



Assessing Ethics in Secondary Science: a report of a seminar held at the Nuffield Foundation

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Foreword

Despite much discussion over the years about introducing ethics into the science curriculum, assessment has been a stumbling block as there has been little agreement about how best to assess students' knowledge and understanding in this area. The Reaching out to Young People group of the Nuffield Council on Bioethics therefore decided to hold a one-day seminar on the issue, which was chaired by Michael Reiss. The intention was that the seminar would provide an opportunity to discuss why teaching ethics in science is important and would examine approaches to the assessment of ethics in science. It was hoped that it would lead to the development of some tangible outcomes for curriculum developers, assessors and the Nuffield Council on Bioethics and Curriculum Programme.

The seminar provided an opportunity to consider key issues in the assessment of ethics, such as the importance of ethical debate in science classes, the specifications which drive the teaching of ethics, and how science can learn from the assessment of ethics in other subjects, such as religious education and philosophy.

The result was a fascinating discussion of the challenges currently facing curriculum providers, examiners and science teachers in teaching and assessing philosophical principles and moral values in what has traditionally been a fact-based subject. We hope this report on the seminar and discussion by Michael Reiss will raise awareness of these challenges and provide a starting point for the relevant authorities to consider how the assessment of ethics in science can be improved.

The ROYP group would like to thank the Chair of the seminar, Professor Michael Reiss, for this timely and detailed report. The report consists of two main sections. The first section is Michael Reiss's summary of the discussion which took place at the seminar, along with recommendations made on behalf of the participants listed on page 2. The second section is a discussion of the background to teaching and assessing ethics in the science classroom, containing Michael Reiss's personal views. Some of the assessment items discussed in section 2 were discussed at the seminar, and some were added by Michael later.

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Section 1: Summary of the seminar with recommendations and conclusions

One reason for including ethical discussion in science courses is that ethics and science are often inexorably intertwined. In addition, students have called for the inclusion of more ethics in science. However, despite much discussion over the years about the introduction of ethics into the science curriculum, assessment has been a stumbling block as there has been little agreement about how best to assess students' knowledge and understanding in this area. In part this stems from the fact that science and ethics are distinct forms of knowledge.

Recommendation 1

When teaching about ethics is included within science curricula, it should be made clear that there are differences between ethical reasoning and scientific reasoning and that the methods used to arrive at scientific knowledge are therefore not the same as those used to reach ethical conclusions.

The most common approach taken when teaching ethics in science is to begin by introducing one or more frameworks within which ethical decisions can be made in science and then to go on to examine particular case studies, whether in biology, chemistry, physics or other branches of science.

Teaching ethics within school science places considerable demands on science teachers. For a start, there is the specialised knowledge of ethics. But, perhaps more importantly, there are additional pedagogic demands. For example, much learning in ethics is more open-ended than in conventional science teaching. This approach is unfamiliar for many science teachers and can be unsettling.

Recommendation 2

Those responsible for devising science courses with a significant component of teaching about ethics should be considerate of the demands placed on teachers, for instance by providing clear guidance about what is and is not expected, carefully prepared worked examples and materials that can be used for professional development.

Recommendation 3

Science specifications that include ethics should indicate what progression in knowledge and understanding is expected, for example when grade descriptions are provided.

Recommendation 4

Assessment of students' understanding of ethics is unlikely to be best achieved when questions are worth only a very small number of marks. Students need to be given time and space to show what they know and to develop an ethical argument.

A number of other school subjects are more used to assessing ethics than is science. Examination of examples of the assessment of ethics in philosophy and religious studies courses suggests that good candidates are expected to be able to write at some length and to craft a developing argument. Furthermore, banding, rather than the allocation of precise marking points, is often employed in mark schemes. Notable too is the expectation that candidates should be able to criticise major ethicists and be familiar with the contrasting views of a range of both classical and contemporary authors.

Recommendation 5

Those who are responsible for devising mark schemes to accompany question papers in science that assess knowledge and understanding of ethical issues should familiarise themselves with best practice in subjects, such as philosophy, with a well established history of assessing ethics.

Assessment is important for many reasons, not least in that it shapes what is taught and valued as learning.

Recommendation 6

The way in which ethics is assessed should reward good teaching, and students should be provided with regular feedback on their learning.

While ethical issues generally feature more strongly in biology than in other parts of science, there is value in teaching about ethics across the disciplines of science both in terms of the ethical issues faced by scientists undertaking their work and with reference to the applications to which science is put.

Recommendation 7

Teaching about ethics should be seen as important across the disciplines of science and not restricted to biology.

Conclusion

There are good reasons for striving to improve the quality with which ethics in science is taught and assessed. Such teaching and assessment is often not easy. However, science education often strives to value aspects that are not easy to assess (e.g. practical work and how scientific knowledge is arrived at). Ethics is only likely to play a small part in science curricula but it is important that when it is included, it is taught to a high standard and assessed appropriately.

Recommendation 8

Professional science organisations and other bodies involved in improving the quality of school science education should examine what they can do to enhance the teaching and assessment of ethics in science.

Section 2: A discussion of the background to the seminar by Michael Reiss

Why engage young people in ethical issues in science lessons?

A considerable part of the history of secondary science education over the last 40 years or so has been concerned with broadening its scope, and an increasing number of people have argued that ethics needs to be included (Reiss, 1999).

One argument in favour of including ethics in science education begins by asserting that, even if we accept that science is open-minded, objective, universalist and disinterested, all scientific knowledge is formulated within particular social contexts (e.g. Fuller, 1997). At the very least this means that the topics on which scientists work – and so the subject matter of science itself – to some extent reflect the interests, motivations and aspirations both of the scientists that carry out such work and of those who fund them. Much funding provided for scientists, both currently and for some considerable time past, has been provided with the hope that particular applied ends would be met. These might be the production of a new vaccine, the development of a new variety of crop, the synthesis of a new chemical dye, the construction of a better missile detection system and so on.

The point is that it can be argued that ethics is inevitably and inexorably bundled up with science in most cases. Both the scientists and those who fund them hope that production of a new vaccine will lead to more lives being saved (presumed to be a good thing), that the development of a new variety of crop will lead to increased food yields (presumed to be a good thing), that the synthesis of a new chemical dye will lead to greater cash flows, increased profits, improved customer satisfaction or increased employment (all presumed to be good things) and that the construction of a better missile detection system will lead to increased military security (presumed to be a good thing). In each of these cases, the science is carried out for a purpose. Purposes can be judged normatively, that is they may be morally good or bad. Indeed, just beginning to spell out some of the intended benefits (increased crop yields, increased military security, etc.) alerts us to the fact that perhaps there are other ways of meeting these ends or, indeed, perhaps these ends are not unquestionably the benefits that may have been presumed.

Further, it can be argued that the separation of science from values in general, and ethical considerations in particular, is a relatively recent, Western and secular phenomenon (cf. Cobern, 1998). In particular, it is important that those who go on to be professional scientists appreciate from the beginnings of their study of science how the ethical issues that attend science can be addressed.

A second argument for including ethics in school science stems from a consideration of what school students would like science lessons to include. It is generally the case that students enter their secondary schooling (around the age of 11 years) with high expectations of science and a positive attitude towards it. Over the succeeding years, though, interest in science in industrialised countries generally wanes, especially in

chemistry and physics (ROSE, 2009). Discussions with both students and their parents suggests that one of the principal reasons for this is that much of what students learn is not perceived to be 'relevant' (Osborne & Collins, 2000; Reiss, 2000). 'Relevance' encompasses a number of things but in the twenty first century it is perhaps unsurprising that for many young people the ethical issues raised by science too often seem to be missing from their science lessons. As an illustration of this, here is Rosi speaking:

But still like this morning we were talking about genetic engineering, and Miss told us about this article, about how they're going to make clones of each baby that gets born. They're going to make a clone of it – so say if it needs a transplant, kidney transplant or whatever he could get it from his clone. And she didn't want to hear that it's wrong. She didn't want to know our opinions and I don't reckon that the curriculum lets them, lets us discuss it further. I mean science, okay you can accept the facts, but is it right, are we allowed to do this to human beings.

(Osborne & Collins, 2000, p. 24)

Similarly, in the Student Review of the Science Curriculum in England, with a sample size of 1493 14-19 year-olds, the first of the students' ten recommendations was:

The science curriculum should include more ethical and controversial issues. These should not be hived off into occasional discrete topics but included throughout the curriculum.

(Murray & Reiss, 2005, p. 91)

However, there are arguments against including ethics in secondary school science. One stems from a consideration of the nature of science and has its roots in epistemological distinctions between forms of knowledge (e.g. Donnelly, 2002). It was the eighteenth century Scot David Hume who pointed out that there is no logical connection between what is and what ought to be. It can be argued, that science concerns itself with what is whereas ethics concerns itself with what ought to be. In other words, the two disciplines of science and ethics occupy separate spheres of knowledge. In claiming that ethics should be taught in science one might as well claim that science teachers should teach aesthetics. The job of a physics teacher is to explain how we get rainbows, neither to pontificate on whether rainbows are beautiful nor to suggest what we should do on seeing one.

A second, pragmatic, argument against the teaching of ethics in science goes something like as follows. Science teachers are generally educated in science and very rarely in moral philosophy. It is therefore unrealistic and unfair to expect them to teach ethics. If such teaching is required it would decrease the time they have available to teach science and lead to lower quality teaching, since science teachers will be teaching outside their sphere of competence. Indeed, in England and Wales a classic study provided clear evidence that school science teachers were less confident than humanities teachers or PSHE (personal, social and health education) co-ordinators about teaching social and ethical issues generally (Levinson & Turner, 2001).

See **Recommendation 1** from the seminar, page 5.

The rise of ethics in school science curricula

Whatever the arguments about the role of ethics in school science curricula, there is no doubt that ethics is finding a more prominent place in secondary school science. In England and Wales, this has been particularly noticeable in biology specifications. For example, Salters-Nuffield Advanced Biology, from its first pilot version, incorporated a considerable amount of ethics uniformly distributed between its topics (Hall *et al.*, 2002). Also at advanced level, two specialised courses – Science for Public Understanding (Applin *et al.*, 2000) and Perspectives on Science (Taylor *et al.*, 2007) – paid particular attention to ethics. Indeed, in the Perspectives on Science course, ethics constituted fully one third of the course.

At lower age ranges too, there is now a greater emphasis on ethics. At Key stage 3 (for 11-14 year-olds), the section on 'key concepts' talks about pupils "Examining the ethical and moral implications of using and applying science" and a hyperlink to 'ethical and moral implications' reads:

Scientists, individuals and society need to think about the balance between the advantages and disadvantages of new developments before making decisions (e.g. examining issues related to selective breeding and genetic engineering of plants and animals, to the production of potentially hazardous chemicals, and to the use of nuclear energy). The way scientific developments are achieved can also raise ethical and moral issues, for example experiments on animals to produce drugs that may prolong human life.

(QCA, 2009a)

Similarly, at Key stage 4 (for 14-16 year-olds) there is a requirement within 'How science works' that 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" (QCA, 2009b). Of the various GCSE science courses it is the Twenty First Century Science suite of specifications that has paid particular attention to ethics because of its especial commitment to scientific literacy for all (Twenty First Century Science, 2009).

Nor are such developments restricted to England and Wales. Zeidler and Keefer (2003) summarise developments about the role of moral reasoning and the status of socioscientific issues in science education in a number of countries including Australia, Canada and the USA.

Teaching ethics in secondary school science

There are an increasing number of resources available to help secondary science teachers teach and their students learn about ethics in science. There is a list of on-line sources of information and resources at the end of this report and hard copy books include Fullick and Ratcliffe (1996), Levinson & Reiss (2003), Zeidler (2003), Taylor *et al.* (2007) and Jones *et al.* (in press).

The most common approach taken by resources supporting the teaching of ethics is to begin by introducing one or more frameworks within which ethical decisions can be made in science. They then go on to examine particular case studies, whether in biology, chemistry, physics or other branches of science.

Ethics is a branch of knowledge just as other intellectual disciplines, such as science, mathematics and history, are. Ethical thinking is not wholly distinct from thinking in other disciplines but it cannot simply be reduced to them. In particular, ethical conclusions cannot be unambiguously proved in the way that mathematical theorems can. However, this does not mean that all ethical conclusions are equally valid. After all most philosophers of science would hold that scientific conclusions cannot be unambiguously proved, indeed that they all remain as provisional truths, but this does not mean that my thoughts about the nature of gravity are as valid as Einstein's were. Some conclusions – whether in ethics, science or any other discipline – are more likely to be valid than others. It is a common fault in ethics courses to assert that there are never correct or incorrect solutions to ethical dilemmas (Reiss, in press).

It might be supposed that reason alone is sufficient for one to be confident about an ethical conclusion. However, there are problems in relying on reason alone when thinking ethically. In particular, there still does not exist a single universally accepted framework within which ethical questions can be decided by reason. This is not to say that reason is unnecessary but to acknowledge that reason alone is insufficient. For instance, reason cannot decide between an ethical system which looks only at the consequences of actions and one which considers whether certain actions are right or wrong in themselves, whatever their consequences.

Is it enough to look at consequences?

The simplest approach to deciding whether an action would be right or wrong is to look at what its consequences would be. No one supposes that we can ignore the consequences of an action before deciding whether or not it is right. The deeper question is whether that is all that we need to do. Are there certain actions that are morally required – such as telling the truth – whatever their consequences? Are there other actions – such as betraying confidences – that are wrong whatever their consequences?

Those who believe that consequences alone are sufficient to let one decide the rightness or otherwise of a course of action are called consequentialists. The most widespread form of consequentialism is known as utilitarianism. Utilitarianism begins with the assumption that most actions lead to pleasure (typically understood, at least for humans, as happiness) and/or displeasure. In a situation in which there are alternative courses of action, the desirable (i.e. morally right) action is the one that

leads to the greatest net increase in pleasure (i.e. excess of pleasure over displeasure, where displeasure means the opposite of pleasure, i.e. harm).

There are at least two great strengths of utilitarianism. First, it provides a single ethical framework in which, in principle, any moral question may be answered. It doesn't matter whether we are talking about the legalisation of cannabis, the age of consent or the patenting of DNA; a utilitarian perspective exists. Secondly, utilitarianism takes pleasure and happiness seriously. The general public may sometimes suspect that ethics is all about telling people what not to do. Utilitarians proclaim the positive message that people should simply do what maximises the total amount of pleasure in the world.

However, there are difficulties with utilitarianism as the sole arbiter in ethical decision making. For one thing, an extreme form of utilitarianism in which every possible course of action would have consciously to be analysed in terms of its countless consequences would quickly bring practically all human activity to a stop. Then there is the question as to how pleasure can be measured. For a start, is pleasure to be equated with well-being, the subjective experience of happiness or the fulfilment of choice? And, anyway, what are its units? How can we compare different types of pleasure, for example sexual and aesthetic? Then, is it always the case that two units of pleasure should outweigh one unit of displeasure? Suppose two people each need a single kidney. Should one person (with two kidneys) be killed so that two may live (each with one kidney)?

Utilitarians claim to provide answers to all such objections. For example, rule-based utilitarianism accepts that the best course of action is often served by following certain rules – such as 'Tell the truth', for example. Then, a deeper analysis of the kidney example suggests that if society really did allow one person to be killed so that two others could live, many of us might spend so much of our time going around fearful that the sum total of human happiness would be less than if we outlawed such practices.

Intrinsic rights and wrongs

The major alternative to utilitarianism is a form of ethical thinking in which certain actions are considered right and others wrong in themselves, i.e. intrinsically, regardless of the consequences. There are a number of possible intrinsic ethical principles and because these are normally concerned with rights and obligations of various kinds, this approach to ethics is often named 'deontological' (i.e. 'rights discourse'). Perhaps the most important such principles are thought to be those of autonomy and justice.

People act autonomously if they are able to make their own informed decisions and then put them into practice. At a common sense level, the principle of autonomy is why people need to have access to relevant information, for example before consenting to a medical procedure. Autonomy is concerned with an individual's rights; justice is construed more broadly. Essentially, justice is about fair treatment and the fair distribution of resources or opportunities.

Virtue ethics

A rather different approach to the whole issue of ethics is provided by virtue ethics. Instead of starting from particular actions and trying to decide whether they fail to maximise the amount of happiness in the world, are divinely forbidden or infringe someone's rights, virtue ethics focuses on the moral characteristics of good people. For example, think about a good teacher. What characteristics might we expect them to manifest? We might want them to know their subject, to treat all students fairly, to be able to maintain order in the classroom, to maximise students' chances of doing well in any examinations, to be able to communicate clearly, to have a sense of humour and so on. Some of these are skills – for example the ability to maintain order – but some are personality traits that we call virtues – notably treating all students fairly, rather than, for example, favouring males, Asians, high attaining students or Manchester United supporters.

Widening the moral community

Traditionally, ethics has concentrated mainly upon actions that take place between people at one point in time. In recent decades, however, moral philosophy has widened its scope in two important ways. First, intergenerational issues are recognised as being of importance. Secondly, interspecific issues are now increasingly taken into account. The term 'bioethics' is often used when such interspecific questions are being considered, though in the USA and some other countries 'bioethics' often simply means 'medical ethics'.

Interspecific issues are of obvious importance when considering biotechnology and ecological questions in science education. Put at its starkest, is it sufficient only to consider humans or do other species need also to be taken into account? Consider, for example, the use of new practices (such as the use of growth promoters or embryo transfer) to increase the productivity of farm animals. An increasing number of people feel that the effects of such new practices on the farm animals need to be considered as at least part of the ethical equation before reaching a conclusion. This is not, of course, necessarily to accept that the interests of non-humans are equal to those of humans. While some people do argue that this is the case, others accept that while non-humans have interests these are generally less morally significant than those of humans.

Intergenerational as well as interspecific considerations may need to be taken into account. Nowadays we are more aware of the possibility that our actions may affect not only those a long way away from us in space (e.g. pollutants produced in one country affecting another) but also those a long way away from us in time (e.g. increasing atmospheric carbon dioxide levels may alter the climate for generations to come). Human nature being what it is, it is all too easy to forget the interests of those a long way away from ourselves. Accordingly, a conscious effort needs to be made so that we think about the consequences of our actions not only for those alive today and living near us, about whom it is easiest to be concerned.

The demands that teaching ethics places on science teachers

Teaching ethics within school science places considerable demands on the teacher. For a start, there is the specialised knowledge, sketched above, that is required – though students, at any rate, may have been taught much of this in other lessons such as religious education, citizenship or philosophy. But, perhaps more pressingly, there are additional pedagogic demands. A great range of teaching approaches may be needed, including more student discussion, occasional formal debates and the use of role play. And then there is the fact that, for all that certain arguments in ethics are valid and others invalid, it remains the case that much learning is more open-ended than in conventional science teaching. This approach is unfamiliar for many science teachers and can be unsettling.

These issues are not restricted to the teaching in science of ethics – they occur, for instance, at least to a certain extent, whenever socioscientific issues are raised, in courses that use contexts or applications of science to a considerable extent and when the nature of science is explored, for example when dealing with frontier science where scientific knowledge is not yet fully determined.

Nevertheless, the demands on science teachers when teaching about ethics are considerable and are exacerbated by the present lack of clarity about how ethics in science should be assessed.

See **Recommendation 2** from the seminar, page 5.

The current assessment of ethics in secondary school science

The aim of this section is not to provide a comprehensive overview of the assessment of ethics in secondary school science. Rather it is to look at examples of how ethics is currently assessed in three courses, one for 14-16 year-olds (Twenty First Century Science), one for 16-17 year-olds (Science for Public Understanding) and one for 16-19 year-olds (Salters-Nuffield Advanced Biology). These examples are used to raise more general issues about the assessment of ethics in secondary school science.

Twenty First Century Science

Ethical issues feature quite strongly in the various specifications of the Twenty First Century Science suite of courses (OCR, 2007). One of the aims of these courses is to encourage candidates to:

evaluate, in terms of their scientific knowledge and understanding and their understanding of the processes of scientific enquiry and of the nature of scientific knowledge, the benefits and drawbacks of scientific and technological developments, including those related to the environment, personal health and quality of life, and considering ethical issues where these arise

(OCR, 2007, p. 6)

and this aim is reflected at a number of points in the specifications, particularly in the biology modules. Interestingly, when it comes to the grade F, grade C and grade A grade descriptions, ethics doesn't feature at grade F and features in precisely the same way at grades C and A, namely:

They demonstrate good understanding of the benefits and risks of scientific advances, and identify ethical issues related to these.

(OCR, 2007, p. 79, p. 80)

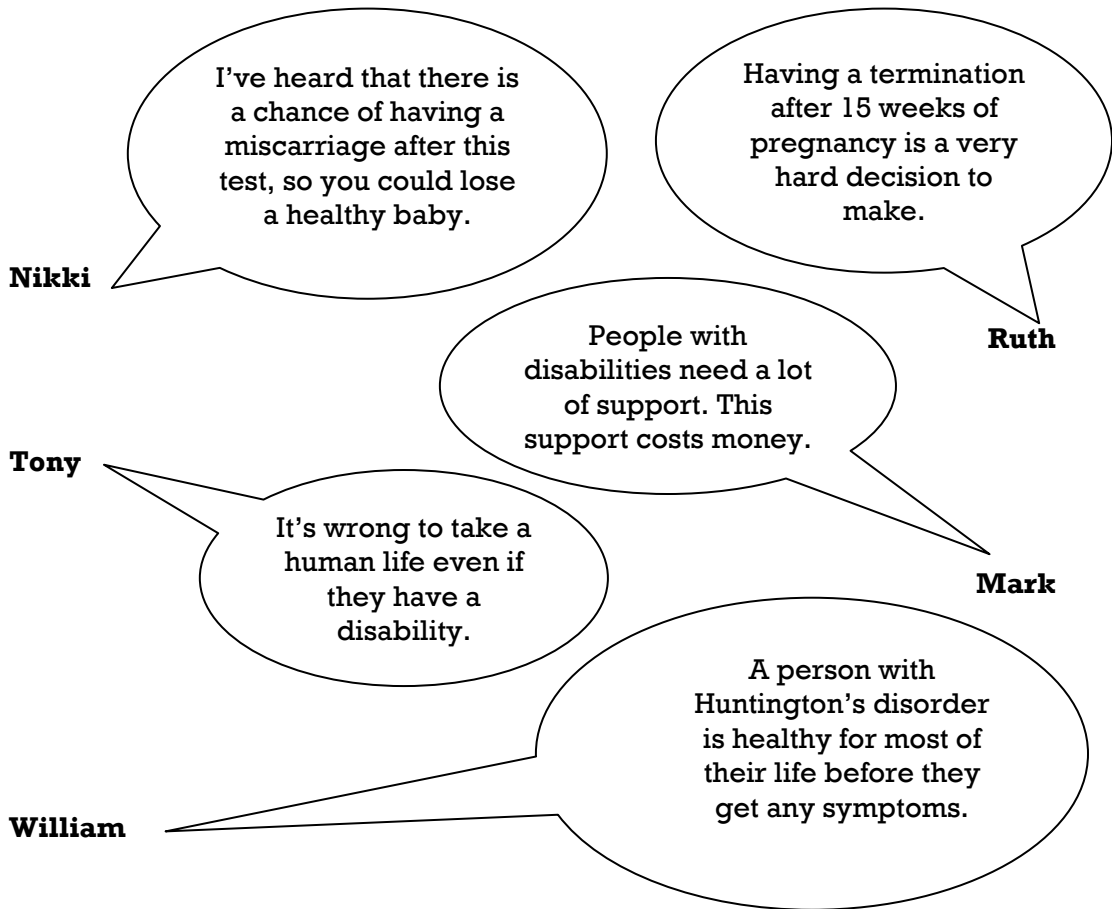
The fact that the same ethical demand seems to be placed on candidates at grades C and A, and none at grade F, contrasts strongly with the grade descriptions for practical skills and for scientific knowledge and understanding where there is clear progression from grade F through grade C to grade A.

See **Recommendation 3** from the seminar, page 5.

An example of the assessment of ethics in the course is as follows:

6. c) Duncan finds out that he has the allele for Huntington's disorder.
Duncan's wife Sarah is pregnant.
A genetic counsellor says that Sarah's fetus can be tested.
They will know the results after 15 weeks of pregnancy.
If the fetus has the Huntingtons's allele then Sarah can have a termination.

Duncan and Sarah discuss their options with their family.



(i) Who is concerned about the safety of the test?

.....

(ii) Who is making an ethical point?

.....

(iii) Who is thinking about the economic effect on society?

.....

(iv) Which two people believe that Huntington's disorder is not a good reason to have a termination?

..... and

[4 marks]

(OCR, 2008a, pp. 16-17)

Interestingly, the only answer allowed in the mark scheme to Q6c (ii) 'Who is making an ethical point?' is 'Tony' (for one mark) (OCR, 2008b, p. 10). It's often easy to criticise Awarding Bodies but while Tony is indeed making an ethical point, surely he is not the only of the four to do so.

This introduces a more general point in that ethics probably cannot best be assessed by questions worth only one mark. The assessment of ethics in GCSE science courses may therefore be helped by the recent Ofqual decision to require the Awarding Bodies to change the ways in which they assess broader aspects of 'How science works' at GCSE (Ofqual, 2009). This will lead to more open-ended questions, requiring candidates to provide longer answers worth more marks.

See **Recommendation 4** from the seminar, page 6.

Science for Public Understanding

Science for Public Understanding was an AS (i.e. one-year) course. It has been replaced by an A level (i.e. two course) course called Science in Society which had its first AS examination in June 2009 and will have its first A2 examination in June 2010. The final Science for Public Understanding examination was in June 2009 (Science in Society, 2009).

Ethical issues feature quite strongly in the Science for Public Understanding course (AQA, 2007). In addition to a number of generic references to "technical, economic, social and ethical constraints" (AQA, 2007, p. 10) – a phrasing which rather suggests science being held back by such forces – there are specific references in the specification to "Ethical issues raised by genetic engineering" (AQA, 2007, p. 18), to "Role of ethics committees in regulating the application and further development of scientific knowledge" (AQA, 2007, p. 18) and to medical genetics:

New medicines: procedures for testing including use of animals, experimental designs in drug trials, double blind studies. Legal and moral obligations of pharmaceutical companies.

Reproduction: use of routine screening tests during pregnancy (e.g. blood tests,

amniocentesis, ultrasound scans), judgements about the quality of life, abortion (techniques, issues and ethical dilemmas).

(AQA, 2007, pp. 17-18)

An example of the assessment of ethics in the course is as follows:

2 (b) The European Union (EU) has estimated that 1% of all disease in the EU is caused by chemicals in current use, including about 4500 deaths a year from cancer. In 2007 new EU regulations, called REACH, were introduced that require all chemicals to be tested for toxicity. Chemicals that have been in use for many years also have to undergo these tests. There are about 30 000 chemicals in use in the EU that have not yet been rigorously tested. Large numbers of animals will be required for this testing programme. For example, to test a single substance for its risk of causing cancer needs 800 rats or mice.

Do you think the risk to humans justifies the use of large numbers of animals in this way? Explain your answer. **(4 marks)**

(AQA, 2008a, p.7)

The mark scheme for this is as follows:

Any 4 for 1 mark each (total 4 marks)

- human health more important than rodent life
- animals bred specially
- animals must be well treated
- cost benefit in favour
- important to understand effects of chemicals/causes of cancer
- many chemicals are not needed/more selective testing
- very large number of animals not justified if only 4500 human cases
- cost benefit argument over expense of testing many animals
- animals suffering/ethics
- animals not a good model
- use alternatives to rat and mice if possible
- only test chemicals that have shown some indication of harm

(AQA, 2008b, p.4)

As this question is worth four marks it rewards candidates who are able to demonstrate that they can develop a reasoned argument. One criticism of the mark scheme is that as there are 12 possible marking points for these four marks, a candidate need only make one third of these to be given full marks. It would therefore be possible to gain full marks with rather a shallow or one-sided answer.

Salter-Nuffield Advanced Biology

Ethical issues feature strongly in the Salter-Nuffield Advanced Biology (SNAB) course (Edexcel, 2005). In addition to general references to the discussion of ethical issues, the specification has specific objectives that relate to ethics in “genetic screening” (p. 20), “stem cell research” (p. 21), “the Human Genome Project” (p. 21) and “genetically engineered plants” (p. 22). In addition, students are expected to “Discuss the way in which scientific conclusions about controversial issues can sometimes depend on who is reaching the conclusions, including their ethical and cultural perspectives” (p. 23), “consider the ethical issues arising from the use of living organisms and for the environment” (p. 28), “Discuss whether the use by athletes of performance enhancing substances, including creatine, testosterone and erythropoietin, is morally and ethically acceptable” (p. 34) and “Discuss the moral and ethical issues related to the use of animals in medical research” (p. 35).

An example of the assessment of ethics in the course is provided by question 3 (a choice of one of two essays) in the June 2007 synoptic paper at the end of the course. Candidates were advised to spend approximately 45 minutes on this (or its alternative) and were also told that:

Marks will be awarded for the following areas:

Breadth: selection of a range of relevant examples (**up to 6 marks**)

Depth: Further description and discussion of the examples (**up to 8 marks**)

Balance: Have you answered the question asked; for example have you recognised the advantages and disadvantages or benefits and risks (**up to 6 marks**)

Style: Coherence, clarity and expression (**up to 4 marks**).

3. Some people claim that many medical problems, such as the shortage of suitable organs needed for transplant surgery, may become a thing of the past. The use of stem cells, which may have had a specific gene or genes inserted, could give rise to many new treatments.

“Write an essay on: ‘Manipulating stem cells: a miracle cure or a dangerous development?’ (**Total 20 marks**).

(Edexcel, 2007a, p. 10)

The mark scheme for this is as follows:

3. ‘Manipulating stem cells - a miracle cure or a dangerous diversion?’

	<p>Breadth: maximum of 6 marks These marks are to be awarded to the candidate if they successfully introduce the general area of Biology relevant to the essay title. If a relevant B point is awarded then the corresponding A point should also be awarded. Key ideas to look for are in bold type – the candidate need only show evidence that he or she realises that key idea is appropriate in the essay to gain a breadth (A) mark.</p>		<p>Depth: maximum of 8 marks These marks are awarded to candidates for demonstrating an understanding of relevant A level biological detail expanding on the areas of biology introduced in A. This list is not exhaustive but is designed to give an idea of the type of response worthy of credit for a (B) mark. Allow a maximum of 4 B marks per corresponding A mark.</p>
A1	Description of Stem Cells:	B1a B1b	Cells that are able to differentiate into more than one cell type/eq; Correct descriptions making use of the words totipotent, pluripotent and/or multipotent;
		B1c B1d	Reference to cell/ nuclear division as source of new cells; Good description of mitosis and/or cell cycle including details such names of phases;

		B1e B1f/g	Introduction of concept that cells specialise during their development; Good description of gene switching/induction/inactivation such as the use of transcription factors/methylation [2 marks available for excellent description including 2 methods of specialisation]
A2	Source of embryonic stem cells:	B2a B2b	IVF as a source of spare embryos; Details of how IVF tends to produce excess embryos and that those embryos may be stored for long periods in liquid nitrogen.
		B2c B2d	Cloning to produce embryonic stem cells; Details of a suitable cloning technique; e.g. description of how Dolly was cloned
A3	Other sources of stem cells:	B3a B3b	Cord blood (from placenta/umbilical cord); Explanation that placenta/umbilical cord contains stem cells that will be identical to the new born child and they may be harvested and stored or used.
		B3c B3d	Adult stem cells; Example of tissue that contains stem cells e.g. bone marrow, testes, etc
A4	Therapeutic uses of Stem cells	B4a/b	Credit two specific examples of a tissue/organ that could be replaced/healed through the use of stem cells e.g. repairing spinal cord injuries
A5	Cloned/Adult stem cells are less likely to be rejected by the patient	B5a	Details of the specific immune system and reasons why traditional transplants may be rejected
		B5b	Details of why cloned cells are not going to be rejected by the immune system e.g. ref to antigens/MHCs etc.
		B5c	No need to use immune suppressant drugs with stem cells/converse.

A6	Adult stem cells will need to be reprogrammed	B6	Use of chemical signals to enable stem cells to differentiate to produce the desired cell types.
A7	Stem cells can be manipulated by gene therapy	B7a	Details of how to insert a gene into a stem cell
		B7b	Description of a suitable vector e.g. liposome, retrovirus, etc
		B7c	Example of specific disorder/disease that could be treated through gene therapy e.g. cystic fibrosis, diabetes, SCID etc
		B7d	Further detailed explanation of the case study named in B7c e.g. replace gene for insulin production into pancreatic stem cells and stimulate them into becoming Islet cells
A8	Alternatives to the use of stem cells	B8a B8b	Xenotransplantation. Details and examples e.g. heart valves from pigs
		B8c	Dangers of xenotransplantation e.g. new viruses become active/ or need for genetic modification of the animal so that it is not rejected by the immune system
		B8d B8e	Prosthetic replacements Specific example e.g. artificial heart valves or hearts, limbs
A9	Ethical Issues	B9a B9b	eugenics Issues described related to selection of embryos, designer babies etc through genetic modification
		B9c B9d	Pro-life issues Discussion about embryos having the potential for independent life in the future – should we be allowed to manipulate/destroy
		B9e B9f	Technology may be misused Once therapeutic cloning is possible others will use the technology for reproductive cloning or similar.
A10	Dangers/Disadvantages	B10a B10b	Developmental deformities/Cancers Explanation linked to cells not being fully reprogrammed/ new mutations/

		B10c B10d	Premature aging of cells/organism Chromosomes come from an older donor nucleus – shorter telomeres etc.
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Unpacking the question:

The C points might be made as discrete points in the introduction and/or conclusion or indirectly as part of the way the factual material has been presented in the body of the essay. But it should be possible to identify precisely where each C mark has been awarded by, for example, writing **C1 or C2** on the script.

C1 Recognition that embryonic stem cells have more potential than adult stem cells but they raise more ethical issues regarding their use.

C2 An issue of balancing risks and benefits for any new therapies.

C3 Adult stem cells will not need to be cloned, but will need to be reprogrammed and may be harder to extract.

C4 Issue of whether it is better to make use of spare embryos resulting from IVF rather than disposing of them.

C5 Essay provides a balanced argument that includes at least 2 good examples of the use of stem cells and 1 danger/ethical problem associated with the use of stem cells.

C6 Discussion of how the human genome project has helped identify candidate genes for gene therapy.

C7 Evidence that candidate is aware of the key issues of needing to understand the precise series of chemical signals required for cells to specialise successfully and form the correct tissues/organs required.

C8 Reference to the role of clear legislation/supervision of work in these key areas e.g. outline of the role of the Human Fertilisation and Embryology Authority (HFEA).

C9 Recognition that stem cells may be cultured and manipulated in tissue culture before use/storage

C10 Need for greater research/understanding careful testing before proceeding with new therapies

C11 Key question is about the status of the embryo – a ball of undifferentiated cells or a potential human being.

C12 Tissue typing may reduce need for cloning as we may only need a few stem cell lines to avoid tissue rejection in most people.

(Edexcel 2007b, pp. 6-9)

One notable feature of the mark scheme is the difficulty of untangling marks for science and marks for ethics. This, of course, is not necessarily a criticism. Although just a small portion of the mark scheme carries the heading 'Ethical Issues', the reality is that there is ethics throughout the mark scheme. Students able, therefore, to back up ethical points with relevant scientific data will gain credit.

Ethics is assessed in other parts of the SNAB course and the impact of this has been investigated (Reiss, 2008). As part of SNAB, students towards the end of the first year of their course (when they are nearly all either 16 or 17 years old) have to submit a report approximately 1500 words in length of a biological issue or of a biological visit that they have made. These reports are marked externally (i.e. by examiners external to each student's school rather than by a teacher within their school) and the criteria include the statement that "They should demonstrate an understanding of the ethical, social, economic and environmental implications of the applications of biology encountered within the context of the visit or issue" (Edexcel, 2002, p. 27).

Examination of a sample of the issue / visit reports written in 2005 (all 17 written on the topic of global warming) showed that all the students were able to employ ethical arguments, the great majority utilising utilitarian ones.

The current assessment of ethics in other secondary school subjects

A number of other school subjects are more used to assessing ethics than is science. Here is one detailed example of the assessment of ethics from philosophy and a shorter one from religious studies.

Philosophy

As one would expect, ethics (moral philosophy) features strongly in philosophy specifications at a number of levels including at GCSE and at A level. Here is an example from an AQA Advanced Level Philosophy Unit 2: Moral Philosophy or Philosophy of Religion. The question is one of two alternatives in the moral philosophy theme within the paper and needs answering in 60 minutes.

- (a) Identify and briefly describe **two** characteristics that virtuous persons are said to possess. (6 marks)
- (b) Explain and illustrate **two** criticisms of deontological ethics. (15 marks)
- (c) Assess whether any form of utilitarianism provides an adequate account of what it is to act morally. (24 marks)

(AQA, 2008c, p. 2)

The mark scheme for this question is as follows:

- (a) Identify and briefly describe **two** characteristics that virtuous persons are said to possess. (6 marks)

Knowledge and Understanding (6 marks)

4 – 6 Demonstrates precise knowledge and understanding of **two** characteristics that virtuous persons are held to possess. Candidates may provide some background material on virtue ethics but full marks can be obtained for clear descriptions of two virtuous character traits. These are most likely to be drawn from the cardinal virtues – justice, wisdom, temperance and courage – and descriptions are likely to emphasise the selected traits as means between two extremes (although this might depend upon which traits are selected). Expect some references to Christian virtues, such as faith, love, charity, etc. Contemporary versions of virtue ethics emphasising the coherence of a narrative quest, immersion in a socially regarded practice and the acquisition of excellences within the practice should also be rewarded. No marks are available for evaluation although knowledge and understanding may be present in evaluative answers. Answers should be placed in this band according to the depth and detail presented. Answers at the bottom of this band may present one clear and developed description of a virtue and make a more general point about

flourishing or living well.

1 – 3 Demonstrates basic or partial knowledge and understanding of **two** characteristics that virtuous persons are held to possess by offering a partial explanation, eg only one relevant trait is identified and described, or a basic answer in which traits are identified but not described, or a confused explanation, eg descriptions of the traits identified are imprecise or inaccurate. At the bottom of this band it may be difficult to accept that the traits identified are genuinely virtues.

0 No relevant philosophical knowledge and understanding is presented.

(b) Explain and illustrate **two** criticisms of deontological ethics. (15 marks)

Knowledge and Understanding (6 marks)

4 – 6 Demonstrates precise knowledge and understanding of **two** criticisms of deontological ethics. Candidates will probably briefly outline what deontology involves (and in doing so refer to different versions of duty ethics) but full marks can be obtained by accurately identifying two criticisms. These may be drawn from: positions such as Kant's are too formal or abstract to be of much use as a guide to action; duty ethics are too rigid or insufficiently flexible; actions undertaken on the basis of strong feelings (rather than duty) have moral worth; whether we can know the motive behind an action; the problem of what to do when duties conflict; whether the consequences of actions are irrelevant or any other relevant point. Responses which list a number of points or which blur three points together as two should be placed at the bottom of this band.

1 – 3 Demonstrates basic knowledge or partial understanding through offering a partial account in which only one accurate criticism is made or through a confused account in which criticisms are not clearly expressed or by identifying a valid criticism but developing and explaining a different point.

0 No relevant philosophical knowledge and understanding is demonstrated.

Selection and Application (9 marks)

Illustrations of two criticisms might be drawn from specific texts (eg Sartre's student might be used to illustrate a conflict of duties or a moral dilemma); from Kant (the rigidity/lack of feeling/relative disregard for consequences etc. of telling the truth to a psychopathic axe man); any situation in which motives for action aren't clear; any situation in which a morally worthy action is not undertaken through duty and/or which conflicts with some version of the categorical imperative (or divine command); any situation in which it is not clear how to treat someone as an 'end'; any action which seems moral but not universalisable (or vice versa).

7 – 9 Selects or constructs at least one relevant point or example and applies this to provide a clear illustration of **two** criticisms of deontological ethics. In this band the illustration(s) provided will clarify both of the criticisms

selected.

4 – 6 Selects or constructs at least one point or example to provide a partial illustration, lacking detail and precision, of **two** criticisms of deontological ethics. In this band the illustrative example(s) will only partially illuminate the criticisms either because they are brief and undeveloped or because only one criticism is illustrated. Responses in this band may be characterised by detailed exposition, explaining various criticisms of deontology, and very brief illustration.

1 – 3 Selects or constructs at least one illustrative point to provide a basic, sketchy and vague illustration of at least one criticism of deontological ethics eg it is not clear how the example provided is relevant to the criticism given **or** to deontology. Answers at the bottom of this band may consist of vague exposition only, no attempt is made to illustrate. Answers in which the explanation provided is clear but not illustrated should be placed at the top of this band.

0 No relevant philosophical points are made.

(b) Assess whether any form of utilitarianism provides an adequate account of what it is to act morally. (24 marks)

Knowledge and Understanding (6 marks)

4 – 6 Demonstrates precise knowledge and understanding of ‘forms’ of utilitarianism. Candidates will probably outline classical utilitarianism as the teleological view that an action is good if it maximises utility and further describe it as the doctrine that we ought to perform an action if it maximises utility and/or leads to the greatest happiness of the greatest number. Answers in this band should refer to at least two variants of utilitarianism such as:

- Hedonism, the hedonic or felicific calculus and/or quantitative approaches to pleasure;
- negative utilitarianism, the minimisation of pain and suffering;
- qualitative approaches, higher pleasures and/or the pursuit and cultivation of certain ideals;
- preference utilitarianism, the satisfaction of preferences or desires;
- Act and Rule utilitarianism.

There may be references to Bentham, Mill, Hare, Singer and others. Responses which refer to two or more positions without clearly distinguishing between them should be placed at the bottom of this band.

1 – 3 Demonstrates basic knowledge or partial understanding either through offering an account of only one utilitarian position or by offering an account of utilitarianism which isn’t clear, precise, detailed or clearly expressed.

0 No relevant philosophical knowledge and understanding is demonstrated.

Selection and Application (9 marks)

The positions identified should be related to moral actions or moral agency. Some of the following, or equivalent, points will be raised:

- practical issues: the consequences of actions may be difficult to predict; there are clearly difficulties involved in measuring the happiness and/or pain an action produces and of comparing the utility of different goods or the same good to different people; in many instances there are difficulties in knowing whose happiness and/or pain is to be included in the calculation, etc;
- indeed, in many situations we generally act without first undertaking a utilitarian calculation and in some situations we wouldn't have time to perform a utilitarian calculation (assuming that such a calculation were possible);
- maximising pleasure is a 'thin' theory of the good and neglects other values which might be socially useful or of benefit to individuals;
- sometimes acts which are simply wrong would be approved of because in certain instances such an act might have positive consequences;
- the same point applied to minority interests and/or acts that neglect or infringe upon individual rights. Difficulties of securing rights generally;
- apart from being excessively demanding with regard to the calculation of consequences, etc does it also have an excessively demanding requirement to ignore personal attachments?
- utility monsters and the problem of acting in a way to promote/secure distributive justice;
- utilitarianism is inconsistent with the moral integrity of agents; we might be held morally responsible for refusing to perform an action that, while having positive consequences, was against our principles.

Or any other reasonable point. Some of these points should be employed to consider whether, for example, rule utilitarianism, preference utilitarianism or qualitative approaches to happiness offer a more acceptable account of moral action.

7 – 9 Selects relevant points and examples and applies these to provide a clear detailed analysis of philosophical arguments about whether any form of utilitarianism provides an adequate account of what it is to act morally. Answers in this band will develop a critical analysis of the points raised for discussion.

4 – 6 Selects relevant points and examples to provide a partial analysis of philosophical arguments about whether any form of utilitarianism provides an adequate account of what it is to act morally, either narrowly focused on a couple of pertinent issues or listing a wide range of points which are not discussed in any detail and which may not be precisely stated.

1 – 3 Selects and applies at least one relevant point to provide a basic, sketchy and vague explanation of philosophical arguments about whether any form of utilitarianism provides an adequate account of what it is to act morally **or** some relevant points feature among many irrelevant points in a confused or tangential approach to the question.

0 No relevant philosophical points are presented.

Interpretation and Evaluation (9 marks)

A range of argumentation is possible and note that evaluative points may feature in the treatment of various issues and points selected for discussion without any additional 'summing-up'.

- it could be argued that utilitarian approaches to morality remain highly influential and that action aimed at the pursuit of happiness (or preference satisfaction) and/or the minimisation of suffering is morally worthwhile;
- beyond this, it might also be argued that utilitarianism, or some version of it, can counter some of the critical points selected, e.g. that utility overrides rights or that the notion of rights is dubious; that utility trumps integrity; that utilitarianism can provide an account of distributive justice; that it doesn't require us to be impersonal or that there's nothing wrong with such a requirement; that majority interests ought to be pursued; that private experiences of pleasure are all that matters etc, etc;
- it could also be argued, following points raised for discussion, that one particular version of utilitarianism is superior to others (faces fewer problems, counters more criticisms);
- alternatively, it might be argued that no utilitarian approach to moral action is fully acceptable and that what is needed is an approach which guarantees respect for persons, which insists that certain acts are wrong or which focuses more on our development as moral agents. There may be references to alternative normative theories.

7 – 9 A critical appreciation of arguments concerning whether any form of utilitarianism provides an adequate account of what it is to act morally is provided and a clear argument or position is advanced. This may be balanced, ie strengths and weaknesses are acknowledged.

4 – 6 Evaluation is present within an exposition of arguments concerning whether any form of utilitarianism provides an adequate account of what it is to act morally but is either largely implicit in the selection of points for discussion (e.g. it is assumed that critical points are fatal) asserted with limited support (either argumentation is limited or the supporting evidence is limited) or not closely linked to moral action.

1 – 3 A simple and basic appreciation of arguments concerning whether any form of utilitarianism provides an adequate account of what it is to act morally is present either in a narrow, sketchy or largely descriptive response, in which points are listed or asserted without justification, or in a response in which the argument is confused.

0 No relevant philosophical insights are presented.

(AQA, 2008d, pp. 3-6)

There are a number of features of this question and its associated mark scheme that are likely to strike anyone whose expertise is in science education. For a start, the candidate is expected to write an essay on a single subject (albeit one divided into three parts) for fully 60 minutes. Good candidates are evidently expected to be able to write at some length and to craft an unfolding argument. Then there is the fact that banding, rather than the allocation of precise marking points, is used throughout. Notable too is the expectation that candidates should be able to criticise major figures (e.g. Kant) – how often do science papers require candidates to criticise the Darwins and the Newtons of science? – and to be familiar with the contrasting views of a range of both classical (e.g. Kant, Sartre, Bentham) and contemporary (e.g. Singer) authors.

Religious Studies

An example of the assessment of ethics in religious studies is provided by a question on the June 2008 paper to examine the AQA Advanced Level Religious Studies Unit 4: An Introduction to Religion and Ethics. The question is one of two alternatives and needs answering in 40 minutes.

(a) Explain how the teachings of **one** religion you have studied can be applied to the medical issue of euthanasia. (15 marks)

(b) Explain Kant's theory of the categorical imperative, and assess the view that any law concerning euthanasia should be based on Kant's theory. (25 marks)

(AQA, 2008e, p. 2)

The mark scheme for part (b) of this question is as follows:

Candidates need to explain the categorical imperative.

Kant perceived that most people behaved well because they felt they ought to, especially if they wanted something back in return. He called this the hypothetical imperative. However, he said that people ought to do things because people 'knew' them to be the right things to do. People worked this out using reason. Kant called this the categorical imperative, and formulated three principles of it; the universal law, treating humans as ends in themselves rather than just means to an end, and living in a Kingdom of Ends.

Maximum Level 3 (6 marks) if no example used.

(10 marks)

Any explanation of the categorical imperative should then be applied to euthanasia, e.g. is it possible to make a universal law regarding euthanasia? Many religions would reject a law allowing euthanasia, although Holland has such a law. UK criminalises euthanasia. It can be argued that allowing euthanasia is both treating a person as an end in themselves, and also as a means to an end (cessation of pain for the relatives seeing a loved one die). Allowing euthanasia country-wide does raise issues of the slippery slope and continuation of the human race.

Assess

For

- UK has a law on euthanasia which is in effect a universal law
- It is very important and commendable not to treat people as a means to an end
- The categorical imperative is not based on emotion which can colour any decision-making.

Against

- Religious groups would be alienated if a law permitting euthanasia is passed
- Kant did not mention euthanasia, therefore we do not know what he would have said about it
- Countries should make up their own laws.

Maximum Level 3 (8 marks) if no reference to a law regarding euthanasia.

(15 marks)

(AQA, 2008f, p. 7)

What is perhaps most notable about this mark scheme, given that there are 25 marks at stake, is its comparative brevity. Many examiners of science papers would wonder about the consequences of this for the reliability of the marking (i.e. the ability of two markers to give the same, or very similar, number of marks as each other to scripts). On the other hand, such an approach does perhaps give candidates considerable scope to express themselves and show originality.

See **Recommendation 5** from the seminar, page 6.

Future possibilities for the assessment of ethics in secondary school science

Assessment is important for many reasons, not least in that it shapes what is taught and valued as learning. The science educator Rick Duschl writes about some of the teaching his daughters received when learning to play the piano:

Performing, be it as a writer, a musician, a dancer, an engineer, a teacher, or a scientist, is a complex task made up of many sub-tasks. I was very impressed, then, and pleased that my daughters' beginning piano teacher had a wonderful sense of the multiple skills and knowledge bases she would need to develop in order to achieve high levels of performance by her students. As I recall there were no less than 4 sets of goals: the development of strength and flexibility in the hands and fingers, the development of the ability to read musical notation, the development of the ability to learn musical phrasing and playing with feeling, and the nurturing of creative musicality. Students would receive feedback on each of these 4 domains of piano playing at each weekly lesson.

(Duschl, 2003, p. 139)

Duschl's tale reminds us of two things. First, that there is more to ethics than knowledge and understanding. There are, for example, attitudes, dispositions, skills and actions. Indeed, I can remember in the mid 1980s an UCLES Advanced Level biology course that required teachers in teacher assessment of coursework to assess students' behaviour towards animals and the environment. It is worth noting that the Qualifications and Curriculum Authority now have "Responsible citizens who make a positive contribution to society" (QCA, 2008, p.1) as one of their three overarching aims of the curriculum. Secondly, Duschl's account illustrates the importance of regular formative assessment: his daughters received feedback on each of the four domains of piano playing in each of their lessons.

See **Recommendation 6** from the seminar, page 6.

There is considerable evidence that teaching can increase students' understanding of ethics (e.g. Straughan, 1988; Bebeau, 2002). Nevertheless, it is salutary to note that this isn't always the case. A number of US states require that those engaging in agency-type selling (e.g. insurance, securities and real estate sales) receive ethical training. However, an evaluation of the effectiveness of this training for sales agents and brokers of United States-based real estate firms in California and Florida found no evidence that such training increased scores on tests of moral reasoning (Izzo, 2000). This was despite the fact that California requires 18 hours of ethics-related material and an additional 18 hours of material related to consumer protection out of 45 hours of continuing education required every 4-year license renewal period.

In science teaching, while it is perfectly appropriate for ethical issues to feature more strongly in biology than in other parts of science, there is value in teaching about ethics across the science disciplines both in terms of the ethical issues faced by scientists undertaking their work and with reference to the applications to which science is put.

See **Recommendation 7** from the seminar, page 6.

Progression in ethical thinking

Is there some natural progression in ethical thinking that might allow us to assess student achievement in this area? The Swiss educator Jean Piaget was perhaps the first person carefully to investigate the subject of moral development, i.e. how individuals progress over time in their ethical thinking. In the 1920s he studied the ways in which children viewed the rules of the games they were playing (Nucci, 2008). He concluded that morality was a developmental process. To a young child, morality is all about obeying rules. So telling lies is wrong because a child has been told not to tell lies. I can remember as a child being very upset that I had broken (unintentionally, I think as a result of excessive bending) one of the metal plates in my Meccano set. But what is intriguing is the sense of moral culpability I felt – perhaps because I had been told not to break objects just as I had probably been told not to tell lies. I am glad to say I can also remember being comforted by my somewhat bemused mother when she found me crying; thus do we learn what we have done that is morally wrong and what is not.

Piaget observed that as children age, and in interactions with others, they move to a more autonomous and less rule-bound view of morality (Piaget, 1932). Piaget's conclusions were developed further by Lawrence Kohlberg who, while also accepting that moral reasoning proceeded in stages, argued that it can continue throughout our lives and that very few of us ever reach its ultimate conclusion. Kohlberg viewed the moral reasoning and practice of individuals as falling into one of six stages (Kohlberg, 1958). Stage one, as for Piaget, is characterised by the acceptance of moral teaching because of a fear that one will be punished if one transgresses. At the other extreme, stage 6, rarely found in empirical studies, is characterised by abstract principles of moral reasoning in which the acceptability or otherwise of actions are judged against principles of ethical fairness that are established as such not merely because most people agree with them but because they result from universal, logical argument (as in Kant's *Groundwork of the Metaphysics of Morals* or Rawls' *A Theory of Justice*).

Kohlberg's work has been critiqued, refined and extended (e.g. Gilligan, 1982; Crittenden, 1990; Thoma, 2002; Walker, 2002) but the fundamental notion remains of moral development from an unreflective position of selfishness to one in which the needs and wants of others are also accepted and acted upon.

Progression in ethical thinking in science

The work of Piaget, Kohlberg and their successors in the field of moral development is valuable but difficult to apply directly to science education. In a New Zealand project on bioethics education (Jones *et al.*, 2007), a range of indicators was developed to indicate how a science teacher might want students' ethical thinking to progress (Figure 1).

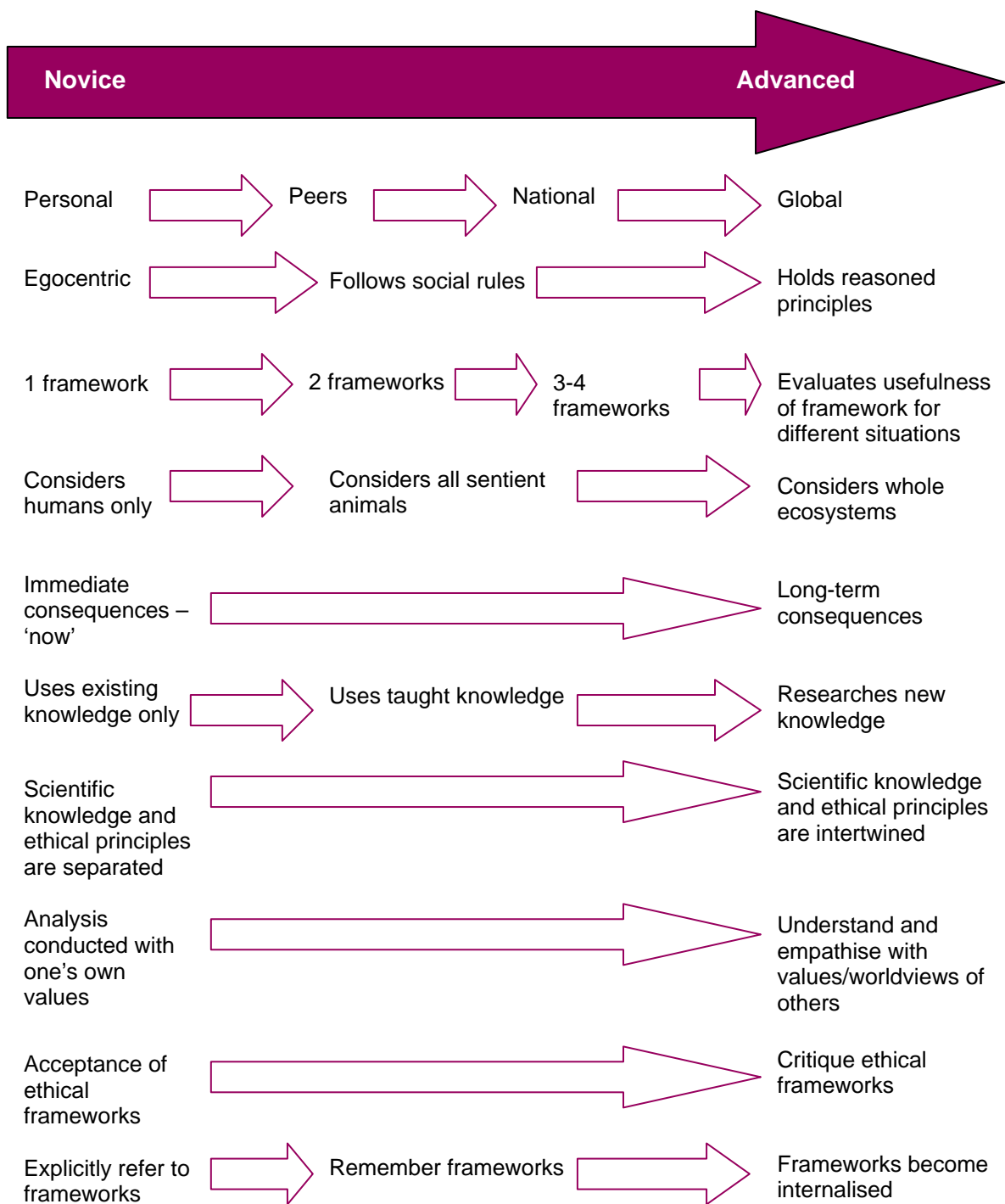


Figure 1. Indicators of progressions in ethical thinking

Figure 1 should not be read rigidly (Reiss, in press). It is not the case that individuals progress uniformly from left to right, nor would it be altogether surprising to find individuals who are situated at the left of the figure in some respects and at the right in others. Furthermore, any individual's position on Figure 1 will be affected by the individuals around them, the particular scientific issue being considered, their motivation and a range of other factors. Nevertheless, it may be that good teaching in this area should help individuals move from the left to the right of Figure 1.

Such movement, indicating progression in ethical thinking, would entail the following:

- Moving from viewing an ethical issue (e.g. eating meat from intensively farmed animals) in terms of its effects for oneself (e.g. the meat tastes delicious) to one's peers (e.g. how does the rest of one's family feel about this?) to others in one's country (e.g. consequences for national employment) to people globally (e.g. effect on world trade).
- A shift from seeing oneself as the moral universe (egocentrism) to following social rules (e.g. one should not buy pets in pubs) to holding reasoned principles (e.g. one should not buy pets where there is a significant chance of an animal suffering as a result of congenital disorders, even when such purchase is legal).
- A progression from only being able to use one ethical framework (e.g. consequentialism) to using two to using three or four to evaluating the usefulness of the frameworks for different situations (e.g. considering the frameworks of consequentialism, rights and virtues when considering whether or not a woman who is pregnant with a fetus that has a severe genetic disorder should be allowed to choose whether or not to have an abortion).
- Moving from considering humans only (e.g. when devising a plan for how to manage a national park) to considering all sentient animals to considering whole ecosystems.
- A progression from considering ethical issues (e.g. mining for gold) solely in terms of the 'now' to the long-term (e.g. pollution resulting from use of mercury).
- A development from relying solely on one's existing knowledge (e.g. when discussing how to reduce one's carbon emissions) to using taught knowledge to researching new knowledge.
- Moving from a situation where scientific knowledge and ethical principles (e.g. about whether time and money should be spent conserving endangered species) are considered in isolation to one where they are drawn together.
- A shift from considering socio-ethical issues only within one's own set of values (e.g. about the relative merits of meat eating, vegetarianism and veganism) to considering them within others' too.
- A progression from simply accepting standard ethical frameworks (e.g. about the acceptability of nuclear power) to being able to critique them.
- A development from needing to consult frameworks before using them to remembering them to internalising them so that one finds oneself using them automatically.

See **Recommendation 8** from the seminar, page 7.

Sources of further online information and resources

BioEthics Education Project

www.beep.ac.uk/content/index.php

BioethicsBytes

<http://bioethicsbytes.wordpress.com/>

Biotechnology Learning Hub bioethics theme

www.biotechlearn.org.nz/themes/bioethics

Ethical Emporium

www.windfalldigital.com/ethicalemporium/

Eubios Ethics Institute

www.eubios.info/index.htm

European Initiative for Biotechnology Education

<http://eibe.info/>

Institute of Physics 'Are you a good scientist?' resources

www.iop.org/activity/education/Teaching_Resources/Other%20Resources/Institute_of_Physics_Resources/page_21355.html

Internet Teaching Resources in Chemical Research Ethics

www.istl.org/01-spring/internet.html

Nuffield Council on Bioethics resources for teachers

www.nuffieldbioethics.org/education

Physics & Ethics Education Project

www.peep.ac.uk/content/index.php

Y Touring Theatre Company

www.ytouring.org.uk/

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- AQA (2008a) General Certificate of Education – Advanced Subsidiary Examination Science for Public Understanding SPU1: Unit 1 Issues in the Life Sciences, <http://store.aqa.org.uk/qual/gceasonly/qp-ms/AQA-SPU1-W-QP-JUN08.PDF> (last accessed 24 October 2009).
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