modes would be important because there may be significant moments in the lives of students which have influenced their viewpoint in one way or another. The purpose of discussing this contentious issue might be the means of bringing forth new knowledge and reasons without necessarily having to arrive at a decision or conclusion.

Enabling such a discussion is not easy and might have to be developed in small steps. Discussions might start out on problems where personal morality and ethical considerations are not at the centre of the issue. Students might disagree on what might be an accurate reading of a titration. Should they take one reading, an average of a number of readings or a number of consistent readings? What precautions should they take to ensure the readings are as accurate as possible? Arriving at a decision would involve establishing appropriate criteria, working collaboratively and making a collective decision and listening to what each other has to say. What could be made explicit to the students are the procedures, knowledge, evidence, limitations of evidence and dispositions they are using to arrive at a decision. These are the kinds of features which are present in controversies and provide an educational rationale for teaching controversial issues in the school curriculum.

Having derived a framework for teaching controversial socio-scientific issues I will now exemplify how they could be used in a classroom at Key Stages 4 and 5.

4.6.1 Case Study - Embryo selection

In Chapter 3 I described three examples of contemporary controversial issues in biomedicine. I want to take the example of PGD and thalassaemia and demonstrate how it might be handled in the classroom in a way which is consistent with the pedagogical framework described in this chapter.

4.6.1.1 Evidence (LoDs 1 and 2)

Where could evidence be used in settling a disagreement in the case of PGD? Suppose that people agree that PGD is a good technique to save the lives of sick children but there is as yet insufficient evidence to indicate how successful this treatment is. The question which students might consider is what constitutes success. If it is a complete cure how much time should elapse before we can be confident it is successful? How much is known about other cases of 'saviour siblings' and the progress of the genetic condition? If it is a gradual improvement in lifestyle how would we measure quality of lifestyle? Which stages in the cycle of treatment could be difficult and then put progress at risk? What are the medical risks and how might they be quantified? What interpretations could be put on the data gathered so far?

The teacher needs to emphasize that what is being considered is evidence, whether in support of or against the effectiveness of 'saviour siblings' in curing genetic conditions. Students might find data which supports the effectiveness of PGD while others could find data which rebuts the data or provisos which might indicate limitations on the effectiveness of the treatment. Useful resources would be the internet with accounts of other treatments, condensed reports from journals such as the *British Medical Journal* and newspaper reports. It is unlikely that students will be able to collect sufficient evidence to demonstrate the case one way or the other but that is not the point. What is crucial is:

- students know that the decision they are trying to make is based on evidence;
- students understand that the evidence has to be interpreted;
- that the question they are trying to answer is not whether PGD should be used but whether it works;
- by asking the right kinds of questions they will know where to gain access to data and evidence; and

- that the evidence is likely to be complex and uncertain (and that is usually the case with controversial issues).

4.6.1.2 Weighting criteria differently/prioritising (Levels 3 and 4)

At present there is no definite evidence to suggest that PGD is unequivocally successful in saving the lives of sick children. It will be some time before that can be decided, not only because of the physical benefits for the sick child but also whether there are psychological effects on the 'saviour sibling'. Even at this stage, however, given the potential of PGD, it could be asked whether it should be available to everyone on the National Health Service (NHS). In the last few years people have paid for PGD outside of the UK where they have preference for a male or female. Now PGD is effectively available it will be those with money who will be able to use it either for purposes of gender selection, possibly for other physical attributes and for saviour siblings. If this is the case then it comes to be a resource available for those who can afford it leading to social differentiation - wealthier people will be able to use the treatment to cure genetic conditions or gender-select their children whereas others will not.

Making PGD available for all on the NHS, say for those who have children with potentially fatal genetic conditions, will have ramifications for NHS expenditure. Resources might have to be shifted from other areas, for example, geriatric care, nursery provision for sick children or hospitals acquiring high technology equipment. In other words it will become a matter of priorities - given limited resources, however large or small, what should we give priority to? Whatever decision will be taken there will be potential consequences (if PGD was made available to all on the NHS what would happen to those services which lost resource investment as a consequence, who would be affected? who would gain? who would lose?), issues of social justice (should we strive to ensure equality of provision or that the most deserving get what is needed), rights (do people have a right to certain kinds of treatment, however expensive?) and cost-benefit analyses (how do we assess benefits against costs?).

These are primarily ethical issues. Again there is no simple answer but the purpose is for students to give due consideration to particular questions. Since there are so many

aspects to consider the teacher should help students focus on one particular question. There are a number of values that need to be thought through in such a situation.

- Is the action or decision being taken beneficent, i.e. directed towards doing good and avoiding harm to the environment and any sentient beings?
- Are individuals' rights being respected?
- And, on the other hand duties and responsibilities towards others need to be considered as well as individual right. Sometimes these can be in conflict.
- Is there a concept of justice, that everyone is being treated fairly?

Students should appreciate that:

- there are no simple answers to these questions, it is often a matter of balancing many different demands;
- priorities might change over time and space.

4.6.1.3 Differing total experiences of people shaping judgement (level 8)

The way we feel, act and believe about something often has a lot to do with our life experiences; events and circumstances that have had a crucial effect on the way we think and feel. Parents will want to do anything to ease and save the life of their child and many will think that PGD and the production of a saviour sibling are justified in helping this to come about. But there are disabled groups who feel that the emphasis on cure and eliminating the disability, rather than amelioration of the condition, threatens the status of disabled people. It can detract from the need to support disabilities if the emphasis is on eliminating it at birth. While it would be difficult to begrudge the Hashmis in their very distressing quest there is certainly a need to examine the implications of such treatments for all disabled people.

To understand this difficulty students need to be able to understand the broader effect of this technology on the rights of disabled people as well as being able to empathise with people in the plight of the Hashmis. Many students will have relatives with disabling genetic conditions and many will want to discuss treatment and how they feel about it with their peers. Others might be a little more reticent which needs handling sensitively. Teachers will need to find out first whether students are happy to talk about their experiences and to ensure there is a respectful and attentive atmosphere in the

classroom. There will also be a literature on disabled rights in which students could be encouraged to read critically but always being able to correctly summarise the views of the writer.

This is a good opportunity for role play or dramatic enactment. Perhaps working with the drama department a group could develop a story which aims to tell the story of a child receiving cells from a saviour sibling. The story could possibly be told from the experience of the child being treated and from the viewpoint of the saviour sibling many years later. Afterwards a class audience could question the actors on their points of view. A film dealing with this topic has been made by Y-touring, (see www.ytouring.org.uk)

The idea is to make sense of a life experience using narrative and imagination. Individuals or the group as a whole might not be able to come to any decision but the point is to gain an insight from people with different interests as to how they would view the situation.

4.6.1.4 Different frameworks of understanding (Level 9)

In terms of embryo selection these arguments almost always revolve around abortion. Such statements are: 'An embryo is a living thing. It is not right to create and take one life in order to help another.' ‘The best of ends, namely to cure a sick child, does not justify the means’. On the other hand, those who take a utilitarian point of view often base their argument on the fact that saving or improving life is supremely important. The embryo is not perceived as a person or of equal status to a living child.

If people have thought about these things at all they are unlikely to change their minds overnight. The danger with such positioning in the school classroom is that students repeat the same positions without moving on. A way forward is to take the Platonic approach by trying to ensure one has understood the opposing point of view. A way to do this is to ask, for example, someone who thinks that the embryo is a person and that destruction of an embryo is murder to articulate their argument and to outline the opposing argument as clearly as possible. Then ask a utilitarian to explain their position and to describe the embryo-is-a-person argument. Students with opposing viewpoints

can then think of critical questions they would like to ask each other. The purpose of this approach is to illuminate, to ensure that whatever point of view is expressed, that it is critical, rigorous and informed.

4.7 How levels can be represented in other issues

This section summarises a range of issues in the form of a table (4.3) to give a sense of how different aspects of an issue can be mapped on to the levels of disagreement.

Table 4.3: Examples of topics

Topic	Levels 1 & 2	Level 3	Level 4	Level 5	Level 6	Level 8	Level 9
Siting of nuclear power station	What is link to leukaemia? Distinguish between correlations and causation. (What kind of evidence would point towards cause and effect?) Risk and perceived risk	Where should it be sited? Investment prioritised to nuclear over non-nuclear		Disputes about levels of risk and how they are interpreted.	Employment at stake if nuclear power station closed down or not built.		
Electric cars	How does fuel consumption in cities compare internal combustion engines (ICEs)?	Should government subsidise use of electric cars in large cities to reduce smog and local pollution?		If fuel consumption is simply displaced can they be said be cleaner than ICEs?			
Animal experimentation	What is the evidence that animals suffer pain?	Should we prioritise research on non-animal models rather than animals for medical research?	How to balance animal rights against human need.	Can animals be said to have rights?		People whose lives have been saved or enhanced based on treatments arising from medical research based on animal experimentation	Should there be a complete ban on the use animals in medical experiments even where this might save human lives and where treatment of the animals is fully regulated?

Chapter 5 : Methodology

5.1 Background

Up to this point I have elaborated an idealised pedagogical framework although it has been critiqued by empirically-rooted literature (Section 4.3.1.5). If this framework can be used in schools it needs to reflect the realities, vicissitudes and challenges of teaching. The concept of 'satisficing'[69] is that achieving what is possible or good enough is often better than the optimal solution, i.e. the best outcome (Reber & Reber, 2001). If we know something has worked well in the past, or we can achieve a reasonable outcome through a well-established cognitive route, then this might be more effective than achieving the best outcome which is unattainable in most conditions of teaching and learning. The former is more efficient on resource use. Satisficing is for teachers to know that the teaching of a controversial issue is based on sound theoretical foundations, what outcomes can reasonably be achieved, and that teaching and learning about controversial issues are not time-consuming, considerations that ought to be consistent with the pedagogical framework developed in Chapter 4.

The objective of the methodology is to map teachers' constructions of science-related controversial issues on to the framework so that a pedagogy can be elaborated providing a bridge between teachers' current practice and that necessary to promote new and versatile approaches to operationalise the framework.

The term 'framework' suggests confinement and restriction; teachers might perceive it as some kind of model to which they have to refer when teaching controversial issues. My intention is to make it a resource or toolkit which teachers can draw upon when planning to teach controversial issues related to science and which is subject to modification, correction and transformation[70]. But what is the currency of this toolkit? On what theoretical grounds has it been constructed? I have brought different strands of theory together - Rawls's levels of disagreement based on the political conditions of 'overlapping consensus' in a liberal and pluralistic society, communicative virtues and modes of thought - to create a new framework. Claims for generalisability are not possible because the framework is untested empirically and generalisability, if possible,

[69] I am indebted to Professor Terry McLaughlin who first told me about this term.
[70] Like Wikipedia I guess

can only be approached when empirically grounded. The framework is best conceived, therefore, as a tool for thinking about the teaching of controversial issues rather than as a theoretical model (Gary Thomas, 2002).

The main thrust of my research is deductive, that is, to seek data and provide evidence consistent with the postulates of the pedagogic framework and to identify those referents in the interview which can be mapped on to the framework. As examples, I am looking for instances of the ways in which teachers use evidence as in levels 1 and 2 of the Levels of Disagreement or how they explain the role of narrative in discussing controversial issues in the classroom. But I am also interested in how teachers construct meanings of 'controversy' which are situated and problematic and therefore the reading of the interviews will be sufficiently open and thematic for the framework to be refracted through diverse contexts.

5.2 Underpinning considerations

In probing teachers' constructions of socio-scientific controversial issues I have collected the data through semi-structured interviews. Holstein and Gubrium (1997) and Kvale (1996) identify two positions in structured interviewing. One is the traditional approach where subjects are conceived as repositories for data which has to be brought to the surface or 'mined' , to use Kvale's metaphor (Kvale, 1996). The interviewer's intention is to elicit decontextualised, unadulterated facts. These facts are meant to be generalisable and the reliability of the research is the extent to which the questioning will yield the same answers when carried out in different contexts, i.e. with teachers in different subjects in different schools (Holstein & Gubrium, 1997). Roles are sharply defined, the interviewer seeks objective data supplied by the respondent.

The active interview is conceived as 'an interpersonal drama with a developing plot' (Holstein & Gubrium, 1997) (p.120) in which the respondent is an active meaning maker where information is co-constructed between interviewer and respondent, the 'facts' cannot be understood in isolation from the respondent. Rather than the decontextualised facts emanating from the traditional interview, the information in the active interview is situated and conveys context-dependent realities that are locally comprehensible (Holstein & Gubrium, 1997). The interviewer is now a 'traveler', rather

than a miner, facilitating a process where the respondents relate their own narratives, interviewer and respondent 'wandering' through the emerging 'lived world' together (Kvale, 1996) (p.4).

Massarik's typology of interview relations (Massarik, 1981) (p.153) ranges from the 'hostile', Paxman-type interviews[71] in which respondents such as politicians are seen as concealing information and combative measures have to be used to expose the facts; the 'limited survey', the 'rapport', 'asymmetrical' and 'in-depth' interviews are all types of traditional interview where the humanity and acknowledged subjectivity of interviewer and respondent become more pronounced but the goals are still attaining specific information: the capture of objective facts. In the 'phenomenal' interview both parties are mutually committed to the enhancement of understanding, 'their respective humanities richly and actively revealed' (p.205). Active interviewing, as represented by the 'phenomenal' interview, can thus encompass a mix of purposes all of which involve the co-construction of meaning, ranging from the emergence of situated information to one in which both parties are involved in a greater purpose of exposing social injustice.

In terms of my research both the purposes of traditional and active interviewing are evident because I see myself as both a 'miner' and a 'traveller'. The semi-structured interview allows for comparison of teachers' perceptions of controversy but the open nature of the prompts allows for greater exploration and use of context than a highly structured interview. Drawing on the work of Converse and Schumann, Holstein and Gubrium (1997) note that although the respondent is actively interpretative this does not necessarily mean it is not possible to glean objective information, 'the repository of knowledge that lies passively behind [the respondent] . . . as lively, uninhibited, entertaining and difficult as the respondent might be at times, his or her passive subject ultimately holds the answers sought in the research' (Holstein & Gubrium, 1997) (p.118).

To enable both the 'mining' and the 'travelling', elements of specificity, range and personal context are built into the interview schedule (Flick, 2006). Specificity encourages 'retrospective introspection' (p.151) in that prompts can refer back to what

[71] Jeremy Paxman is one of the presenters of a BBC TV news programme, *Newsnight*, who is famously – or notoriously – adversarial in his questioning of politicians.

was said earlier in the interview and draw out significant points; range ensures all topics are incorporated relevant to the research question; and personal context is aimed at maximising 'self-revelatory comments' (p.152) which help to convey, explicitly and specifically, the teacher's experiences of socio-scientific issues in the school context.

I am also aware that any interview situation, however open, puts a constraint on the respondent or subject (Hammersley & Atkinson, 1995). To see the respondent as a co-constructor is unduly optimistic; he or she is responding to the agenda set by the interviewer and might wish to give the kinds of answers that will satisfy the interviewer. The respondent is involved in a process of anticipation and interpretation, supplying the interviewer with the information she or he thinks the interviewer wants to hear. Interviewers avoided any facial expressions or leading questions which might hint that they agreed or disagreed with comments (Ritchie & Lewis, 2003). On the other hand in trying to amplify comments which we found interesting, significant or vague, we might have implied a particular interest position. There are a number of occasions where the attitudes of interviewers were likely to have been assumed by the teachers, possibly because they knew that we were employed as academics or researchers. For example, the head of English in school E, refers to the students coming to perceive criminals as individuals and not as 'criminal types'. 'We get the police to come in then . . . and they talk about the criminal type and contradict everything we've said because they say we can spot them a mile off!' I doubt if he would have used the same phrasing if he knew I was a police officer or someone sympathetic to labelling criminals in this way. There were other examples of intonation, or expected agreement, or facial expressions or incorporation into a way of thinking, all of which suggested tacit acknowledgements of agreement. On the other hand there were sometimes hostile responses which suggested the teachers might have been unwilling to talk freely. One example was the psychology teacher in school H who questioned our intentions because we had made it clear that our funding was from the Wellcome Trust. She had made the link to a pharmaceutical company and, despite qualifying that the Trust was a charitable organisation with only limited connections to pharmaceutics, it was clear that the suspicion was still present.

To acknowledge this is to assert that any interaction between researcher and subject, however covert, is always situated, power relations are unequally socially distributed

and there is an unconscious complicity. As interviewers we have asked for the co-operation of the respondents. However it would be impossible to say anything without any kind of intervention, although there are almost always unequal power relations in an interview it does not follow that we cannot identify objective referents (J. Miller & Glassner, 1997). Reliability is built into the methodology because 83 teachers in diverse subject areas have been interviewed with the same interview schedule, similar comments in diverse contexts increase the probability that what teachers say reflect similar experiences and give face validity to the content. Validity is enhanced through iterative inter-coder ratings.

Empirical research seeks validity through triangulation which is a multi-methods approach. In the context of this study triangulation might involve interviewing both teachers and students, non-participant observation of controversial issues in the classroom, textual sources - lesson plans, teacher diaries, textbook resources. In so doing it could improve the reliability of the data. If, for example, a teacher talked about how students with different worldviews convey their disagreements in the classroom, triangulation would allow us to deepen our understanding of what the teacher meant by observing the way she organises such discussions in the classroom and how disagreements are anticipated in lesson plans and schemes of work. But if I think of active interviewing as situated then I understand how the teacher constructs what he or she says about 'controversy' in the context of the interview, it is not a disembedded concept which can be analysed through other contexts. This is not to say that an understanding of controversial issues would not be deepened by a multi-methods approach but that it does not necessarily endow reliability to the way the teachers talk about socio-scientific controversial issues in interview situations (Silverman, 2005). The main focus of my research is to find out what and how teachers think about the teaching of science-related controversial issues. In the methodology I adopt, reliability is approached by analysing the data from the interviews of many teachers in a variety of teaching contexts, and making assumptions and inferences from the data transparent and explicit through a protocol of coding (see appendix C) and inter-coder ratings.

5.3 Methods

1000 schools in England and Wales had previously been sent a questionnaire asking about the teaching of issues in biomedicine and biotechnology. These schools constituted a semi-randomised but representative sample of secondary schools and colleges of further education in England and Wales. More precisely, the sample contained every fifth school or college out of the *The Education Authorities Directory and Annual* published by *The School Government Publishing Company Limited*. The selection was actualised in two phases, each one consisting of the selection of every tenth school in the directory lists, with a different starting point each time. All types of schools and colleges catering for the age range 14-19 were included in the sampling process. The sampler went through the relevant lists in the order they appear in the directory ensuring balanced representations of state mixed comprehensive schools, independent secondary schools, sixth form centres or consortia and colleges of further education (Levinson *et al*., 2001)[72].

For each school there was a pack of four questionnaires, for the headteacher, head of science, head of arts/humanities/social science, and head of PSHE respectively. In doing this we were targeting the areas of the school where these issues were most likely to be taught. 315 schools responded and 20 schools were then selected to interview a range of teachers chosen by the headteacher and in some circumstances the headteacher as well[73]. Schools were selected on the following criteria:

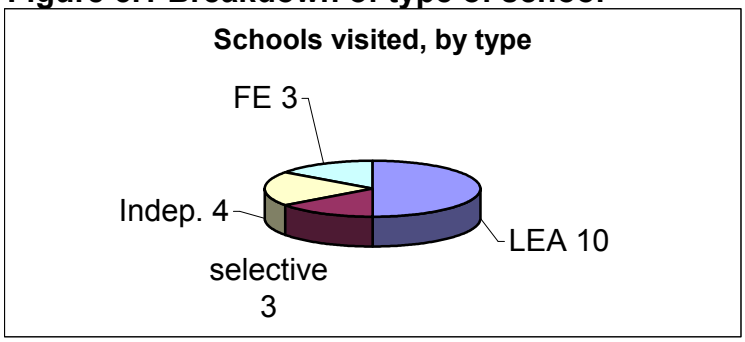
- Whether the school was a state school, independent school or post-16 Further Education College or Sixth form centre. This was proportionate to the questionnaire returns;
- Co-educational or single-sex;
- Rural, suburban or urban;
- Monoethnic or multi-ethnic.

[72] In carrying out the research I am particularly indebted to Pavlos Koulouris, the research officer on *Valuable Lessons*, who sampled the schools. Anna Douglas, Jane Evans and Alison Kirton carried out a number of interviews as I did.

[73] Seven interviews involved more than one teacher

The breakdown of type of school is given in Figure 5.1.

Figure 5.1 Breakdown of type of school



The breakdown by subject area of teachers interviewed is given in Figure 5.2

Figure 5.2 No. of teachers interviewed by subject

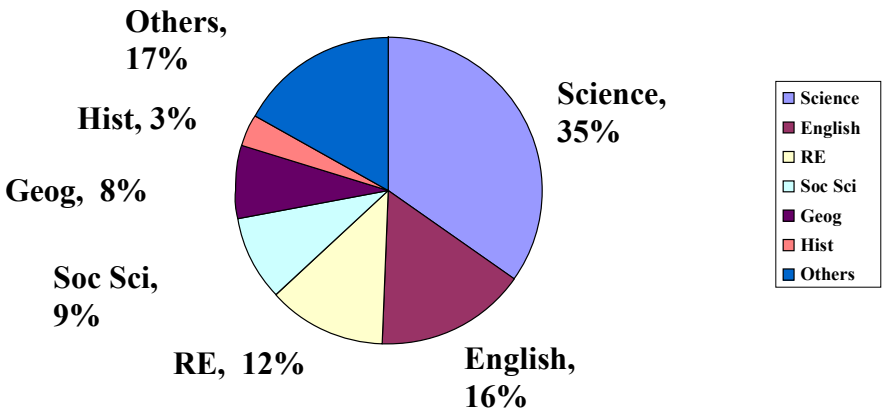


Table 5.1: Characteristics of Schools

School	Location	Type
A	London; suburban	Mixed comprehensive
B	London; suburban	College of Further Educatio
C	Wales; rural	Mixed comprehensive
D	South-East; semi-rural	Mixed comprehensive
E	North- East; suburban	Mixed comprehensive
F	East Midlands; urban	Mixed comprehensive
G	South-East; suburban	Mixed comprehensive
H	West Midlands; suburban	Girls state selective
I	East Midlands; suburban	Girls independent selective
J	East Midlands; urban	Mixed comprehensive
K	London; suburban	Girls independent
L	London; urban	College of Further Educatio
M	London; suburban	Girls comprehensive
N	North-West; suburban	Girls state selective
O	North-East; suburban	Mixed comprehensive
P	West Midlands; suburban	Mixed independent
Q	South-East; suburban	College of Further Educatio
R	South-West; rural	Mixed independent
S	Wales; suburban	Mixed comprehensive
T	North-West; urban	Mixed comprehensive

Interpreting the framework through teachers' narratives was done by interviewing 83 teachers from the 20 schools (later two further teachers in school W in a different project were also interviewed using the same schedule) in a variety of subject areas across the curriculum. I drew on teachers' experiences in interpreting what teaching socio-scientific controversial issues meant to them in the context of their schools and classes (Gubrium & Holstein, 2002). The purpose was to map teachers' constructions of what it means to teach controversial issues against the framework and to suggest appropriate pedagogies as a result of the interview analyses. I devised an interview

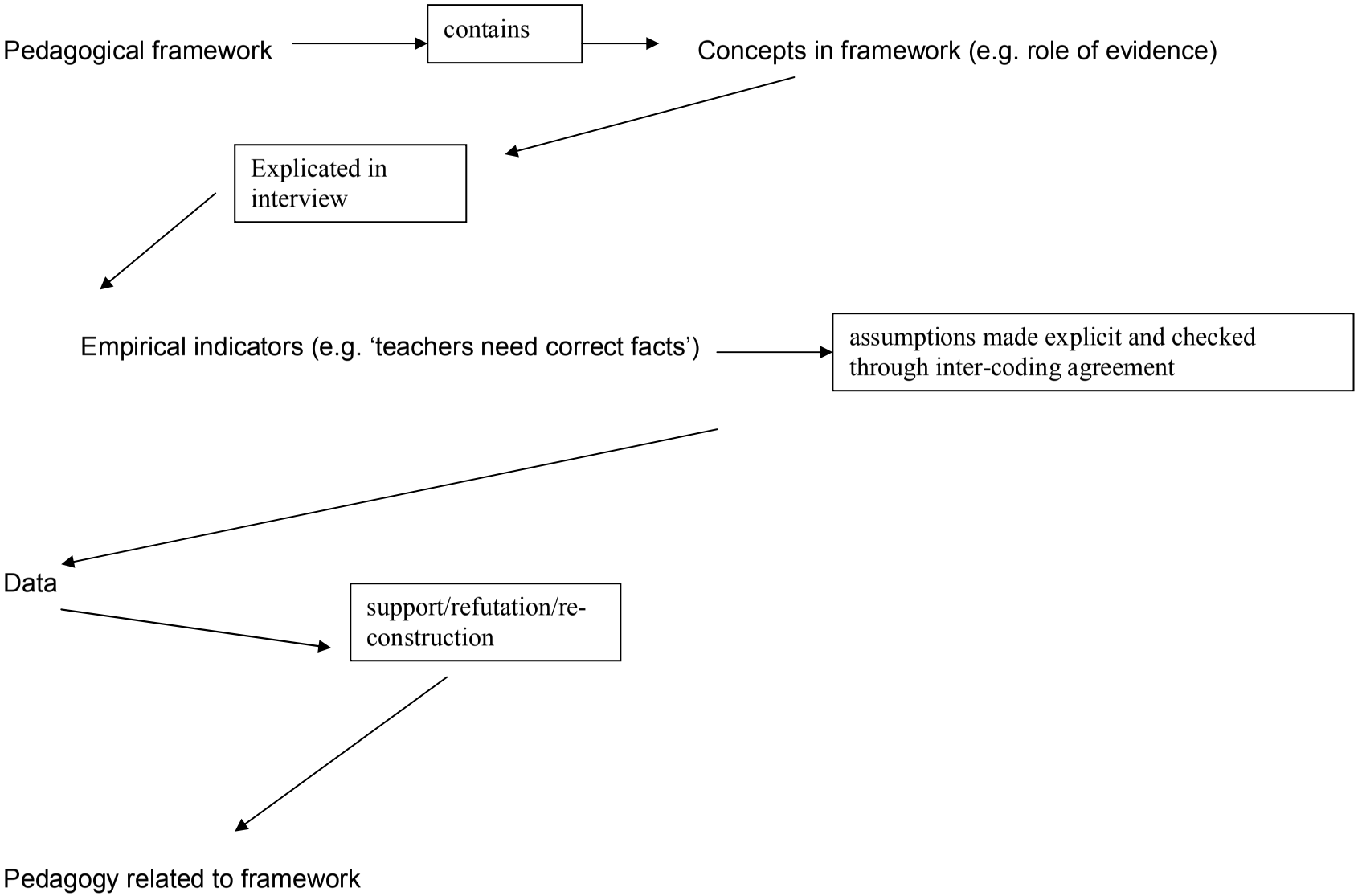
schedule with some colleagues which was then trialed and modified. This took place three times before a final schedule was constructed. In each of the interviews teachers were asked:

- to clarify any points arising from the questionnaire (if they had completed the questionnaires. Most teachers we interviewed had not completed the questionnaires);
- to exemplify any socio-scientific controversial issues they had taught to 14-19 year olds
- to describe the opportunities and impediments in teaching these issues;
- if there were any school policies known to them on the teaching of controversial issues;
- if there was interdepartmental collaboration in teaching these issues;
- if there was any professional development and resources they would benefit from;
- if there were any points they would like to clarify.

5.4 Analysis

Operationalisation is the process of linking theoretical concepts in the framework (Wengraf, 2001) such as particular communicative virtues, levels of disagreement, e.g. level 2 on complexity of evidence or level 9 different frameworks of understanding, modes of thought (narrative – oral, literature etc; logico-scientific), to empirical indicators, broadly the way in which I understand teachers to talk about such constructs. The model for operationalisation is given in Figure 5.3. Thus, a teacher might make a statement such as ‘teachers need the correct facts’ in relation to teaching a socio-scientific issue. This is an empirical indicator and is mapped on to ‘evidence’ as being the nearest component in the strand ‘Levels of Disagreement’.
(See appendix D).

Figure 5.3 Model for operationalisation



Through this methodology problems arise as to how the interview data, the empirical indicators, can be derived from the framework. Is my categorisation of a teacher's statement on evidence valid? Can it have a different interpretation? In making these inferences I have to make my assumptions clear and check them by giving a sample of transcripts to another researcher to code using my coding scheme as a protocol. An interview transcript (appendix A), the coding scheme (appendix B) , protocol (appendix C) and a sample of coded interviews are given in appendix D.

Data from the interviews has been fully discussed in other publications (Levinson & Turner, 2001) but I re-analysed the interviews in light of the pedagogical framework of controversy using content analysis (Flick, 2006). Initially I read through each interview again and highlighted those statements which alluded to any aspect of the framework, e.g. communicative virtues/dispositions; levels of disagreement or any aspect of disagreement; and the modes of thought. After a couple of weeks I read through the interviews a second time but this time I marked those statements which reflected any aspect of the framework in more detail, for example references to communicative virtues where particular communicative virtues were identified. When this was done a new range of communicative virtues were noted such as sensitivity and the need for balance. While the latter was not obviously a communicative virtue, it was construed by so many teachers as a desirable means of achieving an outcome to a lesson dealing with an aspect of controversy, as in ‘a sense of balance’ or ‘appreciating a balanced position’, that I have listed it under communicative virtues. Furthermore dispositions such as sensitivity could be sub-divided into those that were conceived as a virtue possessed by the teacher and/or by the student. (See appendix D for content analysis of statements).

One of the problems in categorising and coding is that statements need to be understood in context. I have included an account of context as I understand it. In the protocol we read the interview twice before coding to get a ‘feel’ for the situation rather than doing an algorithmic identifier. For example, the communicative virtue ‘openness’ refers to being open enough to having one’s mind changed. However, the term ‘open’ is often used by teachers to mean either ‘honest’ or ‘uninhibited’. Through repeated

scrutiny and discussion and awareness of the context through which the teacher uses the term it becomes possible to disentangle these meanings.

After the third reading I wrote a protocol (appendix C) explaining how the mapping was done. This was given to another researcher who used the protocol to map three interviews. There were some small differences of interpretation and these were used to modify the protocol. In talking through the inferences we were making from the statements, we noted our assumptions. A third interview was coded and there was agreement on 21 out of 29 of the statements and again a small adjustment was made for clarity. Five more interviews were coded and there was found to be 90% agreement. Statements were coded under the following headings:

- Line numbers of the transcript which contains the extract referring to a particular code;
- The first and last words of the statement being coded
- The empirical indicator (These were subdivided as far as possible. For example where a teacher referred to students making their experiences of a therapy through drawings this was coded under Modes of Thought/Narrative/Visual/Drawings).
- Sub-indicators. These refer to themes which emerged beyond the framework which, nonetheless, helped to illuminate context or deepen meaning of the empirical indicator.
- Comments. These were comments which the coder made as a note, for example drawing attention to something unusual about the statement.
- Assumptions, where the coders made clear why they were categorising a statement in a particular way, for example, where the term ‘experience’ was used it almost always referred to some form of narrative.

After coding the data I noticed that a pattern began to emerge under coding headings when sufficient data had been collected. New sub-categories were added to the empirical indicators and trawled through previously coded interviews.

The number of statements sufficient to form a pattern is difficult to assess: empirical indicators are gleaned from only one or two teachers for some communicative virtues

and levels of disagreement; for others such as role of evidence there are a substantial number of statements to indicate growing patterns. Where a consistent pattern begins to emerge there were instances of 'deviance' in some cases. For example, most of the teachers interviewed stressed the importance of underlying facts/data/information to support the teaching of a controversial issue. However there were three instances of teachers who gave statements which refuted the need for facts (discussed more fully in Chapter 6). This is a limited case of deviant case analysis because statements are identified and analysed which appear to contradict a strongly emergent pattern based on a comparison between the normative character of those statements and those of the rest of the sample (Silverman, 2005) (p.215). These 'deviant' statements helped to question the grounds for the need for facts which many teachers interviewed took as granted and unquestioned.

5.5 Ethical guidelines

Ethical guidelines were followed which are consistent with the British Educational Research Association's 'Revised Ethical Guidelines for Educational Research (2004)'. All respondents had been approached by letter through the school and consent to be interviewed was given orally by all teachers. Teachers were told that the purpose of the interview was to survey the teaching of socio-scientific controversial issues, that their identities would remain anonymous, that we would need their agreement to tape them, that they could withdraw at any point and that we would turn off the tape-recorder at any point if they requested it. They were also informed that the research was funded by The Wellcome Trust and that the findings would be published in a report. Consent was affirmed before any recording took place. At the end of each interview significant points were recapitulated and respondents were asked if there was anything they would like to change or clarify. Copies of the provisional findings were sent to the headteachers of all the schools we approached and they were asked to make them available to the teachers.

On one occasion a teacher asked for the recorder to be turned off because she felt she was about to make a statement deleterious to the school management. Interviewers had agreed that no disclosure would be made available to management, if requested, but it was also made clear to participants that if they made any explicit criticism of

school management this would not be published and need only be made if it clarified any point they wished to justify.

One lead researcher (myself), two research officers and three consultants took part in the research. Their roles in helping to design the interview schedule and carry out the interviews are fully acknowledged. Written agreements were made with the research funders, The Wellcome Trust, that they would agree to publications of any findings beyond those that were written in the reports and that their funding would be acknowledged. All the analysis of the data based on the pedagogical framework is entirely my own work as are the conclusions that are drawn from it.

The statements were collected and coded in the form of a table in appendix D. In Chapter 6, I discuss the results of this analysis.

Chapter 6: Results and analysis

6.1 Introduction

In Chapter 4 I developed a framework for teaching controversial socio-scientific issues, illustrated by Figure 4.2, in which the Levels of Disagreement (LoDs) form the core of a thread integrated with Modes of Thought (MoTs) and Communicative Virtues (CVs). The content of disagreements is largely elaborated in the LoDs. The coding system has been explained in Chapter 5.

In this chapter I analyse teachers' constructions of teaching socio-scientific issues to see how their perceptions of the realities of teaching underpin the framework, and therefore to identify those practices which operationalise the framework in the classroom and where development or change will be necessary.

The first strand I report on is Levels of Disagreement which I consider to be the major component of the framework. There are nine levels[74] (see Table 4.1). The first two levels are an account of how evidence can putatively be used to settle a matter, although in level 2 the evidence is more complex. I shall be treating these first two levels as one although pointing out differences between them. It is unlikely that the way the teachers talk about evidence follows the pattern of the strand of Levels of Disagreement so those statements have been analysed which relate to some feature of evidence within a disagreement. As I have pointed out in Table 4.1 and in Section 4.3.1.1, concepts of evidence pervade other levels of disagreement in Table 4.1. I want to suggest at this point that there is a difference between the role of evidence in levels 1 and 2 where there is a degree of consensus that it has an explicit and central role in helping to resolve disagreements compared with levels 3 to 9 where disagreements are mediated by differences in ethical judgements, vested interests, experiences and worldviews.

Only six of the teachers interviewed used the word 'evidence' when talking about how they would teach socio-scientific controversial issues. I shall look at these extracts first to begin to exemplify how teachers conceptualise evidence in their teaching and how different parts of the framework come together.

[74] I do not address level 7 because it is subsumed in a number of other levels.

The extracts are numbered to simplify cross-referencing.

6.2 Teachers' constructions of evidence in teaching socio-scientific issues

6.2.1 Use of the term 'evidence'

> *Extract 1*
> . . . I try and stick to evidence and what things are in a very factual way. I mean with evolution, we stick to evidence. I don't speculate. I say: this is the evidence, this is the current model, when a new model comes up then it will be replaced but this is the current model . . . (Q/Biology)[75].

Evidence is presented here as neutral and incontrovertible. Facts and data are the forms of evidence drawn upon to support or refute a theoretical model. Superficially, it reflects the level 1 formulation of evidence although the teacher does not explain how the evidence settles any supposed disagreement, say between those who accept Evolution and its supporting theories and those who believe in creationism, or indeed contending theories which explain Evolution such as punctuated equilibrium and phyletic gradualism. This teacher conceives of evidence as underpinning established scientific theories, as distinct from contemporary socio-scientific issues where disagreements might be susceptible to being settled by evidence, but where the evidence is usually complex, indeterminate and evolving. The point being made in extract 1 implies the possibility of determining the relationship between evidence and theory, that theories involve the collection and use of data but that they are underdetermined by data, 'the current model' – the propositions of the theory or generalisation always go beyond the evidence (Driver *et al*., 1996). To make sense of theory-building in socio-scientific issues students need to understand the difference between the role of evidence in established science – largely used to explain the theory and is subordinate to it – and the nature of evidence in emerging theory in contemporary issues where the theory is, at best, at a seminal stage and subordinate to the evidence (Tytler *et al*., 2001). When students have been educated to collect evidence to explain authoritative science (Zemplén, 2007) they need to understand that

[75] (School/Subject/position in school if any)

the role of evidence in mainstream theories has a different relationship to theory compared with evidence in 'frontier science' (Bauer, 1997)

The headteacher of School C whose specialist subject is English explains how a case study approach helps to bring an issue to life:

> *Extract 2*
>
> . . . you need all the facts and figures to give . . . the pupils something to bite on in terms of why do we think the way we do about this particular issue, based on factual scientific evidence, but on the other hand then for the pupils to relate that to their own lives. If we've got a very small context, well then they can see that at work, whether it's in a particular religious community in terms of transplants, for example, or blood transfusion, then it really comes home to them much deeper than just telling the facts.' (C/English/Headteacher).

The contrast is between the seeming aridity of having the 'factual scientific evidence' against the reality of having insight into a situation. Ambivalence about the distinction between systematic, valid and reliable 'evidence' in the form of facts and figures, and experience, is expressed through the former helping pupils to get to grips with why they think about the issue in a particular way. Factual scientific evidence can help to give an overview but the picture shifts when students begin to be immersed in the details and realities of those who experience what it is like to have a transplant or blood transfusion. The underlying contrast is not between hard evidence and no evidence but generalized scientific evidence and 'anecdotal' evidence (Aikenhead, 2005; Tytler *et al*., 2001) which helps to form a bridge between personal experience and scientific claims. Saying that ' it really comes home to them much deeper than just telling the facts' the headteacher appears to be pointing out that when 'facts' are contextualised they illuminate the issue more effectively. This extract also has a resonance with Section 4.2 where students' initial interest has to be a motivationg factor in discussing controversial issues. In looking again at levels 1 and 2 in Table 4.1 this extract raises the question of whether something more detailed needs to be said about generalised scientific evidence and 'anecdotal' evidence in helping to resolve a disagreement.

Extract 2 also illustrates the distinction between narrative (which carries the anecdotal evidence) and logico-scientific (comprising the scientific evidence) modes of thought. The headteacher emphasizes the difference, and not the connection between the two,

and this is a reminder that both the differences and connections need to be explicated in any reformulation of the framework. This is a point I will return to when analysing statements about Modes of Thought.

'Evidence' is mentioned by another teacher of English who relates how students have opinions but:

> *Extract 3*
>
> . . . they (the students) are very rarely able to bring evidence to back up their opinions and that's why these things need to be taught in terms of some sort of evidence base, so it's just simply "oh eating meat means you're going to get mad cow disease" and that is the sort of level of discussion that you tend to get.' (E/English/Head of department).

To have an informed point of view students need 'evidence' to substantiate their opinion. In referring to 'mad cow disease' or BSE[76] the teacher is suggesting that having 'evidence' will help make the link between the risk of eating meat and contracting CJD[77]. Although the teacher does not expand on the quality or quantity of evidence needed (Gott *et al*., 2006) there is a clear indication that there is space in the lesson for evidence to inform a discussion, i.e. a controversial question has been raised. The relationship between eating meat and contracting the disease is highly complex, presupposing a deep knowledge of risk and probability. While the teacher cannot be expected to provide that knowledge, students might at least have an awareness of the concepts of evidence needed to begin to understand the complexity of the relationship between the causative agent in the meat and the outcome of the disease. This is what the teacher appears to imply here. As Tytler *et al.* (2001) advocate students could start, for example, with simple case studies in investigative work, in which they have to identify simple causal relationships in multivariate investigations, moving on to distinguish causal from correlational relationships. This is particularly true of level 2 where the complexity of the factors involved in studies such as BSE and the risks inherent in xenotransplantation can be illustrated more fully. Case studies could be drawn on which exemplify different types of procedural concepts of evidence (Ryder, 2002).

[76] bovine spongiform encepalopathy
[77] Creutzfeld-Jakob disease

Opinions are contrasted to facts but there is a distinction between opinion given with little consideration, thought or knowledge to substantiate it and opinion which is more fully grounded. Throughout the interviews, opinion is often perceived as the opposite of 'facts' which obfuscates the nuanced relationship between fact, value and opinion, and is discussed in more detail later in this chapter.

The head of 6th form, also head of GNVQ Health and Social Care, in school S explicates the distinction and the implied relationship between 'evidence' and opinion, like the teacher in extract 3 suggesting that there is clear debate.

Extract 4

> I'd want them to come up with different arguments and I'd want them to fight their case, and I'd want to give the two students the opportunities to give their opinions and to back it up with evidence, and at the simplest level most students come up with a gut feeling, which they can't substantiate with logic, argument, law or anything else. Well, you say "right we appreciate and value that gut feeling" because very often it's going to end up how you react, but we say "you've got to justify your behaviour or opinion, and if you were in a position of authority and making a decision, you might be held accountable for it, so you've now got to refer that gut feeling to certain other things to give that evidence and value. (S/Health and Social Care/Head of 6th form).

In this case there is a suggestion that evidence is more than data, it is a means of justification which involves logic, argument and law among other things. The teacher attempts to provide a context for the kind of evidence students would need without stipulating what that evidence would look like, although getting nearer than most.

In school G, the headteacher also refers to evidence as helping to form or even change opinion.

Extract 5

> I encourage them (the students) to talk, to discuss, to listen to me and to look at the material, the evidence, but then to discuss themselves, in small groups and you have to accept at the end, as a teacher however bigoted you consider their opinion is, it is still their opinion and you should do, having tried to show them how it could be different. But you do see it working with

some children and they sometimes go out of a lesson with a different point of view and that's nice. It might not last very long, they might get home and say " we did this in English", and parents say "well, that's a load of rubbish there's no need to think about that". But you've just made them question and that's good, that's what we are about.' (G/English/Headteacher).

This statement comes in the context of a headteacher of a secondary school in a very deprived area with 'grotty housing' and an outlook on life 'between a blinkered existence and totally amoral', hence the rather jaundiced reception he anticipates when students discuss a controversy in school with their parents. His account suggests that the evidence forms part of a persuasive rhetoric to underpin opinion and, from his experience, even changes minds, although he is cautious about whether the effect is permanent.

As is the case in extract 5 and, with five other teachers who refer to this, the historian in school O is sceptical as to whether compelling evidence has any permanent effect on opinion (Yount & Horton, 1992) although he sees evidence as a means of combating prejudice:

Extract 6

. . . with history . . . the whole nature of the subject is weighing evidence. So you look back at both sides, or all sides, and try to weigh the evidence up and therefore if you approach it in that sort of way, you can deal with controversies more. And, again, the questioning of evidence which . . . when you come across individual pupil's prejudice and you start to question it, it can fall apart quite easily. It falls apart, they don't necessarily accept it as falling apart but it does fall apart. . . . I might think I have done a good enough job to blow the myths away but that doesn't necessarily mean they have gone and, at the end, they may walk out and think well, yes, he's a teacher, he would say that, but I'm still going to believe this anyway. (O/History/Head of Humanities)

In extract 6 the teacher discusses evidence in history. How evidence is used is domain-specific and not easily transferable (Fehn, 1997). For historians, what is pivotal is the importance of sourcing documents and situating a text in space and time (Wineburg, 1991), a skill not central to the collection and analysis of evidence in science, although it might be called upon in the interpretation of evidence. What teachers mean by evidence, and its relation to theory and generalisation, might be influenced by the teachers' subject specialism.

Although he does not use the term explicitly only one teacher illustrated in some detail how a careful, sceptical understanding of evidence can be used to illuminate an issue.

> *Extract 7*
> . . . about HIV and AIDS, we touched on that again with a sixth form group, looking at problems in Third World cities and . . how population control, anti-natal policies are being introduced and how their success in the use of contraceptives is not because they are thinking they need to cut the number of people living in the cities, it's actually because of the fear of AIDS . . . it's just proving to the pupils that you shouldn't judge a book by its cover. Just because populations are dropping it is not necessarily because people are realizing the problem of homelessness, it's actually because of another fear that's not in the news. (R/Geography/Head of Humanities)

In this extract the teacher is drawing attention to the problems of inference and the complex relationships between variables, a pertinent illustration for level 2. This is also an example of the logico-scientific mode of thought, demonstrating the complexity of inferential procedures and their relationship to the relevant data.

With the exceptions of the preceding extract and those in section 6.2.2.2 teachers rarely expanded on, or gave examples of *how* facts, data, evidence or content knowledge could be used for purposes such as ethical decision-making or countering opinions. The formulations of levels 1 and 2 in the LoDs presuppose a process through which evidence can settle a disagreement but the vast majority of statements lacked specificity and did not reflect in any detail how evidence could be used to settle a matter. There is some very tentative evidence at this stage to open up differences between science and humanities teachers: extract 1 suggests there is a lack of debate and difference 'I don't speculate', in extracts 2 to 6 discussion and difference of opinion in the lessons of humanities' teachers are manifest even though the role of evidence in pointing to any kind of decision-making needs considerable elaboration.

6.2.2 Evidence themes

Two themes were derived through coding for statements relating to evidence:

- need of teachers and pupils for facts/knowledge/data/evidence/information/science (34 teachers);

- distinctions between facts and opinion/value/ethics (23 teachers).

Besides the extracts from the teachers discussed in section 6.2.1 most common terms that had some correspondence with the meaning of evidence were ‘facts’, ‘information’, ‘science’ and ‘knowledge’. While the uses of these terms were often vague and decontextualised they referred to a body of information, and the associated procedures, in helping to think about and shed light on a dilemma or issue. The meanings derived from teachers’ statements are often much looser than those discussed in the Concepts of Evidence (Gott *et al*., 2006).

Although there are empirical indicators relating to evidence from 51 teachers there are a greater number of empirical indicators than teachers. Statements about ‘evidence’ could have been made in different parts of the interview in different contexts. For example, in one part of an interview a teacher refers to the ‘need for facts if one is to have an opinion’, and in another part discusses the problem of reliability of facts. Sometimes one statement might contain two different themes. For example, the statement ‘It’s difficult for teachers to use newspapers because they need facts not someone’s opinion’ would be coded under ‘need for facts’ and also ‘fact/opinion’.

6.2.2.1 Need for facts

The most prominent explication of evidence in teaching in terms of number of teachers and numbers of statements is the need for facts or information for teachers and for students to bolster the teaching of controversial issues. In this theme the terms, ‘facts’, ‘knowledge’, ‘data’, ‘evidence’, ‘information’, ‘science’ have similar meanings in the contexts of teachers’ statements.

Statements referring to need for facts for teachers could themselves be subdivided into three distinct coding schemes:

a. Need for evidence in the form of information/facts/science/knowledge.
b. Sentences or longer statements which contain explicit or implied logical indicators which justify why the facts or information or science knowledge are needed.
c. Sentences or longer statements about the usefulness of facts.

a. Need for evidence in the form of information/facts/science/knowledge.

Examples of these kinds of statements are:

Extract 8

We need . . . factual information as well, so that you're actually aware of the facts, and any recent research or developments.(T/D&T)

Extract 9

. . . like everyone I see things about genetically modified food in the paper and you hear about rats and potatoes etc. I still only have coming through to me very limited amounts of factual information. Although I am aware the papers do exist, of course, the time as a non-university member of staff it is very difficult to actually find time to read through very detailed information'. (R/Biology/Head of Biology)'

Extract 10

The impediments are lack of information and the danger of giving wrong information or warped information . . . (G/English/Headteacher)

Extract 11

It would be very useful as a teacher, given that we're in a fast changing world and we are constantly dealing with these issues, to have a regular, routine, factual base . . . so, on occasions, we can say "well, that's factually incorrect" (H/Sociology)

Extract 12

I'm not happy teaching anything unless I know the ins and outs of it. So I wouldn't be happy to go in for example next lesson and say "right, let's talk about genetically modified foods" because I may read a bit about it in the newspaper but not enough to actually fully know what I'm talking about if something crops up. (H/Science)

Extract 12 reflects a caution among science teachers both in terms of the need to proceed from a secure rather than tentative knowledge or information base and a suspicion of incorrect knowledge being used in debate in non-science lessons. Extracts 8 to 12 refer to the knowledge base needed by the teacher but there were as many statements about the students' need for an increased knowledge base, for example:

Extract 13

I want them to be doing small, little bits of debate . . . so that they can get the informed opinion. That's the thing, they need the information, they need to know what the facts are. (D/Geography)

Extract 14

Discussion, usually at that point, sixteen/seventeen year olds, will bring very strong views on the matter and so you're going to chair discussion and at the end of the discussion you're probably going to weigh up the various arguments that have been given and say, "all these are valid. Make sure to answer this question properly, you would probably need to know more about the facts of the situation and therefore do your own personal research." And that's why we're saying you should read the broadsheets regularly. (J/English/Head of 6th form)

The emphasis here is on the need to have, or to gain access to, facts or information without discussing specifically the purpose or use to which those facts are put although in the context of 'debate' and 'discussion'. Where a purpose is given, such as extract 11, having the information to correct students with incorrect facts, or in extract 14 to support an argument, the statements do not explain how this information can be used to resolve or illuminate a disagreement, or make a judgement. The majority of teachers were thus aware of the need for evidence but there was no discussion of how that evidence could be used in the context of a socio-scientific issue or any aspect of a disagreement.

Teachers of science prioritise the day-to-day function of teaching their subject or science content knowledge over reflection about the nature of evidence within controversial issues. These findings are consistent with teachers' consideration of evidence in the Evidence-based Practice in Science Education (EPSE) case studies ' . . . when discussing the teaching of a controversial issue in science, . . .where they perceive their primary function as "dispensers of knowledge" providing pupils with factual information' (Bartholomew, Osborne, & Ratcliffe, 2002) (p.17).

b. Sentences or longer statements which contain explicit or implied logical indicators which justify why the facts or information or science knowledge are needed. Examples are:

Extract 15

I'd explain the science simply enough for them to understand . . . and the whole issue of cloning, for example that with test-tube babies, you mix these things together and somehow out pops a fully grown human being. That is no different from having an identical twin, and that

for example cloning happens in plants now because plants asexually reproduce and some animals do and try and make it not as sensationalised and getting back to hard facts. (N/Health Studies/Head of department).

Similarly,

Extract 16

Test-tube babies . . . they don't understand it really, what's involved. they think the baby is in a test tube. So hopefully I educated them on that'. (C/Science/Head of department)

Extract 17

Well. I think with the *ivf* [78]it gives students the opportunity to test out some of their ideas against fact. They might have formulated an idea in their mind about *ivf* but that idea might be based on false assumptions. And I think that one of our jobs as a teacher is to actually lay out before them a factual base on which they can make their decision. (T/RE/Senior teacher).

Students are seen to need the 'hard facts' to correct misconceptions or false assumptions. From a teacher's point of view this is an understandable pre-requisite before exploring a controversy in depth. If, for example, students believe that *ivf* results in a fully-grown human being there can be no purchase in discussing whether the National Health Service (NHS) should or should not fund *ivf*. The discussion is meaningless when one party does not understand the terminology and where that understanding has been assumed by other parties to the conversation. In many situations such as extract 15 - and school N is an academically selective school - teachers have to establish accurate descriptive statements. But the question remains as to how the hard facts can help students to resolve dilemmas where the science is messy and uncertain as it is in contemporary issues:

Extract 18

. . . there were a lot of very homophobic attitudes particularly among the boys . . But we just say, 'well, the statistics say one in five. So the odds are there are three or four of you in this room that are or will have homosexual tendencies before you die' (S/English/head of department)

[78] *in vitro fertilisation*

Extract 19

First of all you've got to have the black and white facts about it . . ., otherwise they have these preconceived ideas . . . (facts) must be bang up to date . . ., kids have got their own very strong ideas, quite often ill-informed because they're at a young age. (C/Geography).

These are representative statements from teachers justifying the teaching of facts for the purpose of combating prejudice, which could be mapped on to Level 1 only in the sense that once accurate information has been provided, it assumes that prejudice based upon misinformation will be eradicated, e.g. . . .'But we just say . . .' in extract 18. Such an approach in presenting information neglects social context, political realities, the role of persuasive language and the logical procedures that connect data to claims.

To summarise, In terms of the LoDs it becomes clear that there are unlikely to be many examples of socio-scientific issues to illustrate Level 1 because of their uncertainty and complexity. Evidence from research suggests that there is scope for exemplars which illustrate the link between domain-specific understanding of the evidence and the relationship to the justification of claims. So far the following pedagogical points need to be included within levels 1 and 2:

Teachers need to explain the difference between the role of evidence in well-established scientific theories, such as Evolution, the Laws of Motion and Atomic Theory, and the role of evidence in contemporary socio-scientific issues. Extract 1 is a clear indicator of the way in which evidence is presented to underpin canonical theory. As evidenced from extracts 2 to 7, 13 and 14 humanities teachers raise questions and run discussions and debates on socio-scientific issues, they recognise the need for evidence but do not specify the nature or content of the evidence or how it can support decision-making. Teachers need to exemplify anecdotal evidence and scientific evidence and teach the nature of the differences between them. Extract 2 demonstrates schematically what these two types of evidence might look like.

Much of the focus from the extracts discussed in section 6.2.2.1 is on the need for facts but little as to process and purpose. Teachers could use scientific investigations to explicate the procedural concepts related to evidence and can illustrate them in case

studies of socio-scientific issues in which the relationship between data and evidence and the justification of a claim needs to be made explicit. As indicated from extract 7, logical processes, such as inference and the detection of fallacious arguments, need to be explicitly taught in relation to a particular case study. Teachers sometimes use facts to correct misconceptions or prejudices (extracts 15 to 19) but there is little sense of how these facts are used to illuminate decision-making or to highlight inconsistencies in arguments. As noted in the comments on extract 6 the subject specialism of a teacher may influence the way they teach about the selection, use and interpretation of evidence so it needs to be made clear in which domain evidence is being judged. And extracts 5 and 6 are consistent with the discussion in Chapter 4 that evidence, however compelling, does not necessarily change minds in the context of discussing socio-scientific issues in school classrooms.

6.2.2.2 Deviant cases

c. Sentences or longer statements about the usefulness of facts.

These statements were conspicuous as instances of deviant case analysis when teachers at some point in their narrative questioned the need for scientifically based facts. Their views are important for the study as a whole because they draw attention to the problem of the use of substantive scientific knowledge and scientific evidence in teaching controversial issues.

Teachers' requirements for information and facts to support teaching of socio-scientific issues contrasted with statements from three teachers which stood out as discrepant in relation to the coded themes. In *deviant case analysis* (Silverman, 2005) examination of outliers or statements which 'go against the grain' give insight into the ways in which teachers draw on evidence in the form of data, facts or information in discussing a socio-scientific issue. These ‘outlier’ statements came from three teachers - a sociologist and two historians. (A/Sociology; O/history; T/history)

While the three teachers offer arguments which question the need for substantive science knowledge, throughout these interviews there is an underlying ambivalence in their narratives. The sociologist wants 'an information pack that has all the data' on an

issue such as 'the current debate about cloning' and adds 'I don't have to discuss the science issues with any real knowledge'.

He is keenly aware of his own lack of knowledge of related science –

> *Extract 20*
> . . . it's actually to do with my knowledge base . . . my only resource at the moment would of course be the press or media . . . I'm not a scientist so I couldn't begin to teach this. (A/Sociology/head of Humanities)

Reflecting further on how he might approach the topic he then elaborates on how his teaching would appear in his own subject area:

> *Extract 21*
> In the sociology department what I would be looking at (are) the whole notions of power and power base and the role of government (A/Sociology/Head of Humanities)

and a sentence later he emphasizes this in detailing:

> *Extract 22*
> . . . my teaching, the way it would come out would be the notion of control, power and the decision-making in our society and relationships between this and the media and democracy and so on. (A/Sociology/Head of Humanities)

A similar point is made by another teacher:

> *Extract 23*
> But really we're looking at the pressure groups and how they behave as opposed to the actual details and the issues behind them. You have some understanding of the issues, that's outlined, but we don't have a big discussion on those issues necessarily. We have a discussion on whether or not those pressure groups are using the right tactics to get those things across. (B/Politics & General Studies/Head of Politics)

Extracts 21 to 23 raise problems in terms of the LoDs. What is highlighted is that power and media are instrumental in decision-making and it is precisely this political role which might afford undue weight to evidence from more powerful groups or individuals as

exemplified in Section 4.3.1.1. This problem is not explicitly included within formulations of the types of disagreement between reasonable people in a democracy or in the social formulations in table 4.1. But unequal power distribution is a consequence of a liberal society based on individualism where those who have the greatest bargaining power have the greatest freedom to meet their needs - the 'disadvantaged in a liberal society are those without the means to bargain' (MacIntyre, 1988) (p. 335). The role of power, influence and the media in, for example, the selection and reporting of evidence needs to be addressed in the overall pedagogic framework. It might be significant that the role of power has been identified by two social scientists indicating that their focus on evidence is different from that of a scientist.

In Chapter 2 I referred to those relations of science and society – *dialogic/negotiated* and *collective praxis* – which contained an explicit problematic of the authority and power of science. However the examples I have chosen in Chapter 4, (Sections 4.6 and 4.7) have been based on the teaching of socio-scientific issues within the school – the *school science & social issues* model - without problematising the relationship of power groups. Authority and power are intrinsic to the discourse of the *collective praxis* model because this model is predicated on social justice and change where authority, particularly that of scientific expertise, is challenged. Established and uncontested Science is dominant in the discourse in the *school science & social issues* model which approximates most closely to curriculum specifications and classroom practice. But teachers need to expand the framework to show how evidence in socio-scientific issues is not treated in a social vacuum.

Later in the interview when asked about resources the sociology teacher returns to the need for knowledge acquisition. When the teacher explains the way he would approach a topic in terms of classroom teaching experience as a sociology teacher the account excludes the need for science knowledge. When discussing the teaching in a general sense he comes back to the science content knowledge.

The history teacher (school O) finds that the purpose of 'facts' in a discussion on moral issues is problematic:

Extract 24

I am not saying that we shouldn't have the facts there, but if we start doing the facts, in terms of any detail, then it is easy to get away from what we are doing and end up sort of teaching the science rather than . . . I'm not awfully happy with the answer because it sounds as if I'm saying . . . we want the judgement without the facts being there which is not what I mean obviously, but what I'm saying is that it's the focus we are concentrating on is on the moral aspect of it . . . (O/History/Head of Humanities)

The interviewer then asks if the teacher means that the science facts might get in the way of focusing on the moral side of things. At this point, after some initial hesitation, the teacher explains:

Extract 25

. . . I don't think from a Humanities point of view or from a history point of view being provided with the scientific explanation . . . would necessarily help . . . what I perceive my job to be is to, say, look at the moral issues behind the holocaust. The chemical composition of Zyklon B makes no difference whatsoever. That's the sort of thing - I know it's not explained well - but that's the sort of thing I am looking at and again it's, yes, if you talk about Hitler's policy of eugenics I don't need necessarily a full genetic breakdown to be able to explain what we are looking at. (O/History/Head of Humanities)

A few sentences later, however, when discussing resources there is still a sense that the scientific facts cannot be fully dispensed with:

Extract 26

If there are scientific facts I would want them simple enough so that even I could understand it. . . . (O/History/Head of Humanities)

A similar ambivalence emerges from the history teacher in school T. Maintaining that 'facts guide decision-making' there is also 'no real need to have an in-depth science knowledge for issues in the context of history.'

In discussing the moral issues behind the Holocaust we might not need scientific facts but we still need to draw on evidence to think about those moral issues. Perhaps the distance between the chemical structure of Zyklon B and its use is not so far as the history teacher in school O implies. Is there evidence that scientists who were engaged in synthesizing the gas understood its purpose? The technicians who used it in the gas

chambers must have had to estimate how much was needed. What moral responsibility do they bear? But the overall point with which I think the history teacher in school O was struggling with is that the moral issues of an event so extreme – and horrific - as the Holocaust again signify how the nature of evidence is so enmeshed with power. As an example:

> *Extract 27*
>
> . . . if it's an issue where the government's taking a particular stand and therefore accurate information may be hard to get at because we may not get full disclosure. An example might be the BSE crisis, with a lot of people hanging out the window saying "I know what's going on" being pulled inside by the government and being gagged and not allowed to speak. So there's disinformation as well. Not just from government. Large companies with large commercial interests – like Monsanto for example in the Biotechnology field – it's not in their interests if they publish a study and there's been one just this week that's a major issue. There was a guy given 10 million pounds to research the effect of mobile phones. He went back and told them "they're very bad for the health" and the phone companies have ditched the report and won't let anybody else see it. So commercial interest, where these issues are not just a matter of single individual decision, like say for a blood transfusion, but actually involve big bucks in terms of commercial organisations. It can then be difficult to get truly unbiased information, because the natural people to go to – like Greenpeace/Friends of the Earth – whom you hope might have more of the truth, they'll have their own political bias they want to put on the article as well and you sometimes have to do some sifting out to say "where is the real truth here?" to arrive at an informed opinion.(J/Ps-RE/deputy head 6th form)

That evidence operates in a socially differentiated environment in socio-scientific issues using institutions such as the media and lobby groups needs to be incorporated in the pedagogic framework and made explicit in teaching. Knowledge of how this operates through institutions such as the media and lobby groups needs to be made explicit when teaching socio-scientific controversial issues in schools. Active participation by students in a focused issue, as exemplified by the *collective praxis* model, might be a means of increasing awareness of the social impact on the nature of evidence.

6.2.2.3 Fact and opinion

> *Extract 28*
>
> When you talk about the ethics of anything you're going to give an opinion rather than something that's fact-based. Once you start giving an opinion then you express disagreement.

> Then they (the students) treat the whole of the subject in the same way that they treat your opinion in that they disagree with it personally. So they might end up treating your fact-based stuff in the same manner. (A/Science)

The second theme in teachers' considerations of evidence is the contrasting of fact against opinion. In extract 28 the teacher expresses a stark warning about the problem of teaching ethics almost as an infection that subverts the authority of facts, a theme which returns when science teachers refer to discussion on socio-scientific issues. While there are few accounts from other teachers which are as strongly worded as this, teachers from all curriculum areas see both the need to distinguish facts from opinion, and that opinion needs to be informed by fact. Most teachers who referred to fact and opinion/values felt that they ought to be treated differently in different subject areas: facts in science, and opinion in the humanities or, at least, separate from science lessons. A statement which typified the curricular approach of many science and humanities teachers was:

> *Extract 29*
> . . . the slant we would take in R.E. would be different to the slant in science: we'd be looking at the moral and ethical issues, whereas they (science teachers) might touch on it but they'd be primarily interested in the make up of it. (J/R.E./head of Humanities).

One science teacher, however, was concerned about professional labelling in dealing with content solely:

> *Extract 30*
> I think a lot of people will tend to see . . . that science teachers we would only be concerned with the mechanisms of things like this, how is genetic engineering done? . . . and so on rather than what it means or any implications of it (D/Physics)

Although not specifically coded almost all science teachers mentioned constraints in the science curriculum such as 'overloaded content' and 'lack of time' but there was also another curricular factor raised by the headteacher of school O, himself a scientist.

> *Extract 31*
> There's nothing in the science course that says "what's your opinion about this?". It tends to be factual about what they know about it rather than an opinion. (O/Physics/Headteacher)

In contrasting facts with opinion, the latter has been deemed to subsume terms which have been distinctly counterpoised to 'facts' – 'emotion', 'gut feeling', 'speculation' and 'hype', and many teachers felt they had a duty to emphasize the former, either excluding any discussion of opinion or only allowing values to enter the lesson if there was time available.

> *Extract 32*
> . . . the ideal scenario is that you present the issues and you give the students space to make up their own minds . . . You can just give them knowledge really, that they'll make decisions. It's incumbent on teachers to give knowledge, not an opinion. (S/English/Head of department).

> *Extract 33*
> I try not to teach the ethical issue, I just try and teach the factual side of things. I raise the idea that there may be ethical issues but I allow people to come to their own conclusions on that. For example, in the science area . . . we have to teach evolution and that may be at odds with a lot of people's religious beliefs and so you have to always treat it with sensitivity and you teach the incontrovertible facts but then you allow people room to accommodate that into their own belief and ethical framework. (Q/Biology).

> *Extract 34*
> . . . on the whole I think – and my other colleagues too in the biology area – we would tend to try and give, if you like, the factual biology issue rather than give a personal opinion. So, for example, a lot of the adverse publicity about genetically modified foods . . . and we're talking level 3[79] students here, they appreciate as far as they can what this actually means at a molecular biological level. What is . . . being manipulated here, and therefore what possible risks could there be. And quite clearly to lead them possibly down a road of media hysteria and that where are there in these articles any facts based on . . . why is this bad, why is this dangerous, why are tomatoes Frankenstein tomatoes . . . we have various videos which we use for the genetic engineering side. Again they don't necessarily value judge things, they give, if you like, just the scientific objective facts of this issue. (L/Biology/Head of science).

Facts are understood, therefore, as reliable and they can be trusted, capable of being objectively true and warranted. Opinions/values, on the other hand, are incapable of being objectively true and warranted. The distinction is between factual knowledge and non-cognitive components of the question being addressed. This distinction also applies to the difference between science and the humanities although some humanities teachers (extract 32) felt that they had to keep to objectively true knowledge.

[79] Level 3 refers to GNVQ.

The problem in assuming that factual statements can be decoupled from value statements is that claims for social views have used scientific research for their legitimation. Scientific evidence has been used to justify eugenic views which are still part of 'scientific' discourse. Stephen Jay Gould (1985) describes how in the 1980s the prime minister of Singapore, Lee Kuan Yew, using notions of heritability of IQ, encouraged educated people to breed while advocating measures to prevent less educated people having children. Lee justified this policy on the basis that 'There is increasing evidence that nature, or what is inherited, is the greater determinant of a person's performance than nurture . . . The conclusions the researchers draw is that 80 percent is nature, or inherited, and 20 percent the differences from different environment and upbringing' (Gould, 1985). Developments in genomics have prompted Jim Watson, the co-discoverer of the structure of DNA, to advocate the use of research in genetics to promote selection against low intelligence and for beauty. 'People say it would be terrible if we made all girls pretty. I think it would be great' [80]. Contemporary debates about evolutionary psychology demonstrate the very distinct premises and discourses with which scientists view their work and interpret data (H. Rose & Rose, 2001). 'Facts' that inform socio-scientific issues can be drenched in values[81], and highlighting the dichotomy for students might distort their understandings of the way evidence is generated and interpreted. One teacher, in referring to the usefulness of newspaper articles in promoting discussion about socio-scientific issues, recognises that the same facts can be interpreted in different ways:

> *Extract 35*
>
> . . . Sometimes it's also possible to see a political slant in that you can see the same story reported in two different newspapers and say "well, hang on, we're supposed to have the same facts here but it doesn't sound the same" . . . ((J/Ps-RE/Deputy head 6th form)

None of the statements by teachers in this theme refer to specific contexts in which disinterested facts provide higher quality evidence than value statements. What

[80] Available online at: http://www.newscientist.com/article.ns?id=dn3451 (last accessed 31st May 2007).
I suspect Watson had his tongue firmly in his cheek. He is noted for outrageous statements which garner publicity. However this rhetoric is made to raise the stakes and is consistent with his broad views on selection.
[81] See, for example, Section 4.3.1.4.

teachers appear to be addressing is the real and legitimate concern that students often give very strident views without any reference to the data which would be needed to underpin those views[82]. But it does not follow that facts are not themselves coloured by value and opinion.

Science teachers in particular referred to the untrustworthiness of the media, particularly the tabloid press (e.g. extract 34). Besides very misleading attention-grabbing headlines, research suggests that the crucial factor is not so much that the content of the media text is untrustworthy but for students to understand how science stories are constructed (Jarman & McClune, 2003) and the skills to interpret them (Phillips & Norris, 1999). The caution with which the press quote sources could be an important lesson in reading text carefully for qualifiers and the importance in identifying named sources - a pedagogic approach which could be embedded in the framework in terms of scepticism and qualified confidence in sources of evidence.

In socio-scientific issues in particular it might not be helpful to focus on the distinction between facts and values and opinions but instead to examine all sources of knowledge critically. Since controversy and disagreement are value-laden it is through 'intelligent reflection' on our valuations, i.e. criticism, that we can find out which value judgements are warranted and which are not (Putnam, 2002) (p.103).

[82] One teacher showed me an essay by a student against cloning which had middle aged clones being born which links with teachers talking about the need for facts to correct misconceptions.

6.2.3 Discussion of levels 3 to 9

This section discusses those levels where factors central to the dispute cannot necessarily be resolved by evidence, if they can be resolved at all.

> ***Level 3: Where the range of criteria relevant for judging a matter are agreed, but the relevant weight to be given to different criteria in a given decision is disputed***

This might include such decisions as cost-effectiveness as opposed to a rights-based based decision. For example, both financial constraints and human rights are deemed to be relevant and appropriate to decision-making but there are disagreements as to what should be prioritised. Four teachers made statements which could be mapped on to this level.

One teacher raised the problem associated with new reproductive technologies in some depth and a host of dilemmas connected with them, thereby broadly subsuming statements made by other teachers which were more schematic.

> *Extract 36*
> Reproductive technologies . . . sometimes there is an ethical issue over the amount of money that is spent. There could be an argument that you let nature takes its course . . . and that's very cold cut and seems a cruel thing to say to somebody who desperately wants children and can't. I . . . would touch on that about the environmental issues and the rate of pregnancy . . . things like is there something in our tap water or what about these plastic bottles we are drinking out of? What's causing the increase in male sterility and the lower fertilisation rates? . . . there is an ethical issue there because an inordinate amount of money, if you want to put a value judgement on this, is actually being pumped into this. It may actually be that there are other issues that ought to better funded . . . (G/Science/Head of department)

This extract demonstrates the complexity of this issue by raising the links between other contemporary technologies and the decisions we make about reproductive technologies. These are the kinds of decisions that are often enacted in role plays on socio-scientific issues (Simonneaux, 2001) but role plays were not mentioned or discussed in any depth by teachers. Role play itself is unlikely to be sufficient for

reasoned decision-making: a knowledge of the ethical grounds on which prioritisation takes place would need to comprise part of the decision-making process.

Level 4: Where a range of cherished goods cannot simultaneously be realised, and where there is a lack of a clear answer about the grounds on which priorities can be set and adjustments made

The statements at this level suggest that there might be agreement between contending parties but that all parties recognise that there are grey areas about difficult moral and ethical decisions, for example, about people's conflicting rights:

> *Extract 37*
> . . . I'm hoping to look at . . . articles which are very much for the freedom of the individual to make their own choices, to express those views, and that sometimes conflicts, doesn't it, with other people's rights. And that's an interesting issue to look at so I think I'll do that at the beginning and set the tone for the rest of the discussion through . . . people's rights. (D/R.E.)

Other teachers used the broad areas of disagreement raised by this level as teaching approaches in the classroom, often personalising the issues so the students had a deeper understanding of their implications:

> *Extract 38*
> . . . if you go for genetic testing, unlike going for an HIV[83] test, it doesn't just affect you. The results of that, if you tell your family, are going to have huge implications for the rest of the family because they might say "Well, I have this". (I/Science)

> *Extract 39*
> . . . Dolly the Sheep, there is another interesting discussion point . . . as to where cloning helps and is of medical use and the huge advantages that could come out of it and where it starts going either unnecessarily or morally wrong. Again, get them to think of some scenarios that aren't necessarily Dolly the Sheep but are perhaps Mark the Boy in Year 10. So, if we clone Mark where are the advantages, where are the disadvantages, where should we draw the line. (G/ English/Head of School)

[83] Human Immunodeficiency Virus

Extract 40

. . . with genetic engineering, look at things like insurance . . . and employment agencies – are you going to get employment if you've got dodgy genes? (C/Science)

Extract 41

. . . if you're talking about treatments both from the point of view of how drugs testing is done and also the ethical view of if, you're testing a life, well an HIV drug for example, an anti-HIV drug, do you withhold it from people because you're doing a test? (D/Science)

These statements provide a rich source of possible scenarios where personalisation and role play help to make the disagreements more immediate. Disagreements will also be related to different ethical frameworks which influence priorities. If one does what one believes to be right out of a sense of duty then the evidence needed to underpin a course of action could be different from the evidence which needs to be weighed to produce the outcome of the greatest amount of happiness. With the exceptions of two teachers, both in school D, there was no reference to ethical principles and no discussion of evidence which might be needed for ethical judgements, suggesting that ethics needs to be made explicit.

For one teacher it was about a dilemma directly related to her teaching content, the vocational needs of some of the girls, the law about dissections and the genuine revulsion felt by students over dissection of animals:

Extract 42

I couldn't really justify killing animals for dissection. However, we do offer a possibility of seeing the dissection of a worm and then possibly a rat, as a club for the upper 6th, which is for a very few girls who actually ask about this because they're going in for veterinary science or medicine. And they're worried it's going to be such a shock when they first get to university and that they're not going to cope. We use it as a vehicle of filtering themselves out but that's kept very hush-hush at school. Most of the girls don't even know it happens. (I/Science)

This issue is considered so sensitive by the teacher that it is 'kept very hush-hush at school'. The teacher did not explicate why the issue was kept secretive or what the consequences would be if the issue was aired more fully throughout the school, or at least the sixth form, but the context of the interview suggested that this was a very difficult area and would be looked upon with disapproval. Secretiveness in this selective

girls school, where teachers feel many of their students will go on to be 'MPs' and 'decision-makers', raises questions in all schools about tensions between school democracy and authority, and how an issue might be transformed if it became something central to the school community rather than being marginalised. Another girls' selective school took a different approach without any seemingly adverse consequences:

> *Extract 43*
>
> . . . the girls do dissect rats as an option. It's an option whether they want to do that or not, and that always involves a discussion why. I explain to them that these rats for health and safety reasons have been raised specifically for the purposes of dissection etc (N/Biology/Head of Health Studies)

Level 5: Where the range of criteria relevant for judging a matter are broadly agreed, but there is a dispute about the proper interpretation of a criterion or criteria, given the indeterminacy of many concepts

I have taken the central idea here as the problem about interpretation of words or terms in contested areas, e.g. different interpretations of 'gene' as discussed in Section 4.2.1. There were only three empirical indicators from two teachers which mapped on to this level. In this first extract the meaning of rights is shown to have different interpretations but the teacher takes care to explain on what criteria interpretations can be judged, in this case the amount of harm caused:

> *Extract 44*
>
> There was a piece in an article that says "an individual should have the right to self-abuse". And I said: "Don't I have the right not to suffer as a result of that freedom of an individual? That I shouldn't have somebody who's going to come and beat me up or rob me in the night in order to exercise their right to self-abuse". So we always try to get the students to think not just what the individual consequences are for you, and whatever path you take, and there may not be a right one but what are the consequences for others around you – your family, your friends. How does it affect them? How does it affect society? (J/Ps - RE/deputy head 6th form)

Words such as 'intelligence' and 'criminality' can have meanings with very different cultural connotations representing different worldviews. In extract 45 the teacher reflects on a discussion about meanings of intelligence arising from a text. Extract 46 is from the same teacher reporting on a discussion after a talk from police.

> *Extract 45*
> *The Tempest*: for nature/nurture. *Brave New World*, is intelligence something that is taught through environmental or is it something that is inherited; and we have the Caliban character who has got natural intelligence, but it's not the intelligence of the western world and that leads into big discussions about Euro-centric behaviour with the discovery of the new world in the fifteenth, sixteenth century. And the word "discovery" is always a contentious word. (E/English/Head of department)

> *Extract 46*
> We have a unit in year 10 where we do the Craig and Bentley case which is miscarriage of justice, and in the trial there is a great deal of emphasis by Lord Goddard, the presiding judge, about the criminal type, and we try and do a fit from Lord Goddard to the criminal type to see if there is such a thing, going back to the nineteenth century idea if there was a physiognamy of the criminal type. We get the police to come in then and the prison service and they talk about the criminal type and contradict everything we've said because they say we can spot them a mile off! So we spend a lot of time saying there is no such thing as the criminal type - and they come in. (E/English/Head of department)

In extract 45 interpretation of the word 'intelligence' generates discussions about the cultural contexts in which people are seen as intelligent or not. Natural intelligence, craft, at-one with one's environment is contrasted with the abstract and decontextualised intelligence of the Enlightenment. These contrasts permeate western culture. When there is a discussion about meanings these often reflect deep rifts of understanding.

For Billig (Billig, 1987) 'the controversial statement does not contain a simple unambiguous argumentative meaning' (p.149). Interpretation then becomes the source of controversy. Sometimes where opposed interpretations are seen as equally reasonable, resolution is not reached by identifying logical inconsistencies. Interpretation of terms, then, needs also to be discussed in level 9: through different frameworks of understanding. The history of scientific theories illustrates many

possibilities here: the concept of combustion before and after Lavoisier would be interpreted differently; before would presuppose the *loss* of a vital ingredient; after Lavoisier and the French Revolution it would be the *gain* of oxygen. Proponents of each interpretation would draw on that evidence which supports the concomitant concept (T. Kuhn, 1962). That is not only to say that meanings of terms change in time but to point out that, as well as scientific terms, ideas such as 'intelligence', 'discovery' and 'criminality' come embedded in distinct and conflicting networks of concepts and evidence.

Different interpretations are often disguised by agreed propositions, in the Socratic method of *elenchus,* argument starts from agreement before particularities and contradictions are exposed (Billig, 1987). Considering the centrality of interpretation and meaning to controversy, and the profusion of contentious terms in socio-scientific issues - abortion/murder; person/ball of cells; nature/nurture; holism/reductionism; vegetative/conscious; pollutant/consumable; climate change/cyclical change - very few teachers in this study have sought out such terms as problematic. A pedagogy is needed which reveals ambiguities and differences in meaning as well as ways of critical thinking which expose fallacies and problems when terms such as ‘climate change’ become part of human discourse.

‘Intelligence’ and ‘discovery’ are used by the teacher as examples for students to think about rather than exposing any deep divisions within the class on the issue of nature/nurture. But the teacher’s point about intelligence and discovery is connected to perspectives and power. ‘Discovery’ in the context of exploration has very different meanings for the discoverer and the indigenous people. Words are imbued with power, as Edward Said points out in the case of discourses about the 'Orient'. Words, phrases, terms are re-presentations, not delivered truths. Language is 'a highly organised and encoded system, which employs many devices to express, indicate, exchange messages and information, represent and so forth' (Said, 2003) (p.21). Uncovering how language is used as a device to control, to persuade, to transform a notion into a fact, is to understand how certain terms become part of everyday discourse and commonsense. Looking for evidence for the assumptions and power relations that underpin meanings (Scott, 2000) can be developed as a pedagogy. How newspapers persuade and present evidence has been used in teacher support texts (Jarman &

McClune, 2005). Differences in interpretations of terms are more pervasive throughout all levels of disagreement. Strategies to unravel fallacies, contradictions, power bases wrapped up in everyday discourse present novel and difficult challenges to science teachers in particular.

Level 6: Where there are different kinds of normative consideration of different force on both sides of an issue, and it is hard to make an overall judgement

The main focus at this level is how competing interests affect stakeholders, making judgements when there are vested interests. Participants in a discussion could start from 'what would I do if I were in your situation?'.

Students thus need to be aware that circumstances influence reasonable people to hold different points of view. Statements from 12 teachers were included under this level. Animal experimentation is an issue where students often have very strong views. Thus

> *Extract 47*
> So you'll have a student with a sentimental view of animals – the animals of Farthing Wood approach: poor little bunny rabbits whatever – and then you say "hang on a minute, if it was my daughter suffering from a disease and I knew an experiment on a rabbit could help her, would you expect me to?" and you find "Ah" and then you begin to get "Hang on a minute, let's think more broadly about this, it's not just about beagle smoking there's more to it than this". (J/English/head 6th form)

Extracts 48 and 49 each refer to genetically modified food. In the first extract the teacher explicitly identifies different interest groups through a role play but is content to leave it at that. In the second extract justifications are given for the actions taken by all stakeholders and the students are left with a clear insight into the problematic nature of decision-making, and the kind of exposition that can be used for discussion around this level of disagreement.

> *Extract 48*
> . . . the use of that sort of transgenic food crop for example is then put across into a role play situation . . . we have the various interest groups in terms of the crop manufacturer, the farmer,

the economics of it, the consumer, the worker, and of course, usually the twist is on that in that there is not the same user. Oh, the need for fertilisers, for example . . . but just identify those interest groups because often, from an entrenched point of view, realising that there are these other viewpoints is pretty much just where we'd like to leave it. (E/Science/Head of department)

Extract 49

. . . the example I was using was the growing of tomatoes in greenhouses in Peru and then exporting the product to Holland, and by genetically modifying the tomatoes in the laboratories in Peru, you are actually providing work for the Peruvians in the construction of greenhouses, there's a job in the distribution so it's right that it's happening for a Peruvian peasant. But, having said that, for someone in, say, Botswana, it might not be a good thing because they have to compete with possibly something that's less superior. Is it right then that it's entering our food chain in this country? It depends from which viewpoint and where you are coming from. I'm not trying to say black is black and white is white; there's a certain amount of greyness. (R/Geography/head of Humanities)

Level 8[84]: Where the differing 'total experiences' of people in the course of their lives shapes their judgement in divergent ways

Extract 50

But the most important thing is personal views. People talking about what they think and what are their experiences of this. So for kids – someone who's been in that situation that's changed their lives and made them think this way maybe, or somebody who experiences an abortion . . . (J/English/head of department)

At this level I was identifying statements where the kinds of experiences people had lived through either had shaped their judgement or have the potential to shape their judgement. I have also included statements where the teacher might have presented vicarious experiences so the students can appreciate another point of view. Drawing upon experiences lends itself to strong narrative structures, and therefore a clear link to the narrative mode of thought.

In extract 51 the effect of the headteacher's experience illuminates the dilemma powerfully because he is telling a personal story about a friend with salient details: the

[84] I have omitted a discussion of level 7. As indicated in table 4.1 it can be subsumed under category 9 and other levels.

brother who had muscular dystrophy, the unhappy childhood, the resultant decision to abort rather than see a child suffer, then adopting a boy. All these details provide the background for J's decision, although it remains to be discussed whether it was a reasonable and justifiable decision:

Extract 51

A friend of mine belongs to a family where the women all carried the muscular dystrophy gene, and when I am talking about abortion and the girls in particular are saying "oh, I could never abort a baby whatever", I tell them about J and the way her brother's muscular dystrophy just dominated their lives. It drove the parents apart, it dominated J's childhood. She had quite a miserable childhood because, for the first sixteen years of his life, all the attention was on A., and J felt neglected as part of the family and therefore her decision was with each pregnancy she was tested and she got rid of every male child, and in the end adopted a boy. Now, by telling them that, generally speaking, I can get them to think. They might still not agree with abortion but I am using experience, I am telling it with some emotion, I suppose, and I can get them thinking. I use it because it was a success. (G/English/Headteacher).

Although the story in this extract brings home the immediacy of the experience, the students have not undergone that experience themselves which gives them distance. Teachers had a varied repertoire of their own stories, or stories of others, to convey experiences, some which are quoted in the section on narrative. In school G other teachers recounted immediate and real experiences of the students which were likely to influence their response to a controversy:

Extract 52

. . . over-prescription of tranquilisers . . . has been a particular issue in this area. It's less of a problem now but there was a time, maybe ten years ago, when we had a significant problem with parents, frequently mothers, who were just zombied and even to the point where young children of eleven or twelve would go to the doctor and they could order tranquilisers. (G/R.E./Head of PSHE)

Another teacher uses the life experiences of the students, not only to illuminate the issue of nature or nurture but to develop an understanding that the interactions of genetics and environment can be transformative:

Extract 53

> I normally would have done that (nature/nurture) in the context of a genetics module at Key Stage 4 . . . but I am thinking about where I am trying to give it to every kid. I actually feel as though it has been a really positive experience for the pupils because it has made them think about, . . . one thing in this particular sort of school that we suffer from is the fact that some of our pupils come from quite impoverished backgrounds. I mean really very, very deprived and difficult backgrounds, social backgrounds, and they are trapped in that if you don't watch out and to think, to actually talk about this openly and to say, 'you are the person that you are because there are certain genes that dictate that that is the way that you are going to be' but also equally important is the environment that you are brought up in and there are things you can do about your environment if you are aware that there are things you can do to improve your environment. (G/Science/Head of department)

Teachers use varied experiences that they, students, other staff, friends and visitors have undergone to spark debate. The geography teacher in School D, an international school, introduces discussion about the terminator seed drawing on accounts from students whose parents are farmers. A teacher in a rural school (S) indicates that the different kinds of experiences between students and between staff on the subject of blood sports might generate tensions, and subsequently opportunities, to bring out disagreements into the open.

Accounts of experiences are situated and contextualised and therefore are rich sources of anecdotal evidence for broader principles of decision-making. Extract 51, for example, could buttress the argument for promoting embryo selection and stem cell research. It widens a discussion on disability rights because it highlights the feelings and reactions of relatives. What needs to be made explicit is how such experiences help to shape judgements and relate to broader principles of rational decision-making.

The geography teacher in school C (extract 54) gives a long and detailed account of the dilemma he related to students when he faced the decision of having to turn off a parent's life-support machine. He gives indications of the kinds of considerations that helped him reach a decision, 'quality of life' for example, and how he felt such a revelation of his experience made him seem more human to the students. Such accounts of experiences can have value, as the teacher suggests, in humanising the situation. It might, however, have the consequence of inhibiting students in advancing different courses of action because they might not want to appear unduly insensitive.

While a personally related experience from a teacher might bring reality to a dilemma it also lacks distance and could prevent options being discussed. Extract 54 resonates with the statement from the biology teacher in school E who feels that when students understand what you feel, as a teacher, they become 'more empathic'. Recounting experiences such as these to students presuppose a certain type of relationship between teacher and student but the teacher also needs to bear in mind that the relationship changes when the teaching context changes.

Extract 54

. . . I think it's important if you've got situation from your own life that you can share with the pupils and make it easier, and they also see that you are human as well, you're not a teacher the other side of the table, things happen to you so that's something like a situation has occurred. (C/geography)

In the final extract in this section, a headteacher tells how artefacts can help students to undergo an experience which, at the least, helps them to feel 'more deeply'. The headteacher also shows how an outside visitor can not only illustrate an issue but command respect from the students because they know the visitor brings strong and lived experiences:

Extract 55

. . . we've bought one of these little babies that you can take home and it'll cry and wake you up in the middle of the night etc, but again the girls got that and come and report back what it was like – it's not a doll, brilliant little things, but again, that's making/bringing in some sort of reality – real context into everything that we telling them about. If we can show them and describe things then it is, they take the lesson on board more deeply. . . Visitors coming in, David O is a friend of mine and he worked on the Iona community, running the community there for a while, and he came into talk about the people who came from the innards of Glasgow over to the Island to work he's the hardest heroin addict etc etc alcoholics and he described in a very lively way the kind of reception they get and the various reactions and the pupils love that because here is someone who's actually done the real work as opposed to us talking about the work that these people do. (C/English/Headteacher)

Experience can be exploited to show how judgements might be formed. Teachers use these experiences widely in the classroom although it is clear from many interviews that some teachers are less confident about drawing on their own personal experiences, or

are judicious about the nature of the relationship between teacher and students in these circumstances.

Level 9: Where there is no agreement about whole frameworks of understanding relevant for judgement

This level provided a range of examples to study situations where the premises of arguments were incommensurable, or apparently irresolvable disagreements between belief systems or worldviews. In some examples, points of view may differ greatly but this might be because the premises of at least one of the sides of the dispute are simply unexamined and there is the possibility that further conversation might produce introspection, if not a change of mind.

There comes a point in some disagreements where evidence and reason cannot help to demonstrate the superiority of one point of view over another. What does seem to be educationally worthwhile at this level of disagreement is that contending parties listen to each other, are well-versed in contending arguments and have the opportunity to examine them critically, i.e. there is a level of dialogical rationality.

In a diverse society such as the United Kingdom there are likely to be issues which involve a clash of belief systems. There are many religious and humanist views on issues such as xenotransplantation and stem cell research, even within religions there will be different interpretations. Culture, ethnicity, social class, background, level of education are all significant factors which are likely to produce different viewpoints (Dhillon & Halstead, 2003). This would be manifested between teacher and students but also between students themselves, between members of staff and between the school and the surrounding catchment area[85]. This level can itself be divided into three categories

- multilayered disagreements

[85] The geographical area from which state schools draw their student population.

- offensive viewpoints
- cultural/ religious differences.

Multilayered disagreements

> *Extract 56*
> I interviewed a girl who was going to Oxford to do Law and asked her the question, what do you think about cloning, because Dolly the sheep was on at the time and she thought it was a brilliant idea because it would mean that we could make sure that the whole of the population was very intelligent if we wanted to. And I asked her the question, who's going to empty the bins? And. . . even at eighteen they still have quite a narrow view of biomedicine I think. (E/English/Head of department)

At one level of analysis this is a level 3 disagreement where the relevant weight given to different criteria is disputed: it could be interpreted that both parties agree that cloning is a given but one party is pointing out that, while we can accept for the sake of argument, that cloning is acceptable we need to consider hierarchy and diversity rather than uniformity, i.e. having everyone as intelligent. But as the teacher points out that the student has a narrow view, my own sense of the context of the interview is that the teacher is suggesting that the student has failed to take on board wider moral considerations about the acceptability of cloning, that it might affect sensibilities of who we are. This is a case where the challenge posed does not necessarily result in a change of worldview or framework of understanding but in a modification of possible outcomes, i.e. have selective cloning so we still have our intelligent elite. I think the importance of this extract is that it points out the possibility of the role of Socratic dialogue to expose problems in reasoning and the need to consider the basis of those questions which challenge a world view rather than being incorporated into one.

Dealing with offensive views

Views held by students might not only represent a distinct worldview but be found to be hurtful and offensive to others. Such a view when it takes a racist or sexist form, for example, can make it impossible for some students to take part. Only three teachers referred to this problem but all were careful to detach the offence from the offender:

Extract 57

. . . if someone said we should put people in gas chambers that's, you know. I think actually if someone expresses the view that it's very anti another section of society, then yes . . . there's a difficulty because you've got to support them and explain, and get other people to join in so that you're not hurting the child who's said perhaps what they've heard at home. And you're valuing what they're contributing, but at the same time, you're letting them see that there is an alternative. Actually I find it enriches the discussion . . . I have had – and it's years ago now – extreme racist views, which was more disturbing. The girls are very thoughtful often, and some do have prejudices – we all do, but I think that's it: you've just got to protect them, but make sure they're hearing the other side. (N/English/head of department)

There is an argument that racist, sexist and views which premise the superiority of one group of people over another are not in fact subject to controversy because moral objections to presumed equality of participants are rationally indefensible (Hand, 2007). These views cannot, for example, be discussed in a climate of respect for everyone's views. A male student with a sexist viewpoint cannot reasonably enter a discussion about gender – or any topic – because he does not respect the views of female students. Selection of content for level 9 should therefore draw on positions which are rationally sustainable even though there is no prospect of resolution.

Cultural/religious differences

Teachers illustrated with examples the kinds of issues that reflected different frameworks of understanding, worldviews, belief systems, standpoints or in the case of the head of English from School S, mind-set. In the context of school S this is an apt description because of the long traditions of settled communities in rural areas. Practices, such as blood sports, have been carried out in a certain way for many years without the flux of population to provide serious challenges to a particular way of life. This teacher also attempts to explain why, in this rural school with a strong local hunting tradition, this mind-set persists:

Extract 58

I think sometimes they've only got one viewpoint – for example those students that go out hunting generally come from a hunting families. You should have come here earlier today – I have a girl, a lovely girl saying "look at my squirrel's tail!" – she literally had a squirrel's tail – bone and all in her pocket that someone who'd been out hunting a couple of days before had got her – and didn't think anything of it. And she's a girl. I'm not saying that's – but normally

girls are “whoa get it away from me!”. But it’s a different mindset. I think it’s the mountains, you know. (S/English/head of dept)

This mind-set prevails over a number of issues. The teacher discusses the ‘phenomenal’ number of girls ‘who become pregnant virtually immediately on leaving school’ but there is the mind-set that ‘abortion is anathema’. While there are clear obstacles in disrupting the content of the mindset teachers could teach students to examine what constitutes a belief in what is right or wrong, as well as a commitment to rationality in discussion such as clarity and self-consistency which could then be applied to a variety of situations (Putnam, 1993).

Teachers were aware of differences between their own worldviews and those of the students. In some cases they acknowledged how this might influence what they would say in a disagreement. Teachers were generally divided on whether they should make their ‘standpoints’ clear to the students. In the extract below a science teacher does make his individual beliefs explicit but this comes with reservations:

Extract 59

I think a lot of the children I teach know that I’m a Christian and that therefore what I’m going to say is probably going to be influenced by that. Some of them won’t know that and one does worry a little bit but then on the other hand I suppose you could say I believe what I believe and therefore I’m always going to put that point of view perhaps . . . I mean this whole thing does hinge on the individual standpoint and I sort of made clear my standpoint and that’s bound to affect what I say and I can imagine that somebody who is a committed humanist, for example, would have very different ideas about some things and that to me in a sense is it’s not a challenge exactly but I think it is one of the most important issues really is the individual standpoint. (D/Physics)

What the teacher is expressing is a more general concern that belief systems cannot be disguised. In this extract the teacher appears to suggest that a viewpoint will be put across and, while it could be considered as one amongst a range of viewpoints, the nature of the teacher’s authority in the classroom is likely to influence the students (Bridges, 1986). On the other hand controversies on socio-scientific issues are never played out in an ideologically neutral space, and to claim such neutrality would be to distort political realities (Apple, 1979). There is an obligation on the teacher to assist students in a rational exploration of different viewpoints and it is not necessarily

inconsistent for a teacher to distinguish between exerting undue influence and acknowledging that political realities influence the context of the discussion. Extract 60 represents a rational approach of openness although it is a psychological characteristic and a moral virtue of a particular teacher:

Extract 60

> So I feel grounded myself that my religious persuasion is such that I don't feel anyone else should be compelled to share my views. I think that gives me the ability to remain extremely open-minded to accept all views . . . There has to be that freedom and support for them (the students) to express views they feel are valid. And for them to explore avenues that perhaps they wouldn't be "allowed" to at home. (J/RE/Head of Humanities)

The extracts below frame the problem of diverse worldviews within a school and how the teacher approaches such a situation. In extract 61 the headteacher perceives a dissenting party or parties as obdurate and immoveable. In the later extracts we see how in a multicultural school diverse worldviews can result in interesting opportunities which carry their own risks. The extract below follows on from extract 51. The headteacher is reminiscing on a lesson he taught where he is explaining to students why a friend of his aborted male embryos because of a sex-linked gene for muscular dystrophy:

Extract 61

> It misfired on me horribly in one session . . . where I was not aware, and even if I had been aware it probably wouldn't have made a difference, that one family was from the pro-life organisation and both parents did a lot of work for 'Life' and they had got into it because there was a handicapped child somewhere in the family and I was accused, through that, of brainwashing children against the sanctity of life . . . And, of course with all these issues you are in danger of treading on that crucial ground. We have got a very strong group of Jehovah's Witnesses in S and we have got to be very careful . . . but it does sometimes mean that you can't take a subject on to a pitch that would really interest other children. (G/English & drama/Headteacher)

In this case the space between different belief systems is seen as an insurmountable wall which cannot be broached. The result is that 'you can't take a subject on to a pitch that would really interest other children'. Relations between school and community might be an important factor in facilitating, or hindering, dialogue.

In the extract below the teacher is also confronted by different belief systems but there is the appearance of dialogue and exchange. It is worth contrasting schools G and J. School G is in a socially deprived area in the South East of England consisting mainly of working class white people. There is above average unemployment and many families will be working within the black economy. School J is in a multi-ethnic working class area in the East of England with a large proportion of Muslim children.

> *Extract 62*
>
> As a school we have a significant number of ethnic minority pupils so we're very conscious of Islam . . . And some of the students are extremely either devout or dogmatic – which word do you want to use? And you have to respect that. It can actually add to the lessons, obviously because you'll get the students with a very firm line on some of these issues, and then as a teacher you've got to do all the bit about 'what's your moral perspective on this? What does the Qu'ran tell you about this? What does Islam tell you about this? And the Christian perspective'. And then of course you are talking about we're a developed European country, we have this attitude to science and whatever and parliamentary democracy, you've broadened the whole thing out. I always think that's very valuable because there is this tension that ethnic minority students feel about lots of issues that come up because their religion tells them one thing and the wider culture's telling them something completely different. And while you have to respect that, you have to help them come to terms with it as best you can. (J/English/Head of 6th form)

This extract brings out a number of issues. First, the teacher is ambivalent in his attitude towards difference: 'either devout or dogmatic – which word do you want to use?'. There is a world of difference between being devout and being dogmatic. Devotion does not presuppose dogmatism, but the attempted elision is indicative and suggests ideological polarity between the teacher and some students. 'And you have to respect that' tends to assume the elision is a given and that he will move on. On the other hand he turns this problem into an opportunity because he uses difference in the lesson to raise interesting questions. And this reveals the contradiction in his attitude because if the students were dogmatic, as for example the Jehovah's Witnesses in school G, he would not have been able to talk about the questions which follow. Both the teacher and students are agreeing to disagree, the preconditions for discussion. Second, this account is understandably from the teacher's perspective. That is why I have qualified that there is the *appearance* of dialogue and exchange, because other than the teacher acknowledging that the students feel a tension between the school values and their

religion, he does not tell us what kinds of things the students say. Third, there are clear signifiers about differences in belief systems: 'developed European country', 'attitude towards science' and 'parliamentary democracy'. The implication is that there is a tension between students and teacher about the value and meaning of those terms. And the teacher is clear about the tension the Muslim students experience between the supposedly antithetical attitudes to science and parliamentary democracy held by their religion.

Another teacher in the same school does however give insight into the details of the conversations that go on in the classroom. In the extract below the context is xenotransplantation:

> *Extract 63*
> But now we've got issues like if someone was dying, but they could be saved by having the heart from a genetically modified pig, but their cultural religion forbade that, who has to make the decision? And we explored the idea that in some religions they organise it so that the individuals aren't faced with that responsibility. The religion makes the decision for them. So they simply say "it's forbidden under my religion". So they don't have that massive individual decisional responsibility. And we talked about whether people would regard that as a bit of a cop-out, that the individual was shirking the responsibility of whether or not that decision could be made. That was one of our best sessions. The students, when they had to actually think about it – whether my son or daughter could live on the basis of the decision I make about how this material is used, about the sanctity of life, whether or not we can use one life to save another. (J/Psy-GS-RE/dep.head 6th form)

If religion is seen by its adherents to be authoritarian and collective, can a teacher from the dominant cultural group use their authority to suggest that is a 'cop out'? The ramifications following from this discussion were not alluded to, and the fact that it was one of the 'best sessions' suggests that students can present a range of viewpoints without contradiction in distinct spaces: that of the home and mosque and that of the school, which is consistent with the experience of the teacher in extract 64.

> *Extract 64*
> The students . . . are nearly all Muslims and obviously take the responsibility of their religion very seriously. But they're also scientifically very curious and very aware of what the possibilities may be. They're quite open in the discussion of what their religion would and wouldn't countenance and how they feel if they were in some of the situations where genetic

> engineering might be the answer but it might not be the answer. . . We talked about the possibility of animal to human transplantation . . . about the transplantation from pigs to humans. This is of course completely contrary to Muslim teaching . . . They're taught it's wrong to consider anything else. When I challenge that, in as gentle a way as possible, they say from the science point of view they can see it makes sense. But they don't feel – even if it was a life-threatening situation – that they could reconcile their beliefs with such a transplantation taking place. (J/Biology/Head of Science).

Teachers in this school see the difference of frameworks of understanding as a real pedagogic opportunity. What could be more thoroughly explored is the teacher's position of authority within the classroom in the debate but the teachers are sensitive to the tension between the authority of religion and individual decision-making that the students experience. It implies openness on behalf of the students, as the science teacher explicitly recognises. Where students can understand the 'science point of view' but are unable to reconcile it with their religion seems to me to be a means of decentring without sacrificing one's beliefs – a precondition for empathetic conceptual imagination.

Discussion

From the discussion on LoDs it follows that considerable change and development are needed in pedagogy to operationalise the framework but that there is also good practice which can be exemplified as a resource. Teaching contexts are also diverse and practice which is unproblematic in one school might demand a huge cultural shift in another school. But there some common practices emerging from the preceding discussion which can be adapted in different schools.

- Helping students to understand that facts in socio-scientific issues are rarely socially neutral.
- Teaching the critical analysis of everyday sources of information such as newspapers, magazines and TV programmes.
- Judicious choice of role plays to appreciate diverse points of view on an issue.
- Demonstrating and modeling how different ethical principles can be drawn on in discussing an issue and that there is a relationship between the type of evidence selected and the ethical framework.
- Problematising interpretations in everyday meanings.

- Detailing conflicts of interests on both a local and global scale and communicating that resolution might be complex.
- Making available accounts of how experiences can validate judgements. Such experiences are common in the teacher's repertoire.
- Confidence and relationships regulate the kinds of experiences which can be openly discussed.
- A commitment to rationality in discussion such as clarity, truthfulness and self-consistency, which needs to be taught, modelled and rehearsed.
- An awareness that the teacher is in a position of power and that certain terms carry cultural weight which might sit oddly with students.

6.3 Modes of thought - analysis

Modes of thought include the two distinct modes of seeking to convince others of an idea, point of view, belief or experience. In Chapter 4 I described a complementary relationship between narrative and logico-scientific modes as one where stories and accounts provide warrants or rebuttals in the form of personal testimonies or anecdotal evidence in deepening understanding of general principles, and therefore incorporated into levels 1 and 2. A narrative was further characterised as specifically reflecting human consciousness, drawing on life experiences in the form of a structured account identifying a three-part schema: situation, a significant event and an evaluation of that event. Since many of the extracts refer to personal experience, particularly oral personal narratives, these include many of those statements at level 8 in Levels of Disagreement where the differing 'total' experiences of people's lives help to shape judgement.

6.3.1 Narrative mode

Teachers raised the use of narratives in diverse ways: through a range of contexts, forms (written, oral, visual), agents (teachers themselves, students, visitors, parents) and purposes (promoting discussion, raising awareness, illustrating dilemmas, increasing understanding). There were two main roles for the use of narrative in discussion: literature and personal stories.

6.3.1.1 Role of literature

Literature provided a fund of narratives but these were drawn upon almost exclusively by teachers of English who were adept at finding socio-scientific themes in a range of texts, often for the purpose of promoting discussion and discursive writing. In the extract below the teacher uses a short story, *Thunderbolt*, which deals implicitly with issues like genetic engineering and cloning:

> *Extract 65*
> . . . And we talk about this short story in relation to "this is what we think's going to happen in the future" and "Do you think this is going to happen? Do you think we're going to be able to clone people? Take this back 50 years. Do you think 50 years ago we would have thought we'd have this, this and this?" And I put it to them that it's frightening. I tend to use the idea "Do you not find this scary, or is it thrilling or exciting?". So they begin to have an idea from that point of view: Does it worry them, does it concern them that we could clone something like Dolly the Sheep? We might next clone humans, is that good or bad? And we start talking about it. (J/English/Head of department)

In extract 66 the teacher discusses how poetry and a film around the theme of war – eventually a nuclear catastrophe - can provoke not only rich discussion but opinions which take the teacher by surprise; narratives can unlock opinions which broaden the discussion more than expected. Awareness and anticipation of issues that can be generated has then to be part of the teacher's repertoire – something in which teachers of English might have particular sensitivity and expertise.

> *Extract 66*
> We do a war poetry piece in year 10 where we compare *The Charge of the Light Brigade* . . . with Wilfred Owen's *Disabled* which is very anti-war and they come up with the most surprising things. We do a role-play, we do a radio interview with the man from *Disabled*, you know, "would you do this now?" and all this business, and you listen to the media you'd assume that no young people would ever go off and fight for their country, but it is amazing how many of them – because I always assume because the man from *Disabled* is so badly damaged because of the first world war in that he's armless, legless, that I think "Oh no I'd never do that" – and yet a lot of them think it'd be an honour for them to go and fight for their country. And that generates a lot of quite interesting debate . . . we've been reading *Children of the Destiny* – just to get some creative writing, which is where a nuclear bomb is dropped just outside Bristol, and then we show them this film *Threads*, which shows you the implications of a bomb being dropped on a medium-sized city . . . the language would break down when those threads that join society are no longer there – they say "Why do they talk like that?" – I say "because they don't need to think grand thoughts any more, all that matters is survival" – so all the language

> revolves around 'eat', 'take', 'give' – you know, there are few adjectives and adverbs in the language 50 years after the bomb, yet *Children of the Destiny* gives a very different, very positive view of what would happen 50 years after: we'd all be mutants, better people – as you do. (S/English/Head of department)

Discussions which emerge from these narratives do not obviously involve substantive science knowledge. The discussion about cloning in extract 65 highlights emotional responses to cloning, 'scary', 'thrilling', and the aftermath of the nuclear bomb in extract 66 results in 'mutants' as 'better people'. There is a need for caution in identifying simplistic relationships, three science teachers were sceptical about non-scientists teaching socio-scientific issues because science teachers, they felt, understood the limitations of the technology, particularly if they had done research and had insight into the relationship between research, development and policy. But these concerns also demonstrate emphasis on the need for correct facts rather than on facts informing discussion. The extract below is representative:

> *Extract 67*
> I think something that concerns me and I think it probably concerns some of my colleagues as well is that when (socio-scientific issues) issues . . . are dealt with elsewhere in the school, we're always a little bit concerned that the science is right. Again, it's a slightly arrogant thing to say but I think with a lot of topics like this people sometimes have a little bit of knowledge about it and again I can think of questions which children have asked and I've sort of thought, "where on earth did you get that idea from about the science side of it?." You know one does worry as a science teacher that when issues like cloning are being dealt with that people dealing with it are clear about the science of it and are not in a way presenting the view which we sometimes get through the media. Cloning is a brilliant example because it seems to me that at least half the population think a clone is a fully formed adult. (D/physics)

If the basic understanding of science is the domain of the science teacher and literature of the teacher of English, what are the curricular implications? Either socio-scientific issues are taught in an inter-disciplinary arrangement, teachers of English take responsibility for teaching science in socio-scientific issues, or literature becomes incorporated in science lessons. Both these putative solutions are problematic, the latter being the least problematic. As I discuss in Chapter 7, inter-disciplinary teaching in a 'rigid curriculum' (E/French/deputy head of school) is difficult, above and beyond resolving the problem of distinct discourses in these subjects (Chapter 2).

Understanding the complexity of concepts of scientific evidence and underpinning theories is an enormous challenge for teachers of English who do not teach science on a daily basis and, more importantly, are not scientifically trained. Using literature in science lessons to raise questions of evidence or experience is the most plausible solution but requires the kind of change in pedagogy outlined in Section 4.5.2. In section 6.3.2 I discuss how narrative and science can work together in dissecting and analysing disagreements.

One teacher discussed the purpose of literature in controversial issues as a way of experiencing vicariously, enabling students to see how events transform experience and promote moral evaluation. This seems to me to be a particularly important point. Literature can help students to come close to understanding what it means to be confronted with a dilemma.

> *Extract 68*
>
> . . . literature enables you to explore experiences that you wouldn't necessarily have. Not every child is going to come up against this first hand. You might say "well they're bound to in other ways, like genetic engineering" but things like dementia or depression they may at this stage anyway feel they're not going to experience it, but when they do come to experience it, they may realise they've vicariously experienced it through literature. Or if they're trying to comfort or help someone else. That's what I hope they get out of it and think about it. (I/English/Head of department)

6.3.1.2 Oral narratives

Teachers

Discussion of controversial issues often prompted teachers to give accounts of their own personal experiences (e.g. extract 54). Some of these accounts were very frank, arose spontaneously and were discussed mainly with sixth form students who had the maturity to respond sensitively. But the teachers recognised that not all their colleagues would be equally comfortable in being so frank. While the problems with a direct approach were discussed earlier one can also see why such narratives provide a source of interesting data in which to examine decisions and social consensus although there was little critical examination of the issues. Extract 70 presents a means of dealing with lack of confidence in colleagues through collaborative planning.

Extract 69

. . . my mother suffers with depression and it's very clear that there's a genetic basis to that and I feel that, and kids are always quite startled when we talk about that kind of thing in class. We do, but I think that's a very personal bend from my teaching, you know there could well be a genetic basis for it and no organic treatment's gonna give help here and because it is a bit of a taboo still isn't it? (E/Science/head of department)

Extract 70

. . . And I talked quite openly to sixth form. . . We always get, "well what do you think?" - prenatal screening – I had an amniocentesis, why, well if it was disabled I would terminate and I'm very, I've been in tears talking to the kids in the past, but I've been up front with them because from my point of view, there's no point for me, standing there and giving them a verbal description of things without them realising that these are factors that directly affect how you actually feel . . . and the kids respond very well to that honesty and some staff, within the biology department, aren't so happy talking about that, so I go in instead, but that's the way our department works, if you're confident on one bit, like miscarriage, abortion whatever, you say well do you want to do that, so we sort that. (E/biology)

These personal accounts from adults were not only restricted to the teachers interviewed. They recognised they could draw on narratives from other teachers and friends, such as the head of science in school F alluding to a biology colleague who has had twins through *ivf*, the headteacher in extract 51 talking about his friend, and the headteacher in School C in extract 55.

These extracts show that such narratives move students and that they respect 'true life' experiences. The headteacher in extract 51 demonstrates a model of the three part schema discussed in Section 4.5: J's situation in her family in having a disabled sibling, the event of feeling neglected and her moral response to that event. Teachers' oral narratives are very useful exemplar. While narratives from the teachers and other adults are detailed and moving, there is also the question of student narratives.

Personal narratives from students

Examples of personal oral narratives from students were fewer and less detailed. As with the teachers most of these were generated spontaneously. Although some of the accounts from teachers about student narratives are short – only a few words – they do imply deeper personal conflicts: the girl coping with the clinically depressed father, the boy whose father has cirrhosis of the liver (extract 71),

Extract 71

"What's liver disease then?" so I told him all about it, "why did you want to know?", "well my Dad's got cirrhosis and he's dying. Yes, ok – let's go through this carefully then. (E/biology)

a student suffering from cystic fibrosis talking to the class about his treatment and the less painful but life-revealing contexts around social differences – usually between students and teachers - over meat eating, for example the girl whose gran makes 'rabbit stew'. Narratives were not only spoken. The science teacher from school F gives some insight into drawings about students' views of suicide in extract 72.

Extract 72

We've got quite a lot of artists who do Psychology and some of the pictures and things that they drew and the mental images and things that they have are quite shocking, you know. They did one when they did depression and it was all about suicide and, you know, not something that we deliberately venture into. (F/Science/head of dept)

The extract below is a very moving depiction of the use of narrative by a student in a delicate and sensitive situation. How the student deals with the anorexia of her friend eloquently demonstrates the complexity of the teachers's point: the ability to depersonalise an intensely personal and problematic moment through a narrative account:

Extract 73

Well, the beauty of English . . . is that you can discuss something without personalising . . . so that, for example, I remember a few years ago I actually had a girl in my class who was anorexic, and her friend was very worried about her. She delivered a speech talking about beauty without and beauty within, and people's perceptions of themselves, and did it matter. In fact, it turned out at the end to be a plea to this girl from her friend, but it didn't come over like that if you didn't want it to. (I/English/Head of department)

Even with these short extracts there is enough to suggest that student narratives can be drawn upon to illuminate issues. There is insufficient evidence to indicate how these narratives were deployed into the structure of socio-scientific issues or whether teachers ought to draw more on student experiences. There is a narrow line to tread between interest and motivation for students in shedding light on an issue through their experiences and in crossing the boundary into an area which is emotionally fraught. But

there was a distinct lack of the student voice in all the accounts. This is an area which needs considerable development.

6.3.2 Complementarity: the two modes of thought

So far, discussion of the use of narratives has focused on how they have been generated and responses in the students rather than their purpose in teaching controversial issues.

> *Extract 74*
>
> Using foetal tissue, for example, for Alzheimers and Parkinsons treatment. And I think that's a very difficult one for people to think about because initially there's repulsion and then, if they personalise it and think this can help somebody – what if you had the disease? They can waver. (I/Science)

Extract 74, for example, about the use of foetal tissue in the treatment of Alzheimer's could be built into a narrative through:

a. *Situating* a story of a sufferer (also their friends and family) from a degenerative condition[86], their wishes, hopes, fears and possible courses of action;

b. the ethical and moral issues that would arise from treatment/intervention, i.e, the *event* in the three part narrative schema, if stem cell research was to become publicly available, identifying the premises of the arguments and possible logical objections, i.e. the logico-scientific mode;

c. the personal experiences, narratives and particularities that highlight objections, help to open up ambiguities or provide supporting detail. The 'how would you feel if' is a crucial aspect in helping to personalise the issue and take a different perspective – the moral and evaluative *reaction* to the event;

d. demonstrating how foetal tissue is used in stem cell research by giving a brief overview showing how foetal cells are totipotent and can be made to differentiate to replace specialised damaged cells (the scientific knowledge and understanding necessary to discuss the issue);

e. the status of stem cell research and that there is still much research to be done (thereby pointing out the complexity of the evidence and at what point it can be said to be effective).

[86] Such an approach has been used in Teachers TV to introduce a discussion on stem cell research. Available online at: http://www.teachers.tv/video/2982 (last accessed 24th May 2007)

Discussion

Teachers of English use literature as a powerful resource to raise issues. Texts are used precisely 'because they are controversial' (identical phrase used by heads of English in schools E, I and J). They provide a wealth of stories which can be used to raise fundamental questions, enabling students to discuss an issue which affects people, and is therefore 'personal' and yet distanced enough to provoke appropriate emotional responses.

Using literature as a resource raises questions about linking the stories in the texts to scientific evidence. This is an opportunity for cross-curricular planning between teachers of English and science teachers but so often in schools, the 'rigid curriculum' (E/MFL/deputy headteacher) inhibits such links and there are more general epistemological questions which I refer to in chapter 7 about the possibilities of cross-fertilisation. But integrating 'human' stories into levels of disagreement will broaden the evidential base (levels 1 and 2) and life experiences (level 8).

Personal accounts are a valuable but ambivalent resource. They carry immediacy and reality but their effects depend very much on the relationship between teacher and student and the ethos more broadly within the school. Given that there were far more teacher narratives than recollections about student narratives, in issues which have such a personal element the student voice tends to be ignored. There is a great deal of research (Engebretson, 2006; French & Swain, 2006; Wigglesworth, 1997; Worsley, 2006) to demonstrate the eloquence and self-awareness of the student voice (extract 73 is a particularly beautiful example) as a narrative resource

6.3.3 Logico-scientific mode

This mode refers to those logical processes of thought which are commonly invoked in scientific thinking such as induction, inference, deduction, critical thinking and consistency of argument, and most prominently associated with levels 1 and 2. Compared to other strands in the framework there were relatively few statements of this

kind. There were for example three brief statements on the value of critical thinking and reasoned judgement. An example is extract 75:

Extract 75

there is like in critical thinking this ability . . . to rise above . . . the first dimensional argument . . . I mean if you can instil that in them they can transfer those skills to other areas and there're lots of other areas in their lives they're going to come across, you know, medical research. (B/Politics/head of department)

While there are rational grounds for knowledge claims in science, one teacher made the point that the grounds on which ethical principles were derived could be made more explicit by modelling the thought processes which move from one proposition to another.

Extract 76

And I think in teaching one of the things we have to do is allow kids to see you arrive at a point of view by considering various approaches and deciding which is best approach. I mean, we do that all the time when we teach. I don't know, you teach the universe and you tell the children about all the different theories there've been and explain to them why the one we believe now is thought to be right, don't you, so I think you need to do the same thing with ethical issues sometimes. You need to show that the way you arrive at a position is from, say, this place, this place, this place, well, which is the most consistent? (D/Physics)

And later in the interview this teacher provided a helpful example of the link between scientific procedures and the ethical issues that arise from them.

Extract 77

I know what else should be on there! I don't know if there's a general term for it but things like clinical testing and double blind testing because I think there is a very prevalent view that something is being tested to see if it works rather than the fact that the test might actually show that it doesn't work and there are clear ethical issues in that if you're talking about treatments both from the point of view of how drugs testing is done and also the ethical view of if you're testing a life, well an HIV drug for example, an anti-HIV drug, do you withhold it from people because you're doing a test? That's something I think should definitely be on that list. (D/Physics)

Although an understanding of risk is central to an understanding of socio-scientific issues (Kolstø, 2006; Ratcliffe & Grace, 2003; Solomon, 2003) only one teacher mentioned that there was an element of risk estimation with everything we do in life but particularly with biomedical interventions. These cannot answer concerns and questions with complete certainty:

Extract 78

> . . . human beings seem to be very poor at estimating risk, you know, the smoking thing "It's never going to happen to me". Everyone is going to have to get some idea of risk associated with having screening from the Genome project. So I think one of the most difficult things to come to terms with is that even with genetic screening it doesn't give them a definite answer, but could give them an element of risk that they may develop a condition . . . later on. And I think at the moment, nowhere in teaching do we help them assess risk and what it means to them. (I/Science)

Discursive aspects of the interviews relating to the logico-scientific mode were surprisingly small which might reflect ambivalence about what science concepts and procedural concepts – science knowledge, understanding and evidence – contribute to decision-making in socio-scientific issues. Another reason might be that science teachers do not often explicitly teach, or tend to marginalise, the teaching of the Nature of Science (Abd-El-Khalick & Lederman, 2000; Bartholomew *et al*., 2002). Yet the examples of double-blind testing and risk from two science teachers highlight their importance. In both those statements it was implicit that such concepts were rarely discussed. In the comment about risk the science teacher makes it clear that it has not occurred in teaching up to this point[87] and the teacher in extract 77 discusses the topic of testing as an afterthought.

Discussion

How scientific, informal or anecdotal data is marshalled, through scientific and logical procedures, to demonstrate claims needs far greater elaboration in the teaching of socio-scientific issues. Narrative is an important data source but it is not clear how teachers use narrative, or other sources of data, to settle a disagreement or to identify elements of the LoDs which can be illuminated by the evidence and those which cannot.

[87] *How Science Works* in the science National Curriculum dating from 2006 does include statements about teaching risk as do new courses such as *Twenty First Century Science*.

There are few explicit links to controversy or disagreements and little focus on critical thinking. Earlier in this chapter, through the example of stem cell research, I showed how this might be done and such exemplars, modelled step by step, as indicated in extract 76, could support teachers in rehearsing the teaching of an LoD with students.

6.4 Communicative Virtues

Communicative Virtues are the third strand in the framework, comprising those attributes of character that enable communication (Rice & Burbules, 1992) and open up the arena in which controversy takes place. These are not linked to specific LoDs or MoTs but comprise a repertoire of virtues that are necessary for rational dialogue. Such dispositions as openness, honesty and criticality have been discussed in Chapter 4. In this section I identify those communicative virtues which teachers highlight in the discussion of controversial socio-scientific issues. While openness and honesty and to a lesser extent, criticality, were mentioned, teachers repeatedly referred to a range of virtues which they saw as so basic to any discussion of issues in school that they pervaded almost all interviews. Sensitivity and teacher approaches to controversy, including balance, were the most prevalent of the communicative virtues which they felt contributed to productive classroom discourse.

In Chapter 4 I noted that students need to have an **interest** and motivation, which I shall take to mean committed engagement to discussion around a disagreement. With an imposed curriculum it is always possible to teach controversial issues where:

> *Extract 79*
> Sometimes students just don't feel that this is relevant to them, something going on outside of their experience and, you know, why should they bother to explore this. (B/Ph&CT/Head of department)

Teachers were aware of the need to stimulate interest which touched on students' lives – although there were few accounts which highlighted an authentic student 'voice' - but also to capture the moments when issues are generated spontaneously in the classroom.

> *Extract 80*
> . . . very, very topical is the genetically modified food. I mean, is our canteen using it? How do

we know? I think something like that you would find students really are keen to find out the facts and know more about. (B/Student Services- G)

Extract 81

. . . one might be teaching about . . . the effect of radiation on DNA and cells and so on and so forth as part of the physics course and then somebody who's bound to say, "yes, but what about cloning", or something like that, and I actually think we're probably more effective in dealing with issues like that in that sort of way rather than actually saying "right, now we're going to deal with this". (D/physics)

To respond to a topic spontaneously requires confidence and ability to distinguish between interest and direction on the one hand and an opportunity for illicit talk and diversionary tactics (Whitty *et al*., 1994) on the other. Teachers of English and the humanities generally seemed to have more flexibility to do this than science teachers; for English teachers the texts are a means of raising issues; for science teachers it is often seen as deviating from the course of the lesson. Unless the teacher is prepared and can anticipate these issues it is unlikely that sufficient knowledge and experience can inform the discussion. I would not want to suggest that discouraging spontaneity might be a way of responding to a contemporary debate. Teachers might want to use the opportunity to flag the issue and plan for a time when they can raise the issue in more depth.

Some issues, particularly animal rights and experimentation, generated strong feelings which were harnessed to help promote discussion and raise new questions although strength of feeling could obstruct productive discourse. Teachers talked about their own **emotions** in discussing difficult issues, with one teacher being in 'tears' (extract 70). An emotive approach could be interpreted as passionate advocacy, sometimes with the assistance of teachers' own feelings, without sacrificing a rational approach.

Extract 82

But if they see you being passionate about it I sometimes think that encourages them "look how wound up she gets about it" – they want to be like that as well maybe. That's what I'd like to push – students to feel the argument they push. (J/English/Head of department)

Openness and **tolerance** of the students were mentioned in a range of contexts. Teachers identified characteristic situations where openness was lacking. Animal rights

were topics about which students were deemed to have very strong beliefs and were unwilling to listen to other arguments even when teachers identify inconsistencies.

> *Extract 83*
>
> . . . the children have a particular view that animal experimentation is vivisection . . . because they have a very narrow view of what that entails, yet they'll all take their tablets when they have a headache without any consideration of what's happened to achieve a safe drug. (E/Biology)

Views that emanate from religious beliefs and parental attitudes can be a particular obstacle to open exchange of views in the classroom although there are subtle variations depending on the religious views and the teachers' strategies in trying to find ways to overcome these obstacles. Three teachers alluded to problems with particular Christian groups. Here one teacher contrasts a variety of religious viewpoints in terms of their openness to other points of view:

> *Extract 84*
>
> In the past we've had a religious group here, the Plymouth Brethren . . . There's quite a large Christian element around which is strange because they always think they're the most tolerant. And we have quite a lot of Muslims and Hindus and stuff and they seem completely OK to talk about it. Whether they do more of that sort of thing at home I'm not sure. I think the biggest thing is making sure that the kids can understand, that they don't feel pressured . .. and they get something out of it, that they walk away, certainly for me understanding a little bit more . . . without sort of saying, 'well I think it's really awful that you're transplanting foetal cells', you know. (F/Science/Head of department)

Another teacher (J/Biology/Head of Science) in a predominantly Muslim school points out that there are occasionally problems of dogmatism and bigotry but these instances tend to be exceptions, and diversity can often be an opportunity to raise new and unexpected issues.

It is beyond the remit of this thesis to explain why certain groups seem more open than others. The evidence from this study is probably too anecdotal and unreliable to suggest that this pattern is more widespread. But it does indicate that different belief systems in a school are not necessarily a barrier to open discussion where the degree of openness might well depend on the topic being discussed. It is not difficult to imagine that a discussion on the putative use of amniocentesis to select boys over girls, or embryo selection for some genetic conditions, might have different characteristics with parties

less affected by the issue although, as noted in extract 64, students are perfectly capable of decentring.

Student **discomfort** was seen as promoting more **criticality** and open-mindedness through a philosophical and reflective approach. Both these comments were from teachers in school B, a further education college, whose students are post-16, of a wide age range and where there is a greater diversity of vocational courses and courses in subjects like critical thinking and philosophy. Relatively few secondary schools have Philosophy and Critical Thinking on the curriculum, vocational courses often bring students into contact with socio-scientific issues when they are on placements. Age range and the nature of the courses might account for a more critical approach in this college of further education:

Extract 85

> Well, the one where there's most agitation I guess in terms of students is around abortion and there they take up . . . quite strong positions initially and then of course through doing philosophy . . . they begin to understand the perspectives behind the viewpoints. . . . certainly in terms of Philosophy I see that as a really useful process. They might not agree at the end. They still may have the same conclusion but unless you see each other views quite differently. . . (B/Phil &CT/Head of department)

Extract 86

> . . . and actually at the end of some classes they've said "Oh, I don't know what I think anymore", . . . which from my point of view I think that's a good response because it means that they have actually thought that there're actually other issues, other standpoints that might actually have some validity and that the idea of the standpoints, of the different bases of behaviour is something that they perhaps grasp more of. (B/Humanities/head of department)

Being open to other viewpoints implies **respect** for your co-participants in discussion. For the populations in some schools, particularly those in deprived areas – although by no means true of all schools in deprived areas - this was a hurdle to overcome where students had low self-esteem or had little respect for their own viewpoints. In contrast to comments about students' dogmatism over emotive issues one headteacher in extract 88 would be only too pleased if his students did at least have an opinion, also drawing to our attention that school might be the only place where they have a chance to consider controversial issues. The skills required to teach controversial issues in one

school might be different from those of another. In school O, teachers cannot assume the communicative virtues are in place because students, at least in school, rarely exchange views systematically or rationally. For low-achieving young people who lack self-esteem, public policy issues such as nuclear power and genetic screening, can seem very remote to their everyday cares. Teachers will need to school students to talk to each other respectfully and openly, and they will be starting from a very different platform of self-confidence than students in schools K, I and N. As the deputy headteacher in school J suggests, it will help if students negotiate disagreements in school. Discussion, combined with the possibility of negotiation to bring about change will give meaning to having an opinion and to understand the value of discussion:

Extract 87

. . . our priority's got to be to ensure the students are wanting to achieve, have the qualities to deal with many difficult situations, and the confidence and that they know where they want to go. . . I think it's to do with wanting to be successful, wanting to achieve, wanting to do justice to themselves, and as part of that it's to do with self-esteem, self-confidence, a willingness to make individual decisions rather than just collective decisions with peers or whatever. (J/RE/Deputy head of school)

Extract 88

. . . it is better that they have an opinion and that a lot of our children don't have, and I think that's to do with something else that's certainly true of this school and I think a lot of schools where there's a deprived area. It's their own self-worth, their own self-esteem and if you don't think much of yourself you don't have much of an opinion about other things and particularly things that are not in their immediate experience . . .human transplantation some of them have come across but it's going to be very few of them really . . . These are things (biomedical issues) that I doubt that they would think of if we didn't bring them up at school. . . and it's one of our major issues is to try and get people to believe in their own values. It's one of the hardest things in the school. (O/English/Headteacher)

Sensitivity

Almost every teacher interviewed talked about the need to be **sensitive** to students' feelings. Although a proportion of these revolved around attitudes towards young women's self-image this was not exclusively the case, for example, there were many references to teachers having to be careful because of the ramifications on home life.

Teachers' experience of PSHE helped to draw attention to, and emphasize, the importance of sensitivity in discussion about controversial issues particularly when drawing upon personal aspects of experience. They frequently had strategies for anticipating and responding to personal and religious sensitivities about these issues when they arose: asking advice of other members of staff and informing parents in advance. The local community in school J was often consulted:

> *Extract 89*
>
> . . . we've the contact with the community and say "this is what we're planning to do. Will that cause offence?". (J/French/Deputy head of school)

But it is difficult for schools to keep up to date with problems students have at home. By alluding to an issue the teacher might be touching on sensitivities which students prefer not to be brought out in the open.

Dealing with sensitive situations goes beyond the relationship between teacher and student, there is a wider context which influences what issues can be addressed in the classroom and how they are addressed. This is a reminder of the importance of the whole school ethos, promoting those virtues which sustain open and critical discussion.

> *Extract 90*
>
> If you have the type of atmosphere and the type of school where there is 'friendly' dialogue between teachers and students, where in lunch time in the dining area, at break time on duty, where you are sitting and just having conversations, then I think a lot of students will use that opportunity to raise issues like this, and I don't think you can underestimate the value of that because often the problem again with a lot of these issues is they are not the sort of issues that you can put your hand up and say "excuse me sir, my Dad's depressed can you tell me". It might well come up in conversation in a break . . . But having the time, and the environment where they can actually say to you, ask that question, is a vital part of any such school – if you have a school where they couldn't have asked that then I think then this sort of thing becomes much harder to deal with. (E/Graphics/Head of PSE)

This extract does raise the question that sensitive situations might best be discussed outside of the formal classroom environment, and that might be the best site for the kind of spontaneity which raises such issues, a point I return to in Chapter 7.

While there were many descriptions of sensitive situations, teachers' reflections about them and ways of responding to them, no teachers discussed the education of sensibilities, dispositions and communicative virtues in students, so individual students could talk in the class about personal issues which might arise without undue insensitivity. In these interviews the teachers appeared to see themselves as central to the operation of talk about controversial issues, that they mediated all communicative interaction, so that observations of students' dispositions towards each other in a disagreement were rare. Extract 73 is an outstanding exception. How communicative virtues are developed, particularly those such as sensitivity which are germane to the school context, is an important consideration.

Teaching approaches to controversial issues

How teachers approach controversial issues, for example, whether to opt for procedural neutrality (Stenhouse, 1970), give their opinions, maintain balance or act as devil's advocate, met with mixed responses from teachers. All these affect the communicative atmosphere in the classroom. Balance was alluded to by all but two teachers and I have treated this as a separate aspect of communication.

Teachers were circumspect about giving their opinion. While some thought it was a good means to provoke students into discussion others were comfortable to give their opinions in only some circumstances. One teacher in particular was very cautious about the effect that teachers' opinions had on students but also recognised there may be situations when a teacher might have to give their opinion. Trust within the classroom is seen to be crucial:

> *Extract 91*
>
> I've seen it happen in classrooms where politically biased teachers expressed points of view and sometimes the children will just sit there and not say anything but you can tell . . . they would never express an honest opinion in front of that teacher again once they lost that trust. . . So really I suppose it all depends on the relationship between the teacher, student and the trust that it fits within the four walls and how honest the children feel that they can be, and they feel safe. (K/English/Head of department)

Teachers' approaches ranged from:

Extract 92

. . . here's the information, here's my point of view if you ask for it but in the end it's up to you. (F/Science/Head of department)

to passionate advocacy of their own point of view. Leaving students adrift without the knowledge or skills to judge the information they have been given is tantamount to naïve relativism. Declaration of the teacher's point of view can be perceived as indoctrination but in cases where there is easy consensus (Rudduck, 1986) teachers find themselves positioned to subconsciously promote their opinion in order to prevent dialogue drying up. Cotton (Cotton, 2006) advocates that taking teachers' beliefs into consideration should be a major factor in curriculum design. But this presupposes that teachers' beliefs can be canvassed validly, particularly where they might be influenced by the teaching context.

.

Five teachers felt that there were certain circumstances where they had to give an opinion - because it would be unrealistic for students to believe they did not have an opinion - with the proviso that students were aware it was the teacher's opinion, one amongst many possibilities. A common position is: 'This is what I believe, what do you think?'. For one teacher it was a matter of reading the situation in the classroom, the confidence to advocate an opinion in full recognition of all possible options but realising that how one would act in one set of circumstances might be different from another set of circumstances:

Extract 93

One of the units that I'm involved with each year is the parenting unit. And in that sort of situation . . . issues such as do you smack a child, would come in. Now the children straight away in a group – one of the first questions you can guarantee they'll ask you is well did you smack your children, do you smack your children? . . . But in that situation, I am quite comfortable in telling the group how I react in various situations and would give examples where I had or hadn't and why I did and didn't. Now the problem you've got is whenever you're asking, in this school, upwards of 120 people sometimes to deliver PSE[88] to different tutor groups, people will have different confidence of whether or not they will give that part of themselves to a group of children. Some will say, oh well I don't want to tell you that, that's my

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business. Others will be quite open and honest about it. And it will vary from person to person. (E/Graphics/head of PSE)

Teachers used the devil's advocate approach but were aware of the consequences and were careful to ensure that students did not take them as the teachers' opinions. But the difficulty of being aware that the teacher is being a devils' advocate and not subsiding into personal advocacy is a difficult line to tread:

Extract 94

. . . a different approach there would be . . . the devil's advocate just to get them stirred up and with a kind of far right Nazi view of cloning and we're using headlines out of newspapers I think the last one was with the cloned sheep and that can be quite hard work . . . as long as you can close the door on that and they don't think that that's what you really are, all's well. (E/Science/head of department)

Extract 95

. . . quite often I'll throw something in that is totally against my own personal view, and argue for it and that, re-opens the argument and gets them rethinking. There's the classic one about abortion. Syphilitic father, depressed mother, alcoholic etc congratulations you've just aborted Beethoven. And it makes them stop and think that it isn't as clear cut, it isn't black and white. Difficult changing their views, though we do get some won over, to re-consider. (E/Biology)

Balance

In many comments teachers maintained there was a need for balance without further qualification. But where teachers had a more discursive view of balance, both the necessity for balance, and the problems which came with it, began to emerge. In some schools students were already campaigning:

Extract 96

We've a lot of girls who are very active animal rights campaigners and are very much against vivisection. I think it's a knee-jerk reaction for a lot of girls. And I'd always want to be very careful about presenting balanced views and encouraging them to present balanced views when they're thinking about this sort of thing. (I/Physics)

Extract 97

But we collect things – K gets leaflets from organisations and we get these files together, and again we have to be very careful in our use of that because often these are propagandist –

there's no other word for it. You have to make sure that you steer students – whichever way it goes - towards the other point of view and that there are other reasons and other ways of looking at things. (J/English/Head of 6th form)

Self-awareness of their own worldview is present in the teacher in extract 98 but this teacher goes on to make interesting and subtle qualifications, that there are certain issues where it would be simply misleading and immoral to present a balanced view, although there may be cases where some positions are rationally indefensible and therefore non-controversial. There are events which at one time were controversial but are not nowadays – many scientific controversies come into this category. There are others which are now seen as morally objectionable but historically were considered controversial, possibly because people could not have foreseen the consequences of their actions or had different belief systems. It is possible, under qualified circumstances to perceive embryo selection, for example, as a eugenic activity, and therefore legitimate to view eugenics historically as controversial to demonstrate why some parties are so vehemently opposed to it.

In extract 76 the teacher adds that modelling decision-making is an effective way to help students make judgements. For example, why one scientific theory prevails over others is given as an example of the way ethical decision-making can take place. Although this could be an overly simplistic view – how scientific theories emerge is widely contested – it can nonetheless be an effective pedagogic tool in helping students to see that views have different validity and can be judged.

Extract 98

The main difficulty is being balanced but not giving the impression that all points of view are equally valid because although there are obviously lots of points about issues, some of them I think most people would agree are not valid. You know, you think of things like eugenics. You can have all sorts of points of view about eugenics but at the end of the day I think most people would agree that breeding human beings is not on . . . And I think in teaching one of the things we have to do is allow kids to see you arrive at a point of view by considering various approaches and deciding which is the best approach. (D/Physics)

6.5 Participation

In Chapter 2 I pointed out that there were different models for teaching socio-scientific controversial issues ranging from the *deficit* model to *collective praxis*. Most teaching contexts corresponded closely to the characteristics of the *deficit* and *school science &*

social issues models but there were hints, although not fully expanded, which alluded to practice where students had acted on knowledge and beliefs, that discourse was linked to action. In one college students had generated their own campaigns:

> *Extract 99*
> We've certainly had some work on animal experiments because again that's something that students feel very strongly about so the Student Union have actually had campaigns against some of the animal experiments . . . the students themselves off their own bat investigated free trade tea and coffee and actually got samples and persuaded the Principal that we should be selling them in our canteens and they are now on offer alongside the other versions and again I think they would certainly jump on the bandwagon of the genetically modified foods if they knew a little bit more about it. (B/Student Services – G)

Extract 99 raises a point that has not been developed in this thesis: persuasion. The teacher does not say how the Principal was persuaded, whether by rational argument, sensitivity to the fierceness of the beliefs of the students or by another means. But convincing others of your point of view, identifying the means of persuasion as well as understanding how to use it is an aspect of rhetoric, a specialised branch of narrative (Billig, 1987; Kress *et al*., 2001). This was the only point at which persuasion, or convincing someone of a point of view, was mentioned but it is clearly important to understand how arguments are made convincing.

Vocational courses, often in Further Education colleges, allowed students the opportunity not only to discuss the issue, such as dealing with dementia but to experience working with these issues for themselves:

> *Extract 100*
> A lot of them do placement with elderly residential homes and things like that where they would actually . . . do work experience where they come across dementia so in order to prepare them, given they're quite young at 16, to deal with, say, confusion so that they're not frightened by it or upset by it we always deal with things like dementia. (B/H&SC)

In one school members of staff took action to make their views known in response to public consultations:

> *Extract 101*
> When we look at abortion, and perhaps that is more so in the light of the papers in the last couple of days, the idea of donated foetal tissue, because that's come up. We've looked at this

particular document and some of the staff sent in responses when the government were considering this legalisation of ovarian tissues. (I/RE1)

Finally, a couple of teachers stressed the importance of integrated preparation for citizenship with discussion of the issues:

Extract 102
And personally I would then take it (animal experiments) into more of a law and order and citizenship connotation and say that if you really do object to animal experiments, how do you protest against it. The way to do it is not to go and fling a brick through the window of the cattery in the next village. There are more subtle ways to do it, right, let's think about petitions and formal letters so that hopefully it's teaching them a little bit of law appreciation. (G/English/Headteacher)

Extract 103
As individuals, they can actually make an impact. Not just on an individual decision they made, but in the way they're talking with others. They can make a real impact. The example I always give the students is the one about CFCs; when information came out about the scientific effects that had been determined about what CFCs were doing, I explained to the students for more or less the first time in history we actually had a public-led revolt whereby they simply did not take the cans off the shelf and the industry said "it would be impossible to change in 5 years" – in fact it changed in 5 months. And showed that that was individuals who were acting and making a moral decision and they changed the world they lived in. (J/Ps-GS-RE/Deputy head 6th form)

Enacting change, therefore, becomes a process of political action. Within the models of teaching socio-scientific issues this is made most possible in *socio-pragmatic, dialogic/negotiated* and *collective praxis* which tend to operate beyond the usual confines of the school curriculum.

What emerges from teachers' narratives is the emphasis on their pedagogy in relation to their specific teaching contexts but there is relatively little about developing appropriate communicative virtues in the students. Teachers are sympathetic listeners, sensitive to the needs of their students, tolerant and respect the views of their charges. However, there is little sense from the conversations of teachers developing these virtues in students. If students are to become active, rational, reasonable and committed participants in controversial issues they need to be supported in practising and developing these communicative virtues themselves.

Chapter 7 Conclusion and implications

7.1 Towards a solution

In this final chapter I will draw together the implications for pedagogy dealing with who will teach controversial socio-scientific issues and where, the pressing questions of student voice, emotional engagement, inclusivity, and finally the possibilities for further research.

The 'story' of this thesis is that social changes and the politics of accountability have thrust controversial issues into high relief in public policy and in the school curriculum[89]. I have attempted to show that 'controversy' is a complex and contested term which needs to be broken down significantly if teachers are to have any purchase on aspects of the core issues. Since controversial socio-scientific issues are now so prominent in the news and public policy, and are an increased feature of secondary school courses in England and Wales as well as many other industrialised countries, they need special consideration because of the complexity that epistemology of science, the nature of science and contemporary formulations of the relationship between science and society bring to these issues. Within a democratic and pluralist society, I have argued that the Levels of Disagreements together with an array of Communicative Virtues and means of articulating knowledge and experience through Modes of Thought provide a plausible framework of pedagogy which locates chunks of controversy to be addressed. On its own this framework is inert unless there is a practical, realisable pedagogy to make it come alive.

I have discussed in Chapter 6 what that pedagogy might look like, taking into account the fact that teachers work in very different contexts in terms of the backgrounds, attitudes and aspirations of the students, school ethos and wider

[89] This is true of the primary and the secondary school curricula but my emphasis throughout is on the latter. Nonetheless there are attributes of primary school teaching that could lend themselves profitably to the teaching of controversial issues in secondary school: for example, circle time, the continuity of relationships between teacher and pupils, and the frequent stronger links between parents, local community, pupils and the school. I would venture that considerable restructuring of secondary schools would need to take place to approach these conditions.

social and political considerations such as the demands and constraints of the curriculum and teacher flexibility when faced with these constraints.

Before coming to the implications and raising the main questions which arise from the research I shall attempt to draw together some broad conclusions and ideas.

7.1.1 Curricular implications: facts and values again

In Table 4.1 I extended McLaughlin's formulation of the Levels of Disagreement. From the table it can be seen that the role of evidence in levels 1 and 2 is distinct from the role of evidence in levels 3 to 9. In levels 1 and 2 evidence is central to the purported resolution of a disagreement whereas in levels 3 to 9 it is one factor among others which needs to be considered. Given the complexity of the use of evidence in socio-scientific issues, levels 1 and 2 need separate treatment in researching and devising an appropriate pedagogy. In section 4.2 I argued that an understanding of ethical principles is a *sine qua non* for an interpretation of many socio-scientific controversial issues. While there are ethical aspects to levels 1 and 2, for example the kinds of procedures adopted in collecting evidence, levels 3 to 9 foreground ethical questions. There is therefore a case for treating the pedagogy associated with levels 1 and 2 separately from levels 3 to 9.

Teachers recognise the need for evidence or, more loosely, information, but there is a lack of clarity and specificity from teachers across subject divides as to how relevant data are collected, analysed and used in resolving a socio-scientific issue and in the logical processes in deriving valid claims from data. Evidence in science teaching is predominantly used a priori to substantiate established theory, or used by teachers in a range of subjects to attempt to correct prejudice or misconceptions and to discriminate between fact and opinion. Where theory is lacking and data are uncertain and ambiguous teachers are, unsurprisingly, much less confident in demonstrating how evidence might be used to illuminate an issue such that decision-making becomes an informed and rational process. Nonetheless teachers in all subjects recognise that students need to know how to use evidence in a disagreement even though there are few examples of how teachers use it in teaching socio-scientific controversial issues. Interviews with humanities and

social science teachers suggest that there is a difference in their approach towards evidence. Science teachers tend to start from the facts without developing their role in illuminating socio-scientific issues (e.g. extracts 1, 10 and 28); humanities teachers raise questions then suggest that evidence can be used to try and find solutions, although they do not explicate how this can be done (e.g. extracts 3, 5 and 7).

The relationship between facts, or at least the kinds of facts available from the school science curriculum, and decision-making is not straightforward (T. D. Sadler et al., 2004; D. Zeidler, Walker, Ackett, & Simmons, 2002). Dawson and Schibeci's work (V. Dawson & Schibeci, 2003) confirms perceptions that many students have not heard of contemporary biotechnological processes (Lock & Miles, 1993) and concludes that better subject knowledge will improve attitudes towards biotechnology and decrease uncertainty. This still leaves open the question of, and the relationship between, grasp of evidence and informed decision-making. Having information, data or evidence does not of itself resolve a disagreement; these have to be linked to logical procedures and theoretical knowledge. But knowledge allied to evidence, where it exists, might still not lead to straightforward resolution of disagreements. Some evidence suggests that higher levels of content knowledge may be influential in justifying claims (T. Sadler & Zeidler, 2005) but that a threshold level is necessary to be overcome for the effect to be significant (T. D. Sadler & Donnelly, 2006; T. D. Sadler & Fowler, 2006). There is some cautious optimism that contextualized teaching of socio-scientific issues to secondary school students, together with an understanding of the nature of science, 'could develop useful domain specific, knowledge and skills and an awareness of how to apply these to new situations' (Lewis & Leach, 2006) (p.1284). Such claims as these are limited and qualified, and researchers emphasize both the constraints of the contexts in which the studies were carried out and the unwillingness to extrapolate findings to rational decision-making on a broad range of socio-scientific issues.

Then there is the problem that, for science teachers at least, the type of evidence brought to bear on many socio-scientific issues is very different in nature from that used in core science. Some of the evidence as discussed in Chapter 4 is anecdotal, sometimes based on experience which lies outside the

boundaries of generalised scientific discourse, and therefore not easily incorporated into science pedagogy. Social and political considerations also influence the nature of evidence, factors which are recognised by humanities and social science teachers (section 6.2.2.2). If the role of evidence in socio-scientific issues is complex for scientists and sociologists, i.e. specialised experts (see for example (C. Dawson, 2000; J. Thomas, 2000)), it is certainly going to be too great a hurdle for most science teachers to overcome. As I have suggested in Chapter 6, one way forward is to study a range of case studies to at least appreciate the ways in which evidence is used. But the case studies will need careful selection so that there is a very clear focus of the type of evidence to be studied and explored. Many case studies of socio-scientific disputes demonstrate that, for non-science participants, what is at stake is not a knowledge of science nor a grasp of the evidence but trust in those who have the scientific and technical know-how, an ability to engage in dialogue with decision-makers, including lobbying and campaigning, and a broad understanding of relevant economic and political issues. These are important points to consider but will be too much to consider at once.

Distinct tendencies in approaches adopted by science and humanities teachers are also reflected in the ways facts are dichotomised from opinion. In Chapter 2, Hall's quote (Hall, 1999) pointed to the problem of conflating 'ought' statements with 'is' statements. On this basis it might be good sense, as indicated by comments of teachers in a range of subjects (extracts 29 and 30 are typical examples), that the ethical programme associated with what actions people ought to do is separated from a description of the state of things. In a nutshell, science is about 'is', the rest is about 'ought'. If we are to teach socio-scientific controversial issues it would be consistent with these comments to separate ethics and science in the curriculum. Thus, Levels 1 and 2 should be taught by scientists and levels 3 to 9 by humanities and social science teachers.

There is, I think, some limited justification for this approach, which I will return to. But the separation of fact from values and opinion is not as clear as that. Comments such as those about 'media hysteria' (extract 34) suggest that much of what is reported in the media is unsubstantiated 'opinion'. If such claims by

teachers are to be taken seriously then it implies that what has been presented in the media has been examined sceptically and found to be untruthful and/or lacking in an evidence base. Interpreting the media should therefore be a good opportunity for students to establish grounds for coming to certain conclusions, examining the reliability and authority of the evidence and checking that any conclusions are logically entailed or inferred from the data as distinct from groundless rhetoric. If there is no way of judging this then we need to understand what trust can be invested in the authorities dealing with the matter and those who are reporting it. So, 'opinion' in some interpretations is gaps in the evidence and problems in reasoning from the evidence. There is therefore no reason why this should not be dealt with adeptly by both science and humanities teachers as indicated in the proposed pedagogies in Chapter 6.

Second, there is the perceived difference between the moral questions and the scientific facts. Humanities teachers deal with moral issues, science deals in facts. There are, however, two problems here. It is difficult to conceive of a moral or ethical question on any socio-scientific issue which is not derived from an evidence and knowledge base. 'Should we prioritise investment in nuclear-powered stations to halt global warming?' cannot be answered without some consideration of the knowledge of what is involved in building a nuclear power station and the consequences of disposal of nuclear waste. 'Should a particular couple risk having a baby when they are both carriers of sickle-cell anaemia?' requires knowledge of basic inheritance, probability and the details of caring for a child with sickle-cell. 'Is embryo selection ever justified?' requires at the least a basic understanding of the scientific reasons behind the question. 'Do animals have rights?' requires an understanding of what constitutes a species barrier. As the history teacher in extract 25 is at pains to point out one does not necessarily need a deep knowledge of science in asking moral questions but it requires an ability to examine evidence and, where socio-scientific issues are concerned, some knowledge of science, even though it might look different from science knowledge in the conventional school curriculum. Thus, a rigid dislocation between scientific knowledge, evidence and ethics would seem to hinder a pedagogy dealing with controversial socio-scientific issues. If, however, these issues were dealt with wholly in science lessons the demands

on the science teacher to do this and teach the content of the science curriculum would be too great; alternatively if taught solely in humanities lessons there is a danger of losing the effect of a topical science context (Ratcliffe & Grace, 2003)

Looking at the problem of the fact-value dichotomy, the disjunction of 'ought' from 'is' and ethics from science, such dislocations are untenable from a pragmatic perspective. For Rorty, pragmatism is an attempt 'to serve transitory purposes and solve transitory problems' (Rorty, 1999) (p.xxii). It repudiates intrinsic and essentialist features of objective reality and concentrates on intersubjectivity. Intellectual inquiry is not about achieving an objective truth but to achieve consensus about ends and the means to achieve those ends (Rorty, 1999). Thus Rorty makes no distinction between natural science, philosophy and literature, or between facts and values, it is simply more difficult to attain agreement about so-called values than about the description of regular objects such as a pair of shoes. This is not necessarily pure nominalism or rampant relativism, such straining towards consensus would incorporate the attributes of dialogical rationality discussed in Chapter 4. In drawing a distinction between empirical knowledge and scientific knowledge, Dewey identifies the origins of the meaning of 'empirical' as gaining skills through repeated practice as contrasted with science which 'aims to free an experience from all which is purely personal and strictly immediate; it aims to detach whatever *it has in common with the subject matter of other experiences* (my italics), and which, being common, may be saved for *further* (Dewey's italics) use' (Dewey, 1916) (p.264). What is central is the deployment of intelligent reflection, the intellectual tools of science, philosophy and the arts in trying to resolve common problems, adapt to new solutions, where 'changing one's values is not only a legitimate way of solving a problem, but frequently the only way of solving a problem' (Putnam, 2002) (p.98). Participants acting openly in a disagreement might have to reconsider their goals, assumptions and values so facts and values are not only instruments in attaining an end but are a means subject to change and reconsideration.

If the virtues underpinning controversy carry with them the intent to co-operate in trying to resolve a problem should the teaching of controversial socio-

scientific issues be taught through an integrated approach by science and humanities teachers? Given also that there is a perception among teachers that they should deal with different aspects of controversy, and that they do have different approaches, the answer would seem to be that ideally it might make sense but practically it does not. Ratcliffe *et al*'s work (Ratcliffe et al., 2004) suggests that an integrated approach which presupposes collaborative planning and agreed assessment arrangements can be successfully achieved but requires substantial investment of resources and professional development.

There is, I think, one way in which the pedagogic aspirations identified in Chapter 6 can be met and that is through teaching socio-scientific issues within a designated subject area such as Citizenship, Critical Thinking, Philosophy or vocational subjects such as Health & Social Care by one teacher, e.g. a teacher of Citizenship. The advantage of this approach is that these subject areas contain much of the knowledge and many of the skills which are contained within the pedagogical framework. It would provide for continuity because it would be mainly taught by one or two teachers who could develop ideas from one lesson to the next. It would also mean that a curricular separation was made between the curriculum subject of Science on the one hand and the teaching of socio-scientific issues on the other. As I have argued in Chapter 2 substantive science and socio-scientific issues employ distinct pedagogies, a separation between them in the curriculum would overcome the problems of framing and boundary posed by the curricular status of science (Bernstein, 1973) and avoid confusing changes.

I believe the pragmatic approach also helps to frame a controversial issue in a different way. It brings the necessary communicative virtues and the repositories of experience and knowledge provided by the modes of thought by asking the question: 'What do we need to know – what resources do we need to bring to the table - to try and resolve the differences which face us?'. Such a question might also best be enacted when the participants have a common interest and emotional engagement in the controversy which drives the need for relevant and personal information, thereby contextualising 'informed decision-making' as described in Chapter 1. With the emphasis on skills of participation and responsible action in the *Citizenship* curriculum for England (Employment & Authority, 1999) controversial

issues can take place within a range of models of teaching socio-scientific issues from the *deficit* model through to *collective praxis*. There is therefore the potential for political participation as well as focused illumination on a disagreement. There would still be scope for complementary treatment of levels 1 and 2 in science lessons which could provide a small and important step for students to see why the application of data is not straightforward, and why even relatively uncontentious decisions can appear more uncertain when viewed more critically.

7.1.2 The Student Voice

If socio-scientific issues are to engage students in school, students must have a 'voice' (Fielding, 2004). Fielding is, in fact, jejune about the possibilities of a student voice; ' . . . so far as I am aware, there are no spaces, physical or metaphorical, where staff and students meet one another as equals, as genuine partners in the shared undertaking of making meaning of their work together' (p.309). Having a voice does not make any concessions to dogmatic posturing, on the contrary it implies responsibility, commitment and conviction. At the heart of controversy is objectivity and distance because we need to see events the way others see them (Dewhurst, 1992). This demands a willingness and ability to convey experience, to tell our story, give an account of ourselves, in such a way that it becomes comprehensible to our interlocutors (Kubli, 2005).

Whereas teachers quoted in Chapter 6 have the facility to tell their stories, or those of their friends, there was little sense of hearing the students' narratives, reflecting Fielding's concerns. In other words the students need to have ownership over the controversy which is often denied them quite unintentionally. That there is a lack of student narratives is understandable: teachers wish to protect students and these issues can be sensitive. Perhaps most compellingly, students might best understand issues vicariously because they (fortunately) might have not had the opportunity to experience matters pertinent to socio-scientific issues, such as having a life-threatening genetic condition, carrying genes which might have harmful effects or living near a nuclear facility. That is part of the reason why literature and other people's stories are so important. But if the issues are to emerge from students' interests and passionate engagement then students also need to speak about things which concern them in order to gain some insight into how to tell their own

stories as a means of convincing (as Bruner puts it) and in positing their arguments. Whether the formal setting of the classroom in a school is the best site for enabling this is met by some scepticism from teachers (extract 90). One possibility is having both formal and informal arenas for these discussions to take place, perhaps days outside the classroom environment, although these make demands of clear inter-disciplinary planning (R. Harris & Ratcliffe, 2005). Democratic processes in schools such as School Councils might be fora in which the components and skills of engaging in controversy can be teased out (Børhaug, 2006; Weir, 2006). But even if democratically elected School Councils existed in every school it would fail to take into account the social and political disparities which exist within the educational system and in society more broadly (Ellsworth, 1989; Giroux, 1988).

In the beginning of Chapter 4 I raised some concerns about power differences and marginalisation in relation to my critique of the Crick definition of controversy. Invitation to engage on equal terms in dialogue assumes an inviter and invited – the inviter is to some extent at an advantage. The nature of the discourse contains those terms which reflect the dominant group where terms like 'parliamentary democracy' (extract 62) or terms like 'equal opportunities', 'work' and 'doctor' take on certain meanings which might reflect enlightenment to some and repression to others. Dialogue itself might be a repressive notion through the discourses that shape meanings and symbolise these power relationships, to 'oust those forms and obscure forces by which we usually link the discourse of one man with that of another' (Foucault, 1972) (p.22).

There is a strong personal memory of a film which seems to illustrate this point. During the coal strike of the 1980s a group of Nottinghamshire miners were interviewed on television to explain why they were on strike. In the television studio in a formal environment the miners conveyed an impoverished advocacy of their position. To address this problem the film-maker, Ken Loach, filmed the miners in conversation in local workers' clubs where they gave a much more convincing and passionate account of their predicament. Loach's film *A Question of Leadership* was effectively banned from television production by the government of the time as being too biased. There are two points I want to bring out from this account. First, conversations about controversy are on somebody's terms which can be about

where and when the conversation takes place. When political leaders are discussing particularly sensitive matters even the shape of the table, or who goes in first through the door[90], is perceived as responding to some of the discrepancies in power between contending sides of the argument. Secondly, the more powerful groups will still be able to limit how deeply the controversy can go. How do they account for the making of consensus or resolution or even illumination where different groups hold particular relationships of power towards each other, indeed where one group might either feel inhibited in telling their story because of the relatively large risks involved or where they are so marginalised that they are not even 'seen' so they can take part in this controversy? But teachers have to start somewhere and the pedagogic tools I have discussed contribute, I believe, towards self-consciousness which is a pre-requisite for participants in any controversy. Even if students, after reflection, reject the premises on which controversy is based the articulation of that rejection can at least be assessed as some measure of success.

The school environment might be forbidding for some young people to engage in open dialogue and explore differences on socio-scientific issues. There are, however, informal fora for precisely these kinds of opportunities, particularly young people who are marginalised by social and material deprivation. The *Pulse* initiative, managed by The Wellcome Trust, supports arts initiatives projects with young people exploring the social and ethical impacts of biomedicine and biotechnology such as issues about eugenics, cloning, left-handedness, stem-cell research and the experience of disability. Each project involves artists and professional scientists working collaboratively with young people who occasionally take artistic control. Some of the projects involve young people who are, for example, school-refusers, transgendered, or participants in inner city youth groups working in alternative dance, plastic arts, music, theatre and multi-disciplinary projects. Evaluation of such projects suggested that involvement in the arts not only enhanced interest in the issues but increased commitment, enjoyment and emotional engagement. In some cases the result was a positive shift in attitudes towards science (CATR, 2006). Where these projects were particularly successful was when scientists were fully

[90] The Israeli prime minister Ehud Barak used his superior strength to literally manhandle the Palestinian president Arafat through the door first after there had been a polite tussle during Palestinian –Israeli talks in the closing stages of the Clinton presidency.

involved with all aspects of the project and where young people were a core part of the creative process representing the issues. Most of the projects produced opportunities for discussion with young people and the audiences at the final productions. Informal inter-disciplinary approaches might be a site to build up work on analysing how effectively young people develop the knowledge and attributes enveloped in the pedagogic framework.

7.1.3 Further research

I have developed the pedagogic framework for controversial socio-scientific issues and discussed practically what it might look like. This leads to the next question which is to gain some insight into its effectiveness in illuminating controversial issues, gaining insight into rational decision-making and promoting democratic participation. These objectives will have different meanings depending on the model adopted of the Science and Society interface (table 2.1). But a research approach into the effectiveness of the framework will draw on the formulations and descriptions of levels in table 4.1 as well as the associated communicative virtues and modes of thought, aspects of which will have to be evident if engagement in controversy is taking place. With professional development activities supporting the kind of pedagogies discussed in Chapter 6, it should be possible to describe aspects of the level formulations, use of evidence within them, social interactions, the communicative virtues and modes of thought. Through these descriptions we could then begin to conceptualise the learning and interactions as students engage in socio-scientific controversial issues.

In the description of the *Pulse* initiative, the emotional engagement of the young people was a distinct contributing factor to the success of the projects. This is something that has been subsumed in the framework and was mentioned by some teachers in terms of their own, and the students', emotions being aroused by some issues. In Chapter 4 I referred to Mary Midgley describing the engagement of emotions as complementary and supportive of rational decision-making (Midgley, 2003). Emotions cannot therefore be sidelined in issues involving ethical judgement and, as Nussbaum asserts, need to be accompanied by a theory of emotions (Nussbaum, 2001). The responsivity to emotions in teaching controversial socio-scientific issues could be foregrounded in future research.

Towards the end of Chapter 1 I listed obstacles facing a pedagogy of controversial issues. Having worked on the thesis I do not feel those obstacles are any less formidable; on the contrary I realise what a difficult, but not unmanageable, enterprise it is for teachers, keeping in mind the need to satisfice. The framework is a small start in developing such a pedagogy.

7.1.4 Critical evaluation of the framework

In this final section I want to highlight three health warnings to qualify any attempt to make a wholesale use of the framework. First, it can be seen from analysis of the interviews that the framework needs to be much more fully fleshed out and contextualised in 'teacher-friendly' language before it can become realistically applicable to a teaching situation. For example, in level 2 of LoD terms such as 'trust', 'risk', 'probability', 'double blind testing' need to feature and be exemplified. A term such as 'trust', emerges as an important component from the research literature and the other terms were identified by a couple of teachers but are nonetheless important in understanding many contemporary socio-scientific issues. In this chapter I have also discussed the dichotomy of facts and values and the need for procedures and warrants that help to say something about the validity of evidence. In fact, the formulations, examples and explanations of the role of evidence in table 4.1 only cover the surface of procedures and exemplifications and possibly glossaries of terms that encompass each of the levels. This framework can serve as a discussion point, indeed a 'framework', for schools to amplify case studies they can use to illustrate particular levels and important concepts and ideas that will emerge. Furthermore, issues change over time as I argued in chapter 4, and a host of new terms with subtle changes in meaning connected to specific issues will need to be incorporated within the framework.

Mapping teacher's perceptions of controversial issues against the framework yielded areas which pointed to considerable development in teacher practice. While I have defended this using only interviews in Chapter 5, more could be understood about the challenges teachers face in teaching socio-scientific controversial issues through an analysis of practice in lessons and over an extended period of time. As I have

pointed out in the preceding section the framework can be used to test its efficacy in the classroom when the teacher makes aspects of the three strands explicit in discussing a particular issue and checking how students then use those aspects in discussing a different issue. But it might also be the case that classroom observation yields deficiencies in the framework. I have no reason to believe that classroom analysis will prove fatal to the framework but it might well result in some modification.

Finally, the evolution of the framework has been formulated in terms of pedagogy. Nothing has been said about student learning and how young people begin to construct their own understanding of controversial socio-scientific issues when studying specific cases (Lave & Wenger, 1991). This is an area of research which again could emerge from a critique of the pedagogical framework and could result in considerable modification. The framework is far from all-encompassing but its value might be as a progenitor of further discussion and research.

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Appendices

School E - Head of English

I: Talking to P K., head of English. P. can I give you a list of topics and if you could just look at those, down the list and just tell me what your thoughts would be about teaching those topics.

PK: Some of them we would teach in a very direct way, overtly and some would be issues that would be raised through speaking and listening exercises which would either be planned where the topics would be given directly to the children before having to prepare or they would be given what we call "hot-seating", where they are just given them blind and asked to talk them off the top of their head. Some would be taught overtly through a set book, so for example genetic engineering, that would come up such a novel, such as Brave New World by Huxley where they have alpha, beta, delta, gamma, epsilons and the amount of oxygen that's put, allowed into the brain with the foetus just before birth is controlled so you have an organised society in which you have the correct number of people at the correct level of intelligence to fulfil the needs of society so that would be taught through fiction. But those would be the three ways in which generally what we would do is planned discussions, spontaneous discussion and deliberately chosen set books to raise those issues and it would go across from year 7 to 13.

I: Right, year 7 to 13?

PK: Yes, so example, animal experiments would be something that would be especially in lower school, which is a topic that children of eleven, twelve, thirteen are very, very opinionated about, usually anti whereas in years 10 and 11 they've got a much more distanced view of it and they understand the difference between animal experiments for medical use and for cosmetic use. Animal to human transplantation would be, I don't think that would come up as a planned thing, it would be something that would be spontaneous. Some of the others, behavioural, brain tissue, dementia, would be things that we probably wouldn't touch on because they'd be far too complex and depression we would because that comes up through literature and the effects of it and quite a lot of children have parents or relatives who do have some of these disorders so they are able and quite happy to talk about it. I think there's a gender issue as well where in quite a lot of them, things like cloning is a very, very, the girls tend to be very much against this whereas the boys think it's a much more acceptable thing. I interviewed a girl who was going to Oxford to do Law and asked her the question, what do you think about cloning, because Dolly the sheep was on the time and she thought it was a brilliant idea because it would mean that we could make sure that the whole of the population was very intelligent if we wanted to. And I asked her the question, who's going to enter the bins? And she sort of so, and even at eighteen they still have quite a narrow view of biomedicine I think.

I: So could you

PK: So HIV, all of these would be taught either in implicitly or explicitly at some point.

I: Can you give us an example of say one or two of those, you mentioned the girl, we just talked about, about cloning. I'm thinking particularly post-fourteen here, so it's really years 10 an upwards and are any of those issues you'd have covered say in English and I know you also talked about Brave New World, but if you, is there anything else specific you can think of that either isn't spontaneously or being deliberated.

PK: The Tempest: for nature/nurture. The Brave New World, is intelligence something that is taught through environmental or is it something that is inherited and we have the Caliban character who has got natural intelligence, but it's not the intelligence of the western world and that leads into big discussions about euro-centric behaviour with the discovery of the new world in the fifteenth, sixteenth century. And the world discovery is always a contentious word. So that would be post-fourteen. Equally the language acquisition which is taught explicitly and we would look at Skinners behaviourist theories as opposed to Chomsky language acquisition development and PLJ so those would be the nature/nurture would also be taught through Pope, Alexander Pope's poetry, the idea of the formal garden and the ability to organise life and the garden as a symbol of organising life. So I am trying to link them to specific texts that we would do because that is the way in which we would do it because we don't tend to teach issues, we tend to teach a novel or a play or some verse and from that the issues will arise, rather than looking for the issues and trying to sort of …

I: So it's content led rather than issues?

PK: Is there anything you think should be covered that isn't? Or even if it isn't in there, that isn't in what you're teaching that you might like to cover?

I: We can come back to that.

PK: I was thinking of criminality. We have a unit in year 10 where we do the Craig and Bentley case which is mis-carriage of justice and there's, in the trial there is a great deal of emphasis by Lord Goddard, the presiding judge about the criminal type and we try and do a fit from Lord Goddard to the criminal type to see if there is such a thing, going back to the nineteenth century idea of there was a physiogamy of the criminal type. We get the police to come in then and the prison service and they talk about the criminal type and contradict everything we've said because they say we can spot them a mile off! So we spend a lot of time saying there is no such thing as the criminal type and they come in. It just gives them another.

I: When that has happened what has sort of taken place, I imagine there's been quite a sort of tension about that.

PK: It has, I think the students tend to think well you're not looking at these people as individuals you're looking at them as something that has to be processed

through a system and they get very empathetic towards a something who has had a, there's been a miscarriage of justice and when we look at, we spread it out to the Birmingham six and Guildford 4 and they see them as individuals, whereas the police, the prison service, they, because of their, they've only got an afternoon to do this, they are, they've got another agenda which is, we don't want you to end up like these types, which they then demonstrate this life style that leads to this. That sort of thing. I think, to go back to your question, things like depression, should be more overtly taught and how to deal with it. Because there is a lot of children do get very depressed at school. They find the pressure is heavy from home and from their teachers and there is no organised counselling system within the school at all. It tends to be you're stuck with a tutor and whether you get on with that tutor or not, that's the person you have to go to.

I: So there's nothing built in to the curriculum, as it were, to say that we're actually going to discuss and talk about these issues.

PK: No, they'll talk about exam pressure, they'll talk about transition from key stage 3 to key stage 4 or leaving school but the only time you'll know that someone is depressed is if they're not performing in their work. I have a boy in year 11 was in last year's eleven, I taught him two years and he had a, a very clever boy but would not, couldn't do any work. He had a morbid fear of blank paper. He was okay with a small screen word processing, if you gave him a blank sheet of paper and asked him to write on it he couldn't do it, he couldn't look at it, he was terrified of the blank sheet of paper and in the end he now has a psychiatrist, well psychologist, who is helping him but the school had no idea how to deal with that. And I said to his mother at parent's evening, just refer him to the GP and the GP has referred him on for help but the school's attitude would be, that's nothing to do with us.

I: Because there's quite an equal opportunities issue there as well. That's quite …

PK: HIV and AIDS, that's not, that something that of course is put in to a PSE programme as part of something that I think we feel we have to do, but it's probably too late, it's probably again an issue that can't be raised to early because parents would object. Perhaps it should, like with drug education is now gone into the primary school, I don't think HIV and AIDS is ready to go into year 7 and 8, sort of year 10 and 11.

I: Tends to be dealt with in the upper school

PK: Yes, when it could be, as with drugs education, too late.

I: OK In your opinion, what might be objectives or the purposes of teaching about social and ethical issues linked to biomedical research? Such as those.

PK: My purpose, or my objectives?

I: Well what do you think the objectives are for the kids? For teaching them to the pupils?

PK: It seems an obvious question.

I: Well go on, tell us the obvious.

PK: Well. School is a very narrow academic environment, whereby children tend to be spoon fed information. What they don't get is any teaching whereby there are no yes or no answers and tend to go down this track of "what is the capital of which country, these are the facts of science, these are the things you have to do in maths, you do this in geography" and there are very few areas where they are presented with a dilemma and I think it prepares them very well for life, which is going to be about facing up to dilemmas, not particularly major issues like this, but day to day dilemmas. I think this is very good because they soon realise, very quickly, that there is no straightforward answer. We have a lot of pupils with eating disorders in schools – all girls and they talk about them quite openly in front of the other students and the other students very soon realise that you can't simply say "oh this girl is just trying to be thin, this girl is just selfish" and so on, it also helps them through English to write about this and express feelings that they have, especially with parents, you know the conflicts they have with their parents, and it's those dilemmas of I've got to keep happy a step parents and a real father, a step sister, step brother and how do I come to terms with these kinds of dilemmas? And this is the objectives that I would have underlying the teaching of any of these sorts of issues.

I: So in terms of that, the objectives, it's the sort of dilemmas that in day to day, in life in general, either in public policy of in day to day life, we have to deal with dilemmas that don't have a straight forward answer.

PK: And these are academic things which will never touch their lives perhaps, but they need to have a world view of things rather than simply "oh, cloning is wrong".

I: On the other hand, you can say something like BSE for example does touch our daily lives because when we buy beef, meat it does, we might. And the press does inform our, It's in the tabloids as well as the broad sheets.

PK: And GM foods as well.

I: Indeed, yes. So in view of that, in view of what you've said, what do you see as the main difficulties of teaching about these topics?

PK: All of these is without doubt a total ignorance by the students. They've got opinions but any discussion is always at one level. It very rarely reaches the next stage because beyond the level of opinion, they are stuck. They are very rarely able to bring evidence to back up their opinions and that's why these things need to taught in terms of some sort of evidence base, so it's just

simply “oh eating meat means you’re going to get mad cow disease” and that is the sort of level of discussion that you tend to get.

I: So, the difficulty is what,? For the teacher to have….. what is the difficulty there?

PK: The difficulty is getting the correct level of information which the children can then understand and then synthesise and use in developing an opinion. Rather than just prejudice.

I: And where is the difficulty for the teacher then? There’s difficulty for the kids, is having the opinion without all the facts. What is the difficulty then for the teacher?

PK: The difficulty for the teacher is how, do they feel comfortable about dealing with these issues and a lot of people would just say “no way”. As teachers say “I am not teaching about sex education, I refuse to do it. I refuse to teach drugs education. I don’t feel qualified, or I feel embarrassed. It’s not my job” I am a geography teacher.

I: Do you have a policy, either in your department or in the school as a whole on how to handle controversial issues?

PK: I don’t think the school has a policy that says controversial issues. But I mean, built into English, because we deal with controversial issues all the time is the only text worth doing are those with controversial issues in them or else there’s nothing to talk about.

I: Right. Would you work with say, science staff or PSHE staff if you’re teaching you know say would there be an occasion where you might be deliberately talking to another member of another department because they might have an expertise in that particular issue?

PK: Not really with science, it would tend to be with other humanities subjects. Say if we’re doing the first world war, we’d talk to the history department. That sort of level.

I: If you were to have inset on say teaching these things, what sort of inset would you like?

PK: I think the sort of inset would be to develop a handling of these issues by the teacher to give the teacher confidence to deliver them and different ways of there being some outcome for the kids because I can see in here there is a unit that has to be done called “original writing” for GCSE and original writing tends to be nearly always imaginative and what I would like to see is much more discursive writing, argument and persuasion writing and this would be perfect for it where they’re putting forward opinions rather than just using imagination and it would also, how to handle a group discussion on this subject. You know the structuring of a group discussion with large groups of children who perhaps don’t have the same level of knowledge. How to build

up the knowledge and role play. They're very good for role play in Drama. A lot of this.

I: So, I think you touched on this before, but are there changes to the National Curriculum that you might like to see to encourage kids to perhaps deal with these issues?

PK: Well yes, they could include it for a start. They could, I mean the new orders, less prescriptive which means that instead of prescribed authors and prescribed texts we are simply given a prescribed area like the nineteenth century, the twentieth century, poetry, prose and drama. It's left as open as that. So there is the opportunity if you wish, to do it.

I: To include some of the specifics.

PK: Yes, to put something in there. But I can't see the government prescribing something as controversial as this into the English curriculum because it would give English teachers the opportunity to be too subversive.

I: That's an interesting comment! Although there is a […] coming up in 2002.

PK: That's going to be watered down. It's been on before, citizenship – it was called something else before, then it was called citizenship. But it all comes down to the same thing, it's a civics course by any other name, which is your place in society, your individual responsibility, knowing something about government, knowing something about the workings of the law, the local authorities and so on. And these sorts of issues … They're not touched on, they're paid lip service to, but…

I: I take your point. Are there any additional questions you think we should have included? Or is there anything you'd like to ask us?

PK: I think really, because these issues are so important in many ways in, especially for the future of children, I think within English text books, they ought to get beyond the first one. Every single English text where you have the chapter on "controversial issues" is always about animal experimentation, it's never about anything else and I think they think that is the level that students can operate at. Publishers, I don't know whether publishers are too frightened or they're not too sure of their facts, or they think they may offend some schools, or offend some parents so they keep away from it. So they keep away from it completely. I think animal experimentation, homelessness and child labour in the third word are the three areas that come up time and time again. There's never anything else, and of course drugs. Drugs and how bad – text book. There's never any discussion though. They tend to be heavily biased against.

I: Thanks every so much

End of interview chat.

Appendix B

Pedagogic Framework Coding scheme

Strands	**Main empirical indicators**	**Sub-indicators**	**Other themes**
Communicative Virtues	Tolerance Patience Respect for differences Willingness to listen Openness Sensitivity Sincerity Honesty Balance Curiosity Impartiality Criticality/skepticism Empathy	Context Owner of CV	
Modes of Thought	Narrative Logico-scientific	**Narrative** Context Form Purpose Agent	
Levels of Disagreement	See Table 4.1		

Appendix C

Protocol

I would like you to code three interviews with teachers on the teaching of socio-scientific controversial issues. You will need to do the following:
a. Read the instructions below. They are quite long (about 20-30 minutes) but I have tried to make them as non-technical as possible. If there is anything you feel unclear about please highlight the relevant section and I will talk it through with you. It is vital that the instructions are as clear as possible.
b. When you have read the instructions you will need to highlight any statements by the teacher which correspond to the codes on the attached sheet. When you do this you need to enter the information on the table provided as explained below.
c. I have coded the same interview. We will need to compare our sheets to see if we have coded the statements in the same way. If there is a significant discrepancy, i.e. we disagree on more than 10% of the statements, then we need to discuss the differences and I will re-write the protocol to accommodate the changes.
d. Once we have agreed the protocol we will need to code another two or three interviews.

There are three parts to the coding system.

Dispositions or Communicative virtues
These concern dispositions or attitudes people have in a controversy or disagreement or conflict. Even where the disagreements are deep such as about religion or abortion people need to agree implicitly or explicitly about certain procedures. At a fairly basic level we must agree that we are not abusive to each other even if we have strong disagreements. If we try to degrade someone because of their race or sex or sexuality or age then we do not show the required respect and it would be very difficult to discuss anything in this kind of environment.

We have to be prepared to listen to each other, show respect, see participants in the discussion as equals so everyone's contribution is judged based upon what they say not upon who they are. People also need to be open to having their opinions

changed and not enter a controversy dogmatically. We need to be thoughtful, tolerant and critical. If someone says something you feel is incorrect an appropriate disposition is to bring that respectfully to light. Too much toleration might not in the end be fruitful to controversy. We need also to be sensitive to people's feelings, for example, taking care how we talk about obesity with people who are either obese or anorexic or who are known to have close relatives who suffer from a particular condition.

As well as the positive dispositions one can have there can also be negative one, those in fact which are the opposite of those mentioned such as ‘opinionated’, ‘dishonest’, ‘dogmatic’. In the context of a discussion we call these dispositions, Communicative Virtues or CVs for short.

I would like you to read through the interview highlight any statements from the teachers which refer to any CV. If in doubt, highlight the statement as a CV.

CVs can refer to students, teachers or others such as outside visitors, other teachers or parents.

In coding the interviews please use the sheet to indicate
1. The line numbers containing the statement. For example if the relevant statement is between lines 113 and 120, please write down ‘113-120’. The coder should be able to identify the CV in a context which makes it clear that it is a CV being identified.
2. In the next column headed ‘statement’ please write down the first and last couple of words of the relevant statement connecting the two by a series of dots, e.g. ‘When you are discussing . . . condition.’.
3. In the third column, the empirical indicator is a way of categorising the statement. Suppose a teacher says: ‘When you are discussing disabling conditions such as cystic fibrosis you need to be very careful that you are not upsetting students in the class who might have family members with the condition.’ Here the teacher is demonstrating *sensitivity* towards certain students in the class. In the empirical indicator column you need to write ‘CV; sensitivity’. If possible go further and indicate who possesses the CV. In this case I think it is the teacher but the use of ‘you’ may

be more generic and include students. Indicate any doubts or qualifiers in the 'Comments' column.
4. Sub-indicators. These include any categories which you might consider relevant to the statement identified. In this case I would add 'Context: Discussion of cystic fibrosis'.
5. Comments. These should include anything else you might wish to add particularly if you are not sure about the statement. Please also use the 'Comments' column if you feel the statement is very illustrative of the empirical indicator and could be quoted.
6. Assumptions. Use this column to justify your categorisation in the Empirical Indicators column. In the above example you could write: 'taking care to not upset students indicates sensitivity to their feelings.' If a teacher actually mentions a particular CV such as openness or honesty or tolerance or sensitivity, simply mention the word in the Assumptions column.

Modes of thought

Modes of Thought (MoTs) are the ways in which we convey an attitude, opinion, judgement, argument. Jerome Bruner suggests there are two main ways of doing this:
a. through **narrative**: telling a story, giving an account, relating some kind of experience. Generally a narrative will contain non-scientific words but there amy well be exceptions. (either explicitly or implicitly)
b. **logico-scientific**: This relates to scientific ways of conveying information. These will include logical processes such as inference, induction and deduction, drawing conclusions, sampling, estimating risk..

1. In the table use columns on 'line numbers' and 'statements' exactly as described for Communicative Virtues.
2. The main empirical indicator will be MoT followed by either 'narrative' or 'logico-scientific' mode. There might also be opportunities to identify who drives the narrative or logico-scientific mode and the form it takes. As an example, take the following statement: 'When we were discussing whether embryo selection was right or wrong, a student in the class who suffered from

thalassamia was happy to tell us about the injections he takes and how he feels about it. The class were really interested.' In this case the teacher is telling us about the thalassaemic student telling the class about his experiences. In the empirical indicator column you would write: MoT; narrative; oral; student.' (note that the student being happy to tell the class and the class being interested would constitute CVs). Another example is 'We were used The Tempest to discuss nature-nurture'. Here Shakespeare's plays is a narrative form and the categorisation would be: MoT; narrative; play'. There is not enough information to know whether it was the teacher, students or both who decided to use the play. A final example is: 'They (the students) have problems generalising from the data in deciding to take a course of action'. 'Generalising' indicates a logico-scientific mode and the categorisation would be: MoT; L-S'.

3. Sub-indicators: As for CV describe any information you think is relevant. For example, in the thalassaemia statement the context would be thalassaemia, and since the account is about his personal experience I would also include 'personal'. There is nothing to add for the other examples unless you know the context in which the statements were made.
4. 'Comments' column: as for CVs. The first statement on thalassaemia seems rich to me and I would include it as a quoted comment.
5. Assumptions: As for CVs.

Levels of Disagreement (LoD)

Please see the attached sheet. There are different levels to any controversy and examples of the levels are given in the table. Below are examples as to how evidence might be recognised.

Levels 1 and 2. Use of evidence in resolving a disagreement. An example might be 'Once the students know the hard facts that should help them to make a decision on GM foods.' Under 'empirical indicators' this statement would be coded as : LoD; Ev'. In fact analysis of these statements can be a lot more complicated. In the comments column it would be helpful if there was anything else you feel needs to be added to the categorisation of Evidence for levels 1 and 2.

Thank you very much for taking the time to read through this and the attached sheets.

Please read through the attached interview to get a ‘sense’ of it. You might want to initially mark any statements which relate to any of the three parts. Once you have read through the interview please go through it again and complete the attached table.

Appendix D

School E/head of English

Line numbers	Statement	Empirical Indicator	Sub-indicators	Comments	Assumptions
11-16	Some would be taught overtly . . . . fiction	MoT Narrative mode (imposed?)	Specific topic Teachers choice of narrative Medium Explanation of mode	Mentions topic, GE; Taught through a set book, teacher sets task and medium (set book); Explains how named text, BNW, illustrates the dilemma, differentiation of society, although isn't strictly about GE	I am taking the mention of a set book as being the indicator of an imposed narrative, that is a novel is taken as a form of narrative.
17-19	planned discussions . . . year 7-13 (too inferred)	MoT Narrative mode organised or framed by teacher	Strategies given	Strategies to give scope for narrative but also any mode of thought	Any means of promoting communication between individuals is seen as an opportunity for a mode of thought.
23-27		CV in students	Topic mentioned	Topic in context of dispositions: animal	'opinionated' suggests a

		'opinionated' lack of openness more distanced view, more open		expts. Explains contextual difference between openness and lack of openness in students. (lack of distance suggests 'interests' as LoD) (Animal over cosmetic use suggests prioritisation)	disposition as does 'more distanced view'.
27-8	Animal to human . . spontaneous	CV Spontaneous (students) (+) Recognition of spontaneity (teacher) (+)		Spontaneity from the students but teacher has to recognise this.	Recognition of spontaneity suggests a disposition of recognition on the part of the teacher.
30-31	comes up through literature	MoT Narrative literature	Topic: depression		Literature as a form of narrative
31-2	quite a lot of children have parents . . are able and quite happy to talk about it	MoT Narrative pupil voice CV honesty (+) on part of pupils		depression; pupils talking from experience	Pupils talking about experiences of parents with depression. I am taking any account of experience as a form of narrative, Happy to talk about something suggests

					openness/honesty on the part of the pupil.
33-4	things like cloning . . . acceptable thing	LoD vague/general	disagreement between boys and girls Topic: cloning		Doesn't mention cause of disagreement but does mention disagreement on cloning between boys and girls
34-40	Oxford . . .narrow view	LoD worldview but could be others CV narrow view (-) pupil	disagreement between teacher and pupil; topic: cloning; could be a whole range of levels, eg requiring evidence/interests /prioritisation etc.		Quotes two opinions on topic so suggests a disagreement.
52-56	The Tempest: for nature-nurture . . . and we have Caliban character . . . century	MoT Narrative (literature); LoD *Interpretation/meaning* of 'intelligence'	Topic: Nature-nurture; Form: Shakesperean play Specific: Caliban's intelligence. Justification of use of narrative		Canonical play as form of narrative; meaning of term: intelligence as 'natural has a different Euro-centric meaning; subject justifies what he means
52-3	Brave New World . . .inherited	MoT Narrative (novel); LoD	Explains: intelligence as inherited or		Brave New World novel as narrative form;

		meaning of intelligence	environmental; Form: Brave New World as vehicle of ideas		justifies interpretation of meaning of intelligence.
56-7	Discovery . . contentious word	LoD interpretation of discovery as contentious		Assertion: Discovery as a contentious word (no justification)	Explicit assertion that discovery is a contentious word.
57-9	language acquisition . . .LAD	LoD (looking at different theories)	Topic: language acquisition	Levels (not sure which - should there be another level for this?)	Levels suggested by looking at different theories of language acquisition but I'm not sure which level it would be assigned to.
60-1	Pope's poetry . . symbol of organising life	MoT Narrative (poetry)	Topic: nature-nurture Justification of pedagogy		Poem as narrative; justifies why he uses the poem
61-2	Link . . texts	MoT Narrative (texts)	Justification: Linking issues to texts		Texts as narrative and explains he is linking issues to them
63-4	teach a novel . . issues	MoT Narrative (novel)	Explanation: of pedagogy	Issues arise from the narrative rather than looking for narratives based on issues	mentions novel, play as narrative form from which issue arises.
73-7	Craig and Bentley . .criminal type.	LoD Evidence (for the criminal type) Meanings (criminal types)	Evidence: doing a fit to the criminal type; Meaning: criminal		doing a fit to a term suggests using evidence to do that

			type		(deductive); differences over meaning of criminal type
75-6	criminal-type . . fit	MoT Logico-scientific	Logico-scientific: trying to make a deduction		linking evidence to a theory
77-9	Police to come in . . mile off	MoT Narrative (talk about criminal type); LoD Meanings (criminal type)	Topic: inferred experience of criminal type; meaning of criminal type		Bit of a guess at narrative here as role of narrative inferred probably from stories police tell
85-91	not looking at these people . . life style that leads to this	LoD worldview (between students and police; or do police have different priorities/interests?)	Examples: B'ham 6 and G'ford 4;	students look on people as individuals whereas police see 'criminal' types because they have a different agenda.	Certainly reasobaly deep differences either inetersts or world views, pupils see individuals, police see criminal types.
87	empathetic . . miscarriage of justice	CV Empathy (+) Students	Topic: people who have suffered miscarriage of justice	Student empathy towards people who have suffered miscarriage of justice	empathy suggests disposition/CV
144	talk . .openly . . students	CV honesty (+) students MoT Narrative Students (talk about their eating disorders)	Topic: eating disorders;		'openly' suggests disposition; narrative talk because relating an experience
145-6	soon realise . .	CV		overcoming	context of

	selfish	reflectiveness (opposite of opinionated)		opinionated view	sentence suggests a disposition
146	through English to write	MoT Narrative Students: writing their experiences			writing about contextual experience
147	express feelings that	CV Expression of feeling			feelings suggests disposition
157-8	need to have a world view . . cloning is wrong	CV Grounded opinion (opposite of unfounded opinion)	Explains: why they need to have considered view		difficult one but type of thinking in discussion is suggested
171-4	rarely able to bring evidence . . evidence base	LoD evidence (to back up opinions) MoT logico-scientific (relating evidence to opinion)	Explains: importance of evidence in giving weight to an opinion and therefore possibly resolving difference;		evidence suggests level; use of evidence suggests logico-scientfic
178-9	getting the correct level of information . . an opinion	LoD Evidence MoT logico-scientific (synthesis of info into an opinion)	Explains evidence: as information Explains: logico-scientfic: synthesizing into an opinion		equating information with evidence; teacher saying that something is happening with this evidence.
184-5	do they feel comfortable . . no way	CV Comfort level (in running controversy) (-) teachers			'no way' suggests strongly an attitude of a teacher, suggests negativity

209	more discursive writing, argument and persuasion	MoT Narrative (discursive writing, persuasion, argumentation) (teacher (imposed)	Form: narrative: through discursive writing/persuasion		narrative, modes of thought suggested through forms of pupils writing.

Head of Humanities (geographer)/School R

Line numbers	Statement	Empirical Indicator	Sub-indicators	Comments	Assumptions
27-52	animal experiments . . yob cultures can develop . . gives currency to what I was saying	LoD interests	Context of interests: farming geography and of producers in the food industry	**Good illustrative section**	subjectivises the farmers and food producers to explain how contexts affects actions/points of view
54-6	in the context of the EU . . benefits of Britain	LoD normative considerations	Context: food production regulations		
57-9	what I tried . . views on them	CV Balance CV respecting student autonomy			allowing students to come to their own valued judgement and his role in not imposing his views
65-6	fear of AIDS . . . emotive issue	CV recognition of emotive issue	Context: AIDS		
60-70	I would say . . . .news	LoD Evidence Problems in interpreting evidence	Context: population levels in third world cities	**Complex statement on interpretation of evidence**	identifies issue of populations dropping and shows problem of

		MoT L-S inference problems			inference
92-4	judge success . . .down their throats	CV respecting student autonomy			Not forcing views down students' throats
111-15	another impediment . . .huge gamble	LoD Evidence Complexity/Access CV empathy	Context: new technologies in farming	**Unusual – worth quoting**	Makes the piint that difficult to understand actions if you're not immeresed in the evidence
115-21	I think . . veil over their thinking	CV problems of empathy students			Students' affluent b/gd, comfortableness can draw veil over their thinking
128-31	I tell members of my dept . . fine.	CV promoting autonomy of teachers	In teachers' role as head of dept		tells teachers that they are free to engage pupils in controversial issues
140-2	I think sensitive handling . . key thing	CV sensitivity teacher towards students			mention of sensitivity
152-4	The impediment . .Sahal	CV problem of empathy students		**Worth quoting - rich**	mentions empathise with shanty dwellers

160-2	We'd be more practical . . family	LoD Ev information subject-specific	Information as socio-economic	**Evidence outside of pure science**	mentions information but very subject-framed
168-70	my gut feeling is . . in the past	CV lack of teacher autonomy	Context: new specifications		teachers having their hands tied
198	I would like facts to speak for themselves			**Although mention of facts, any coding could distort what teacher was saying. Talking in the context of balance**	
198-203	I think with these issues . . economy	CV balance context-dependent			balancing up the moral issues
203-13	If, for example . .greyness	LoD interests LoD priorities	Context: GM tomatoes	**Rich and worth quoting**	identifying stakeholder interests then pointing out how we might prioritise
226-37	We also look at the Chernobyl disaster . . throat	LoD interests (motives) LoD Ev CV emotive CV respecting student autonomy	Refers here to emotive evidence (see Aikenhead)	Essentially repeating points about student autonomy	Evidence about radiation sickness but pointing out the emotive factor. Again, respecting student autonomy by not forcing views down their throats