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ABSTRACT

This paper presents a study that investigates the teaching and learning aspects of controversial issues in science education. Teaching ethical issues is mandatory for science teachers in England; however, teachers may experience difficulties in exploring contemporary issues in science due to rapid and unpredictable changes. The study carries an exploratory nature and was conducted with the participation of (n=29) students where they were asked to answer three questions: (a) How do you think a "designer baby" is made? (b) What do you think a test-tube baby is? and (c) Some people think parents should have the right to choose things like the sex or eye color of their baby, what are your thoughts? Results indicate that teaching ethical and social issues raises issues in the instructional effectiveness of teachers. (Contains 11 references.) (YDS)

TEACHING ETHICAL ISSUES IN SCIENCE

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Introduction

It is now mandatory for science teachers in England to teach ethical issues arising from dilemmas in science, (DfEE/QCA 1999) although the national curriculum of England takes as unproblematic the challenges that teachers may face in exploring contemporary controversies in science. Biomedical research, for example, is developing with great rapidity and the social and ethical problems concomitant with these changes are, to some extent, unpredictable. So, what problems do teachers face when addressing contemporary issues in science? And what do young people think about these issues?

Of the many controversial issues in science, advances in the genetic and reproductive technologies have a personal relevance for students. Understanding the implications of a genetic screening programme, for example, and the possibility of having an inherited genetic condition, concerns not only individuals but also their families and the wider society. Decision-making is likely to involve the private morality of the concerned individuals, their specific socio-economic contexts, their personal and social relationships and their educational background. Debates about cloning and genetically modified food indicate that political decisions are sensitive to public opinion. For example, the Human Genetics Commission, a non-executive advisory body to the UK government has circulated a questionnaire to the public on their attitudes towards developments in genetics[1]. The dissemination of information resulting from genetic testing has important civil rights implications. Formulating public policy and creating the conditions for democratic accountability on these issues presuppose a citizenry that has some grasp of the underlying science and an awareness of the values base. Young people entering medical vocations, the social services and teaching will need an appropriate background that enables them to deal with the many ethical, social and legal questions that will arise. The school education of an emerging lay and professional citizenry is crucial in providing a forum for rehearsal of these issues (Nuffield Council of Bioethics 1993).

A team at the Institute of Education, University of London carried out a large scale survey for The Wellcome Trust on the teaching of social and ethical aspects of developments in biomedical science (Levinson and Turner 2001). Questionnaires were sent to teachers and headteachers in 1000 schools in England and Wales followed by 111 interviews with individual teachers and groups of teachers across the curriculum. Findings from the survey indicate that science teachers tend to have an epistemological view of science as value-free, that they have little experience of managing ethical discussions in the classroom and that all teachers have a limited knowledge of what young people think about these issues..

An exploratory pilot study has focused on developing empirical tools to study the teaching of ethical issues in the new genetics. While ethical ideas and perspectives can be taught in a transmissive way, any understanding of them relies on belief, experience and emotions. Indeed the immediacy of research in the new genetics is the implications for individuals, families and communities. Interchange of ideas in the classroom in science, and certainly ethical issues in science, should involve opportunities for talk, discussion and argument (Newton, Driver et al. 1999). This preliminary research study focuses on two aspects of teaching and learning controversial issues in science: first, developing a probe to characterise the range of ethical arguments that students use when thinking about dilemmas in the new genetics, and, second, formulating a description of the strategies used in dialogue between student and teacher. The research therefore draws on ideas of discourse analysis that focus on dialogue, ((Edwards and Mercer 1987), (Lemke 1989), and current ethical thinking in aspects of genetics (Singer 1979) (Glover 2001).

[1] HGC Business: Consultations. See http://www.hgc.gov.uk

The context

The medium that was chosen for the study is a one year post-16 course, *Science for Public Understanding(SPU)*. As the name of the examination course suggests, one of the important aims is to cover a range of issues which members of the public will need to understand if they are to participate in scientific and technological decision-making. It thus stands distinct from other syllabuses that have a more overt science content, and the course attracts non-science as well as science students. The module selected for the research is based on developments and ethical dilemmas in genetics covering inherited diseases, antenatal screening and pre-implantation genetic diagnosis. Four two-hour sessions were observed by the researcher. A fifth session not attended by the researcher, brought together strands of the module and a previous module for examination purposes. In the first session the teacher addressed the underlying science concepts – genes, chromosomes, alleles, dominance, recessive, genetic conditions, fertilisation, (including *in vitro fertilisation*), zygote. The second session broadened out the range of genetic conditions and the need for screening. Discussion of ethical dilemmas – the focus of this study – occupied the third session and the fourth session addressed the topic of designer babies through the video *The Gift*.[2] A wide range of strategies were used: videos, direct teaching, group discussions, true and false statements, question and answer sessions.

There are twenty four students on the course, although two did not attend any part of the module, and numbers attending the sessions varied from 22 to 12. For three of the four sessions, however, twenty or more students attended. There are ten young men in the group and fourteen young women, and in each session there were always slightly more women than men.

The teaching sessions take place in a further education (FE) college in London. A further education college is usually larger than a secondary school and runs many more courses, including a mix of vocational and academic courses. Mature adults attend courses at FE colleges and often work in classes with students in the 16-19 age group. Most of the students in this group are in the 16-19 age group, although there is a Somali refugee in her early twenties who, the teacher told me, had a disabled two-year old child. The class is ethnically diverse, consisting of refugees from Afghanistan and Somalia, students from the Asian sub-continent, Afro-Caribbean students as well as white UK-born students. The class reflects the ethnic diversity of the college, and those of many schools and colleges in metropolitan areas of the UK.

The Research Study

The course tutor is an experienced teacher, a chemistry specialist, who has taught SPU since the course was being developed in 1997. Researcher and teacher agreed dates for the researcher to observe the teaching of the module. In an initial interview the teacher discussed the components of the course and the educational background of the students. Most students had some qualification in science and about half were doing academic or vocational post-16 courses in science. Letters were sent to all the students on the course outlining the aims of the research project and asking for their co-operation, offering them the opportunity not to take part in the study. No students opted out. Due to the nature of the timetabling in the college it was not possible to interview the students.

The teaching room is small, unattractive and noisy and the researcher sat in a corner, able to observe students, without being obtrusive. Audio-tapes of the teacher's talk during the lesson were taken and transcribed. Two groups of students were also recorded during group discussions and their conversations and dialogue with the teacher were also transcribed. Classroom talk was logged on a 30 second timeline and regular timed observations taken of teacher strategies, position in the classroom, gestures, activities of two randomly selected students, resources, lesson content and researcher's thoughts. Copies were taken of all paper resources used.

Semi-structured interviews took place with the teacher at the end of each session. These covered:

[2] Information about this video and the company that produced it can be found at: http://www.ytouring.org.uk/

- the teacher's description of the session and perceptions of what was learned;
- responses to 'significant moments' in the lesson raised by both researcher and teacher;
- impressions of what students had learned;
- the teacher's understanding of what students knew, understood and felt before and during the session;
- challenges perceived by the teacher;
- responsibilities of the teacher in discussing particular ethical dilemmas.

In the first session of the module, before formal teaching began, each student was given a copy of the front page of the *Daily Mail*, a popular British tabloid newspaper. The front page began with small headlines '24 hours after the U.S. designer baby storm, a British couple demand a test-tube daughter' followed by the banner headline 'NOW, THE RIGHT TO CHOOSE A BABY'S SEX'.[3] The story referred to a British couple wanting to 'choose' a girl after their three year old daughter had died in a fire. A link was made to the case of a six year old girl in the United States suffering from Fanconi anaemia, whose baby brother was 'selected' to provide blood for a transfusion. The front page contained a picture of the little girl who died in the fire as well as a report of the story. Students were not required to give their names but a number was given to them by the researcher which they were required to record on the task sheets and to use again when repeating the task at the end of the module. The group was asked to answer three questions in relation to the headline and the article:

1. How do you think a 'designer baby' is made?
2. What do you think a test-tube baby is?
3. Some people think parents should have the right to choose things like the sex or eye colour of their baby. What are your thoughts?

Analysis of diagnostic tasks.

A total of 29 students from both the 'test' and 'control' groups responded to questions set about the newspaper article. Responses to the three questions were coded for knowledge of 'designer babies' and 'test-tube babies' contained in the headlines of the article, and in constructing an ethical argument for the third question. The codes were separately checked by the teacher and the few differences that emerged were discussed and agreement reached.

Designer babies

A designer baby is a perjorative term used to describe babies born as a result of the technique of Pre-implantation Genetic Diagnosis, PGD. Drugs are administered to a woman to stimulate ovulation. The eggs are then removed and fertilised *in vitro*. When the resultant embryos have divided a few times a cell is removed and diagnosed for a particular disabling condition, such as Fanconi anaemia or muscular dystrophy, using a 'DNA chip'. Two or three embryos without the condition are selected and introduced into the mother's womb through a long hollow tube, to increase the chances of successful implantation. The salient technical points about this technique are *in vitro* fertilisation, genetic diagnosis resulting in selection and implantation.

Student responses to the diagnostic task

HOW DO YOU THINK A 'DESIGNER BABY' IS MADE?

None of the responses mentioned the *selection* of embryos with particular genetic characteristics. The responses were categorised as follows:

- Genetic code read on gamete before fusing
- Removal/addition of genes
- Genes made dominant or recessive
- Replacing an undesirable allele
- Parents choose child's genome

All the above categories included responses by more than two students. Other responses included 'denying embryo hormones' and 'artificial insemination of an ovary to get specific results'.

[3] *Daily Mail*, October 5th 2000

While it is possible to change the genetic constitution of embryos, the newspaper article concentrated on
a. the use of pre-implantation diagnosis for selecting an embryo to provide healthy cells for a sick sibling; and
b. the potential use of PGD for sex selection.

There was no evidence in any of the responses to suggest that students had used information from the text; rather they had answered the question based on conceptions they had held before reading the article. The thrust of the answers implies something being changed in the embryo's genetic make-up rather than the selection of an embryo with particular genetic attributes.

WHAT DO YOU THINK A TEST-TUBE BABY IS?
A test-tube baby results from an egg fertilised in vitro. Twelve of the students responses were very close to this description. Others mentioned a baby 'incubated in a tube' and seven students responded that a test-tube baby was grown or born outside of the womb. Some responses included the term 'baby made by a scientist'. Nearly all students thought that a 'test-tube' figured as the container for the fertilisation process. Terms used about test-tube babies included 'non-human' or 'unnatural'.

Some people think parents should have the right to choose things like the sex or eye colour of their baby. What are your thoughts?

Analysis of these responses was based on the ability to formulate an argument and the types of ethical argument used.

FORMULATING AN ARGUMENT
The definition of an argument is based on a simple logical structure. The minimal ingredients of an argument are:
- at least one statement that is reasoned for (the conclusion)
- at least one statement that is alleged to support it
- some signal or suggestion that the argument is underway (the logical indicator)
  (Beardsley 1975)

The texts of student responses were subdivided into statements and the responses configured into a flow diagram. Examples are given in figures 1 to 3. .

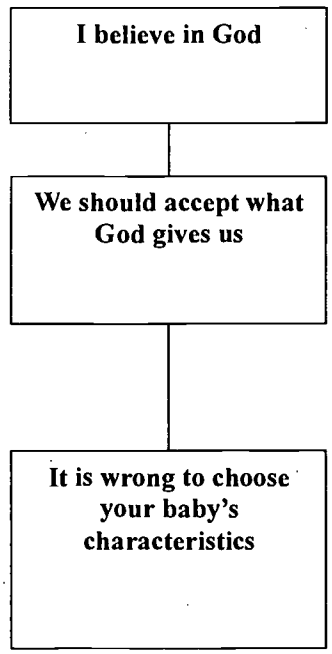

Figure 1: One line of sequenced statements

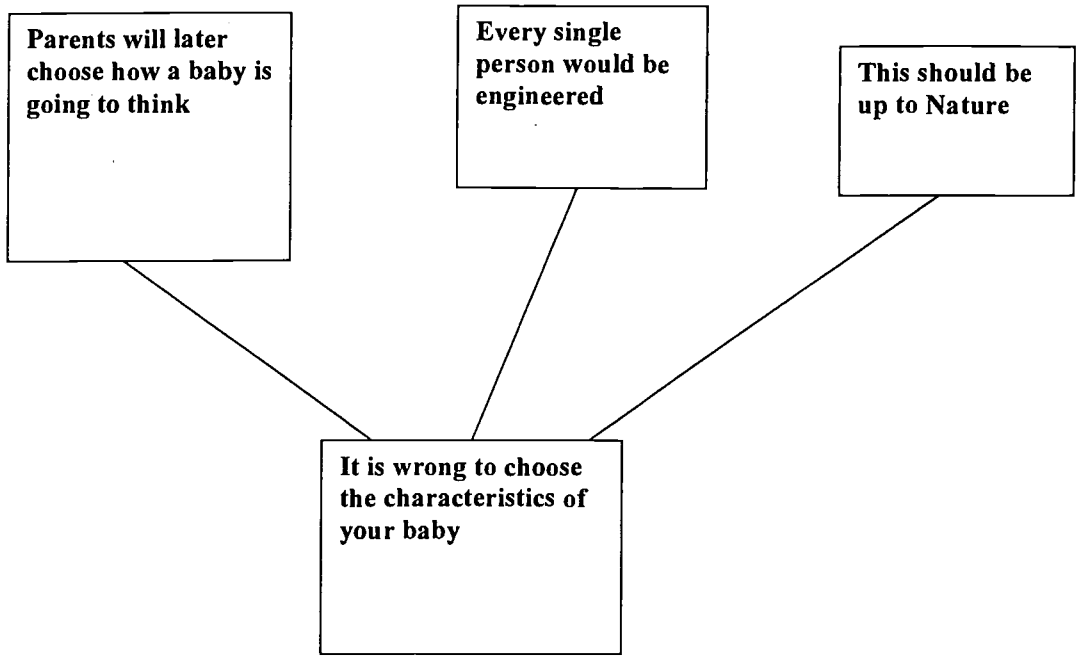

Figure 2. Multiple lines (Can be two or more statement sequences in each line)

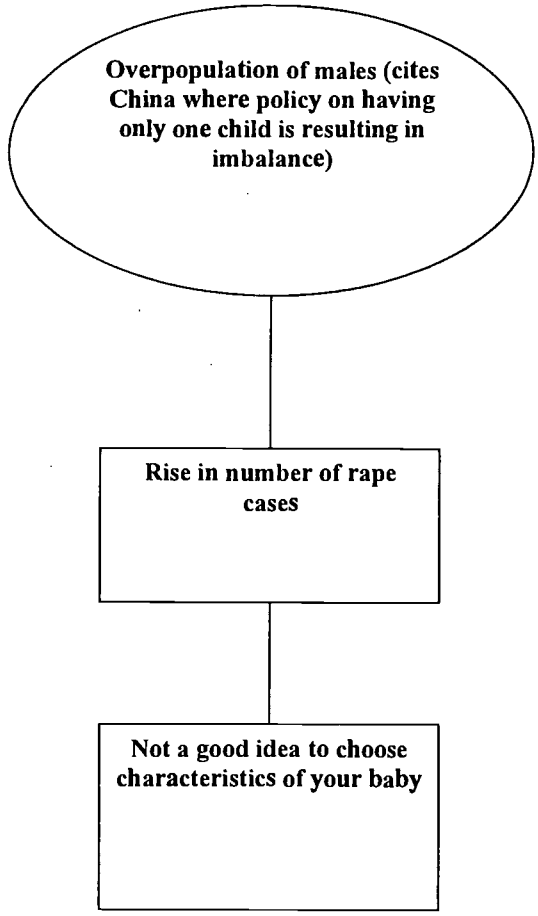

Figure 3: Sequence of statements including evidence

Three students did not produce an argument. Two of these contained assertions only, e.g. 'it is wrong', and one was incoherent. Arguments were configured in the following categories:

- two statements containing the minimal ingredients, e.g. 'It's wrong because parents don't have the right to decide';
- a line of supporting statements resulting in a conclusion, e.g. 'this should not be allowed because history has shown that messing with Nature invites the wrath of God' (another example is given in figure 1);
- more than one line of supporting statements resulting in a conclusion, e.g. 'It is wrong, inhuman. Imagine if everyone wanted a child of one sex there would be an imbalance of males to females.' (another example is given in figure 2)
- interconnected lines of supporting statements resulting in a conclusion e.g. 'It's wrong. A baby is not a fashion accessory. These decisions should not be based on opinion or subjective choice'.;
- statements based on refutable evidence resulting in a conclusion (figure 3)

Only two students based their arguments on evidence that was refutable. Both were based on reports that birth control policy in China has resulted in a sex imbalance, one of the students suggesting that this has led to a rise in the incidence of rape cases. Characteristics of societies with dramatic sex imbalances are marriage at an early age for women, emphasis on female chastity and women regarded as inferior in terms of power. (Guttentag and Secord 1983) These characteristics do not include rape, and appear to be characteristic of societies where there is no apparent sex imbalance, but the point is that the arguments proposed by the students can be tested, possibly with recourse to the literature. The rest of the students had often used arguments based on metaphysical beliefs but without empirical evidence that could be refuted. The arguments can be divided into three main categories, with examples, as follows:

Type of statement	Examples of statements
Arguing towards consequences	
Unpredictability	Who knows what the long term effects would be, physically, mentally, emotionally
Slippery slope	In the end parents would be choosing what babies should think
Measurable consequences, e.g sex imbalance	It would lead to many more boys than girls, like in China
Arguing through a values position	
Social justice/image of society	This technology would only be for the rich
Nature/God	I believe in God and we should be grateful for what God gives us/ and it goes against Nature
Cosmetic	Having a baby isn't like choosing whether to have chocolate sauce on a vanilla ice cream
Love for baby	We should love the baby for what it is
Arguing from rights	
Parents' rights	It shouldn't just be up to the parents to decide
Rights of the embryo (potential child)	Wasting the life of the child that might have been/no one asked the embryo what it wanted

Discussion

I have attempted to create a typology of pupils' ethical perspectives and therefore how these might be anticipated and addressed in the classroom. It should also be noted that where students made interconnected

statements they frequently used more than one type of ethical statement. Arguing towards consequences was popular among students' written responses. These arguments resonate with Warnock's claim that there must be 'some limits beyond which people must not be allowed to go' (Warnock 1985).Discovering these limits, however, and deciding their ethical status are further problems. Risk assessment would be deemed integral to determining these limits but risk was not mentioned by the students. As Wynne has pointed out there is less popular resistance to new technologies when the outcomes are both predictable and familiar, even though the risks may be higher than those with less predictable and familiar outcomes (Wynne 2001). Public perceptions may thus have a role in ethical decision-making.

Students often used the 'slippery slope' argument without avoiding 'black-or-white' fallacies. Development of a new technology might make the possibility of controlling minds more real, for example, but it does not follow that the predicted consequence will be enacted. Arguing toward consequences is essentially a utilitarian argument involving the equality of interests (Singer 1979). Benefits have to be weighed against possible harm done, but students seem to consider the harm without assessing the benefits although this may be the result of a research fault in the way the question was presented.

Metaphysical assertions are common, referring to belief in God or the danger of disturbing Nature where God and Nature were broadly treated as equivalent. No students justified this deontological position. For example, interference with Nature in the development of medicines for curing diseases could be invoked as a permissible intervention to underpin the grounds on which genetic selection might or might not be allowed. But belief in a Deity or Nature was used more as a mantra than as a justification.

Teacher-student dialogue

Learning takes place in the context of the classroom and is mediated by both the teacher's and students' implicit understanding of the ground rules of educational discourse (Edwards and Mercer 1987). Beyond the ostensible confines of talk are the beliefs and shared understandings that both teacher and students bring to the classroom. Edwards and Mercer have produced a list of discursive devices that typify classroom discourse and the aim of this preliminary interpretive study is to capture and to problematise the nature of the interactions between teacher and student.

In session 3 the teacher concentrated on teaching aspects of ethical dilemmas which contextualised the science previously taught. The analysis is divided into a. The teacher's comments at the beginning of the module; and b. A discussion of a classroom interaction in session 3. Any names mentioned have been changed.

Analysis and findings

PRE-MODULE INTERVIEW

The teacher outlined her hopes and challenges for the topic. It should be 'interesting' and 'enjoyable' and within the SPU course it is the subject 'that gives most scope for debate, where there are really no right answers.' Her objectives were that the students would have the 'confidence to weigh up these issues', to 'improve their discussion skills' and to be 'aware of other opinions so they can freely make up their own minds.'

To achieve these objectives the teacher's strategy was to ensure the students were 'fairly clear' about the science because in issues where there is a 'fuzzy morality you have to grasp quite a bit more science to actually understand what's happening'. Given time constraints in covering the content of the module, the teacher acknowledged there was a potential tension between teaching the substantive science concepts and the time needed for open and reflective discussion of the moral and ethical issues that emerge from ethical dilemmas.

Other problems she felt she would face were that it 'would be easy to go off on a tangent and to be easily sidetracked.' The students were thought to be 'not very good at discussions'.

TEACHER-STUDENT INTERCHANGES

Session 3 turned out to be the most interactive session. It was characterised by long tracts of teacher talk interspersed with interventions from students, and from one student in particular. During the first hour of the session the teacher asked one closed question but there were a series of questions, clarifications and counter-arguments from students. One of these exchanges is discussed.

TABLE 1

Context	Exchange	Code	Researcher thoughts	Teacher reflections from interview
The teacher has discussed a couple where the mother is considering having an amniocentesis to test for Down's Syndrome and is mapping a scheme on the whiteboard to identify the consequences of taking different decisions. Directly before this interchange the student asks how an amniocentesis is carried out and how the test can precipitate a miscarriage.	S: So why doesn't it happen all the time then? T: Because you don't poke around inside the womb all the time. S: What I mean is it's one in one hundred (chance of miscarriage). Everytime they do that test, it's one in a hundred. T: Yes. That's right. Well it probably depends . .some pregnancies are more . some people seem to hold their pregnancies better than others, may be it depends on the skill of the surgeon who's doing the procedure, I honestly don't know. Most biological things are like that, aren't they, there's a random finite chance of one thing happening or the other, it's not absolute. Most biological things are like that. S: Yes, but not with the same severity. T: You know if there's flu going around in this room will half of us catch it and the other half won't? S: Yes but if we catch it we're not going to die, are we? T: No. But that's not the issue, we might do. S: Of course it is. Obviously it's more important if someone's going to die than someone's going to catch a cold, do you know what I mean? T: Yes it is. But the question of why is not one we can answer, it's biological randomness, things are all different, and the reason we're all different is partly genetic, of course. Right. So if she does have the test . . .	Spontaneous contribution from student.	A sense of growing irritation between teacher and student. His contribution interrupts her purpose of listing the possible consequences on the board.	' there's an element of showoffness"you do need to move the lesson forward a bit."It is difficult if someone takes a fundamental Islamic position as he does. I felt it was a discussion the others wouldn't have responded to at that point.

The student queries the consequentialist position presented by the teacher. Having an amniocentesis involves risk of a miscarriage but teacher and student interpret the concept of risk in different ways. To the student any risk is unacceptable if it endangers the life of the foetus; in the teacher's presentation the risk of miscarriage is but one factor to take into account when making a decision. Understanding the concept of risk is not a problem for the student, it is the moral framework within which he treats the nature of risk that creates the difference between his argument and the teacher's. The student's ethics are predicated on a religious basis (in this case stemming from his Islamic beliefs) so he makes a very clear distinction between 'natural' miscarriages as being due to the will of God and miscarriages resulting from human intervention as wrong. In a later group discussion on the consequences of testing for Down's Syndrome the student outlines his position at the beginning of the activity: 'From my Islamic beliefs . . . we're told that God gives us tests in different ways, yeah? If we see any little problem that we're running away from then we're not standing up to that test, even if we don't understand things now.' Differences between teacher and student in this interchange reach an impasse with the teacher

affirming 'that's not the issue' and the student countering 'Of course it is'. The teacher shortly continues her narrative with a rhetorical flourish 'Right'.

Edwards and Mercer have characterised the basic I-R-F structure in classroom teaching as a commonality of all patterns of classroom discourse; there is an Initiation by the teacher, a Response by the student and Feedback by the teacher. The IRF framework can be extended, as this section of classroom exchange illustrates, to student assertion with a follow up by the teacher (Martins, Mortimer et al. 2001). Misunderstanding generated through the student's intervention appears to be more than a breakdown in shared understanding of the implicit rules of classroom discourse. Negotiating beliefs in ethical perspectives constitutes a more formidable challenge to the teacher, as these are balanced against the content knowledge to be taught and the inclusion of all the class in the discussion. The intervention is problematically dismissed as 'showoffness' and the difficulties in discussing a fundamentalist position.

Discussion

While this paper cannot generalise from an exploratory study it is clear that teaching social and ethical issues in science contexts raises difficult problems for the teacher in managing discussion and in anticipating the kinds of questions raised by students. An analysis of the patterns of the types of ethical arguments that students use will at least help the teacher to anticipate students' concerns and prepare arguments that will challenge and clarify their thinking. Further research will need to explore whether students use similar ethical arguments in other contexts. It also reveals that the level of content knowledge needed to discuss these issues appears to be low but this may depend on the context of the discussion, the type of ethical question asked and whether the discussion is targeted at matters of policy or areas of private morality.

Analytic frameworks such as Edwards and Mercer and Toulmin (Toulmin 1964) do not appear to be suitable techniques to analyse dialogue in relation to ethical dilemmas between teacher and student. Several themes have emerged from analysis of the lesson transcripts involving classroom exchange and teacher interviews, 'control of discussion', 'teacher-student difference in belief systems', 'distinct classroom discourse between science and ethics'. The challenges identified by the teacher in 'control of discussion' are consistent with those found in the *Valuable Lessons* report.

'I remember that there was something about genetics that came up, looking at animal testing. At the end of the video a couple of kids picked up on it and there was a debate and I wasn't really involved. One child spoke vehemently against testing for cosmetics. And these sort of issues are raised in an uncontrolled way and that's part of the problem and can catch people unawares.' (Science Teacher, School A) (Levinson and Turner 2001)

It is a different proposition to manage I-R-F patterns of classroom talk of substantive science concepts compared with the ethical issues raised by students. Scott, for example, has reviewed studies of classroom discourse in science (Scott 1998), but these studies rarely transcend science concepts and procedures. As we have seen, broaching ethical issues can have an effect on the teacher's authority, which changes the power relationships and subsequently the nature of the classroom discourse. Edwards and Mercer's categories are drawn from studies with younger children. There needs to be a broader description of the cognitive and affective domains that a teacher has to contend with in a discussion of ethical issues in a science context. These domains have been shown to include:

- substantive science concepts: e.g. 'gene', 'carrier', 'chromosome';
- nature of science: e.g. 'reductionist', 'susceptible to values', 'uncertain/certain knowledge'
- technological concepts, (know-how): e.g. procedures of an amniocentesis
- procedural concepts: e.g. 'probability', 'risk', 'screening';
- ethical concepts: 'religious beliefs' (teleological); 'acting according to strict moral principles' (deontological); 'appraising and balancing consequences' (consequentialist/utilitarian);
- feelings and emotions, sensibilities: how you and a partner might feel about being a carrier; 'killing a baby', relationships within the family;
- contextual factors: students' and teachers' beliefs and attitudes shaped by their own personal experiences.

Further research will explore how these domains manifest themselves in other types of argument and whether there is scope to provide a more general framework.

It is demanding a lot from science teachers to address the ethical aspects of contemporary science issues: few teachers, whatever their specialism, can handle this area with much confidence or experience. This is not due to any inadequacy on the part of the teachers but to the complexity of the issues. These new technologies are loaded with imponderables: assessing risk, the complex nature of the scientific process (how much can teachers know whether experiments have been carried out with proper controls in place; the different assessments of the developing technology); changes in both the nature of the ethical and legal processes as the technology develops. These are difficult tasks for government appointed committees staffed by experts, let alone teachers who have pastoral, administrative and academic duties, and a varied curriculum over which they cannot possibly have full up-to-date knowledge all the time. As we have seen the teacher has to work across domains and deal with different forms of enquiry. Translating the aims of incorporating ethical issues in science to the micro-processes of teaching in the classroom is deeply problematic.

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