Ethics, issues and consequences: conceptual challenges in science education

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Abstract: The goal of this study was to examine how ethical judgement and decision-making is learnt, taught, and understood across undergraduate science courses at The Australian National University (ANU). 'Behaving ethically' as a generic graduate attribute usually is interpreted as professional ethics relating to behaviour in a professional setting. The idea that science can and should have guiding principles which are understood (or understandable) and acceptable to the majority in society is not a new one. This study investigates the range of courses specifically related to ethical thinking and behaviour available to science undergraduates at ANU. Data relating to the uptake of these courses and feedback by science students are presented. A pilot survey of science lecturers at ANU explored their understandings of how they incorporate ethics into their teaching. Conceptual challenges emerged for both students and staff.

Background/Introduction

Science education has traditionally focused on the learning of knowledge and performance of methods relevant to specific scientific disciplines and, in later undergraduate years, on the development of critical thinking and intellectual skills to analyse this scientific information. 'Behaving ethically' as a generic graduate attribute is usually interpreted as professional ethics relating to behaviour in a professional setting. Recently there has been more focus on the inclusion of personal values related to science as a graduate generic attribute (Barnett 2004). Barnett argued this is because of the unknown nature of the future we face. An example of Barnett's unknown future is the hidden potential of technologies such as genetic modification and nanotechnologies – technologies that have the potential to alter the destiny of the human race and our environment. Students must be empowered to make decisions that are appropriate for them and which allow them to participate in the shaping of future societies and humankind.

In 2002 the United Kingdom Quality Assurance Agency for Higher Education included a threshold standard in bioscience that required 'some understanding of ethical issues and impact on society of advances in the biosciences' (Quality Assurance Agency for Higher Education 2002, Section 5.3). In response to this benchmark the Higher Education Academy's Centre for Bioscience established a special interest group (SIG) called 'Teaching ethics to bioscience students'. The Steering Group of the SIG helped the forerunner of the Centre for Bioscience to deliver annual workshops on the teaching of ethics to science undergraduates with some focus on the inclusion of personal values related to science as a graduate generic attribute (http://www.bioscience. heacademy.ac.uk/ network/sigs/ethics/index.htm). They also commissioned a survey to map current and planned ethics teaching delivery in bioscience programmes across the UK (Willmott, Bond, Bryant, Maw, Sears and Wilson 2004). An outcome of this survey was the provision of teaching resources from the Centre of Biosciences.

In a separate study Clarkeburn, Downie and Matthews (2002) introduced a short ethics program at the University of Glasgow with the goal of supporting the development of students' ethical sensitivity. They investigated how to measure ethical development (Clarkeburn, Downie, Gray and Matthews 2003) and devised a Meta-Ethical Questionnaire (MEQ). Clarkeburn went on to construct an 'ethical audit tool' which can be downloaded from the Centre of Biosciences Network web site (http://www.bioscience.heacademy.ac.uk/network/sigs/ethics/index.htm).

In Australia, The University of Queensland has surveyed first year and final year students from 2001 (UQSES, 2005) and included ethical and social sensitivity as one of their parameters. Overall students showed a moderate level of satisfaction with their experience of ethical and social sensitivity and the increase of this satisfaction was taken as evidence of the successful development of this graduate attribute.

As an extension of the ongoing UQSES, Bath, Smith, Stein and Swann (2004) examined whether what is espoused and enacted through the curriculum is aligned with what students experience and learn. One of the three graduate attribute scales they used was ethical and social sensitivity (ESS) attributes. These were defined as 'knowledge of ethical issues and standards in the discipline, awareness and understanding of cultures and perspectives other than one's own, openness to new ideas and perspectives, and understanding of social and civic responsibility'. This and the other two skills of communication and problem-solving and discipline-specific knowledge and skills were mapped in School of Music students at the University of Queensland but no specific results were given for ESS attributes.

There have been various Australian studies examining the teaching of ethics in science, from the perspective of both the student and the teacher. Lysaght, Rosenberger III and Kerridge (2006) examined the views of Australian biotechnology undergraduates towards the teaching of ethics. They found that students valued ethics education but focused on professional ethics rather than personal ethics. They also found that there is a strong argument to extend ethics education in life sciences although biology curricula are already overloaded (Lysaght et al., 2006). Another study examined the content of biotechnology programs, including ethics, in Australia (Gray, Barnard, Franco, Rifkin, Hine and Young, 2003) but classifies ethical and social skills as 'biotechnology generic'. In addition, most published data pertain to professional rather than personal ethics.

This study investigates the range of science courses available to science undergraduates at ANU specifically related to ethical thinking and behaviour. Data relating to the uptake of these courses and feedback by science students are presented. In addition, we present the findings of a pilot survey of science lecturers at ANU to explore their understandings of how they incorporate ethics into their teaching. Conceptual challenges in the design and delivery of such courses emerged for both students and staff.

Methodology

Current undergraduate courses (subjects) addressing ethics
The ANU Student Handbook (http://info.anu.edu.au/studyat/) was examined to identify all courses available through the College of Science that mentioned ethics as a part of the course description. The conveners of these courses were asked to provide student comments, relating to ethics, obtained from both formal and informal course evaluations.

Pilot survey of lecturers and teaching of ethics
We constructed a 13 question pilot questionnaire based on our collective experience in teaching ethics, conducting social research, and advising students within the ANU College of Science. The information we sought covered four broad areas: a basic background on respondents regarding their formal ethics training and experience; an estimate of the amount and category of ethics taught in their courses; respondents' opinions on the ethical principles most important to their course; and how their students engage with these principles (including key challenges students might face when learning about ethics). The lecturers were selected to encompass the teaching of as many scientific disciplines as possible in the College and to cover a sample of first, second and third year courses. Finally, as this was a pilot study, feedback and input regarding the questionnaire itself were gathered with a

view to conducting a broader and more representative study guided by the results and conclusions presented here.

Before the survey was conducted the questionnaire was given to three academics who were not involved in this research, for feedback on both content and structure. Two of the academics had explicit social research expertise. A selection of 13 academics representing five disciplines: mathematics, biology, physics, chemistry and psychology were surveyed in the pilot study. One of the authors (Newitt) personally delivered the questionnaire forms and explained the purpose of the study, answering respondents' questions and ensuring they understood the purpose of the study.

Basic descriptive statistics were employed for categorical responses, and emergent themes from text responses were identified and described under the four major areas covered by the questionnaire via iterative thematic analyses.

Results

Current courses addressing ethics

Three courses offered to students through the ANU College of Science included ethics in their course descriptions. These included two courses offered by the Centre for the Public Awareness of Science and one by the School of Biochemistry and Molecular Biology. There was one first year course, SCOM1001 Science and Public Awareness, and two third year courses: SCOM3001 Science, Risk and Ethics and BIOL3191 Biotechnology in Context. Table 1 describes the numbers of students enrolled in these courses in 2006 and the ethical content of the courses.

Table 1. Data pertaining to ANU undergraduate science courses which overtly include ethics in their curricula

Courses	SCOM1001	SCOM3001	BIOL3191	Total
Number of science students [a]	51	29	59	139
Percent of all science students	3.6%	2.1%	4.2%	9.9%
Percent content of course relating to ethics	8%	30%	90%	
Distribution of ethics content in course	2 lectures 1 tutorial	8 lectures; 4 tutorials	All lectures 80% seminars All tutorials	
Ethical categories included in course [b]	A, B, C, D, F, G, H, I, L, M	All categories	A, B, C, D, E, F, G, H, I, J, M	

a Science students are defined as all students enrolled in a science or specialist science degree program, and all combined degree students for whom one of their programs is a science or specialist science degree. In 2006 this totalled 1406 students.

b Ethical categories used in this table are the same as used in the pilot survey of lecturers

A Academic honesty – plagiarism, fraud, collusion, cheating, recycling
B Ethics within a context (social, cultural, temporal, political, discipline/ subject-matter)
C Ethics and changing cultural values
D Personal values (ethics as compared with morals)
E Informed or assumed consent
F History of ethics
G Ethics and different standards
H Ethics and scientific method

I Application of ethics to difficult situations–ethics and controversy/ contradiction; multiple ethical views
J Professional ethics and law
K Professional ethics as a restriction or facilitation of research and teaching
L Professional ethics and professional obligation/responsibility to your discipline and/or to society
M Professional ethics committees (such as Animal Experimentation Ethics or Human Research Ethics)

The two SCOM courses focus on public awareness of science and communication between scientists and the public. The BIOL course examines the societal, ethical, legal and regulatory issues raised by new biotechnologies. The BIOL course is a required course in the Bachelor of Biotechnology program at ANU; however the numbers of these students is about 20 to 30 per year, which is about 5% of all science students (see Table 1 for a definition of 'science students').

Table 2. Student comments from course evaluation surveys or informal feedback

Course	Student comments on course
SCOM3001 *Science, Risk and Ethics*	I have been pleasantly surprised that my science degree is pertinent to my law degree. The realm of ethics combined with the devastating social and legal implications of not communicating a science related risk to the public is something I find most captivating. With absolutely no prior knowledge of the implications of good and bad public relations, I have most definitely come out of the course with a better understanding of the far reaching effects that good communication has on the public. Hopefully from here I will be able to combine my degrees by using the science to shape my knowledge of real world situations and thus invoke the law as well.
	…I have really enjoyed the last few weeks studying ethics. I came into this course pretty much unaware of how ethics related to science, and I still don't pretend to completely understand them now, but I feel as though I am more informed.
	Ultimately, I realised that my emotions were dictating my ethical reasoning and I was able to confirm my initial speculations. This is the most useful lesson for me as it completely challenged the view that I have of myself and has made me want to be more critical in my analysis of ethical situations.
	I think knowing about ethics committees and how they work will help me in future work and also help me appreciate it that little bit more when I read that a project has been approved by an ethics committee or I need to submit something for ethics approval.
	I particularly enjoyed the ethics component of this course. After studying ethics theory and practice I realised that ethics are a highly relative phenomenon that are dependent on social, cultural and historical context.
	Scientific ethics seem to work by pushing science forward in the directions that the public and policy makers deem appropriate rather than in directions that open the way for science's destructive power to take effect. (This) shaping and directing of science in a socially responsible manner was the most important theme that I took from the course.
BIOL3191 *Biotechnology in Context*	Good explanation of ethical and scientific issues covering a broad range of biotechnologies
	… it is a chance to put the science we learn into a broader context and consider the implications of our research on society and the environment.
	… a good course for anyone who wants to gain some insight in the ethical issues associated with biotechnology.
	Challenged morals and ideas and made you make up your mind about different topics, and not sit on the fence.
	It is very important for future scientists to know about the ethical implications.
	… gives you an insight into the ethical considerations of science and biotechnology which is not covered by other courses.
	… an excellent course for science students – writing, evaluating and critical thinking skills on issues that are important for scientists to be aware of!
	[This course] gives you a wide scope of the issues surrounding biotechnology and it would be very easy to graduate without having any real appreciation of the impact your work has on society. It is important to see the bigger picture.
	[I] really enjoyed learning about cutting edge technology and the ethics that might confront science graduates one day.
	Made us consider important issues that would barely be mentioned in other science courses.
	Touched and discussed issues that have not been discussed in other unit.
	[This course is] different with context that many other courses lack.
	…it makes your science degree and everything you've learnt in it come together and makes it relevant to the real world. You can apply your knowledge and perspective on science to debates and issues that are actually happening.
	…different to other courses because students are able to make their own views.

Student responses to the courses

Qualitative data relating to the feedback by science students were examined and comments relating to the ethics of the topics are presented in Table 2. The comments presented have been selected from

many and so are not necessarily representative of the opinions of all students. Another example of the value students place on these courses is their recommendation of the course to other students; for example 85-96% (average of 89%) of students who have done BIOL3191 *Biotechnology in Context* in the last six years recommend this course to other students.

Pilot questionnaire of lecturers and teaching of ethics
Thirteen ANU science course convenors teaching courses in Semester 1 were approached to complete the questionnaire. The courses they nominated to describe were in the five discipline areas of biology (2), chemistry (3), physics (3), psychology (2) and mathematics (3). The survey responses related to first year (5), second year (2) and third year (6) courses.

Ethics training
Eight respondents indicated they had undertaken no formal ethics training; 3 nominated seminars or parts of workshops that had focused on ethics; and 2 had received ethics training associated with animal experimentation (1 psychology, 1 biology).

Ethics categories taught or mentioned
All lecturers in this study ticked the category concerning appropriate academic conduct, or 'academic honesty' (Table 3). The second most frequently mentioned category was 'ethics within a social context' (7 respondents) followed by 'ethics and the scientific method', ticked five times. After these top 3 categories, responses fell to three or below with one category, 'history of ethics', receiving no attention in any of the respondents' courses. Only one new category was mentioned, the use of animals in research, though arguably this is covered under the category 'Ethics committees…'.

Table 3. Ethics categories referred to in respondents' courses

Ethics category description	No. Ticked	Category
Academic honesty – plagiarism, fraud, collusion, cheating, recycling	13	A
Ethics within a context (social, cultural, temporal, political, discipline/ subject-matter)	7	B
Ethics and scientific method – e.g. is there a difference between the theory of scientific method and scientific practice?	5	H
Ethics and law	3	J
Ethics and changing cultural values	2	C
Informed or assumed consent	2	E
Application of ethics to difficult situations – ethics and controversy/ contradiction; multiple ethical views	2	I
Ethics and professional obligation/responsibility to your discipline and/or to society	2	L
Ethics committees (such as the ANU Animal Experimentation Ethics Committee or the ANU Human Research Ethics Committee)	2	M
Personal values (ethics as compared with morals)	1	D
Ethics and different standards – e.g., DDT use in the developing world, human egg harvesting and coercion in South Korea, executed criminals and organ transplantation in China	1	G
Ethics as a restriction or facilitation of research and teaching	1	K
OTHER – 'Use of animals in research'	1	
History of ethics	0	F

Ethics content
The total amount of time in a course devoted to ethics ranged from 0–10%. Only one respondent reported spending 10% of the course on ethics, three spent 5-6%, and the remaining nine reporting <5%. One in fact reported they spent 0% of the course on ethics, though this respondent also indicated that they 'at least referred' to academic honesty.

Ethics content was distributed throughout respondents' courses in one or more of four ways. Six responses had academic honesty (such as plagiarism) mentioned in an introductory lecture or lab class. Five responses reported ethics subject matter deliberately woven throughout the semester, with another three responses suggesting ethics topics were handled as they arose. Only two of the 13 respondents reported having a dedicated 'block' of ethics. One spent a three hour lab on ethical matters, one a two week block of the course.

The subject matter covered in respondents' courses ranged over a number of sub-categories. To begin, academic honesty, particularly plagiarism, was a ubiquitous theme. Also common was some notion of 'respect', however the object of this respect could be diverse. Overall, respondents variously covered ethics and respect in reference to: animals and animal research; the scientific process and the data it generates; laboratory safety and co-workers in labs; respect for conservation; and finally more ambiguously, 'others'. Another broadly mentioned category emerged in relation to 'real world applications or implications', though the brevity of comments makes it problematic to explore in this pilot study. In addition, one respondent said that they covered no ethics material because ethics was not relevant to their subject matter.

Finally, we turn to cultural and academic diversity of students and how this influences the presentation of ethics. Nine respondents reported that the diversity of their students had no influence on the way they taught ethics, and a tenth respondent did not answer as they felt ethics were irrelevant to their subject matter (mathematics). The three remaining respondents' comments suggested that different cultural backgrounds caused some confusion when it came to academic honesty criteria and how the notion of what is acceptable (particularly collusion and plagiarism) could differ.

Impressions of ethics/ ethical challenges
The ethical principles respondents deemed both most important to convey to students and as essential elements of ethics focussed very broadly around three themes: academic honesty; integrity of science, scientists and science methods; and respect for others (including animals).

When it comes to the aspects of ethics respondents believe students find most interesting or engaging, the most prominent theme is that of real world cases, or ethics in social contexts. In essence, material that includes some application of ethics, even if only broadly, was most frequently reported as engaging students (six respondents). This result is given some additional context when we consider that six respondents wrote 'not applicable'. There was also a suggestion that students might generally like ethics components and discussions because there are no 'right' answers, unlike the rest of the subject matter (two respondents).

In relation to perceived student interest or engagement in issues of ethics, six respondents considered the question not applicable, neither to them nor their students. Five comments included some notion of academic honesty as being the least engaging, one believed it was all uninteresting to students, and one suggested that ethics might 'worry them'.

Six of the 13 responded that 'yes', students faced conceptual challenges when learning about ethics in their courses. Three responses concerned confusion over academic honesty, two perceived confusion among students about producing the 'right', versus their 'actual' results, and one referred to differences of understanding between domestic and international students regarding harvesting of wildlife (fishing and whaling). When asked to explain how they actively knew these were challenges faced by students, answers fell into two categories. One can be summarised as 'plagiarism or academic honesty is easy to spot', the other, 'discussion with students'. There was no apparent reference to systematic feedback being gathered from students about this.

The research and the questionnaire

The mean time to fill out the questionnaire was 15 minutes. The range however, was broad with three people taking five minutes (the lowest), and another three taking 30 minutes (the highest). The majority of comments about the survey suggested respondents found it easy, though two comments were made about how it was difficult to articulate their thoughts about ethics. Four actively described the survey as irrelevant to their course or subject matter. One respondent wrote that they found the survey difficult, but this was apparently related to the extent to which an active consideration of ethics was beyond the purview of their day-to-day academic activity. No respondent had any structural or content criticisms of the questionnaire form itself (available from http://science.anu.edu.au)

Discussion

This preliminary study investigates the relevance and importance of ethics in the teaching and learning of science for both students and lecturers. Students who have completed the courses that discuss and explore ethics are highly positive of the value of such courses. This value in their lives is seen as both a current and future one.

Lecturers too consider ethics very important but many only discuss academic honesty issues with students. The staff responses that indicated that ethics were not relevant to their courses (while at the same time selecting the academic honesty category from the 'ethical categories' list) suggests a challenge to their concepts of ethics in science education. Staff feedback suggested that they do not explicitly refer to 'ethics' when talking to their students about academic honesty.

Comments about lack of time or relevance were most often made in the context of science courses with a focus on abstract, technical, or mathematical content. Lecturers teaching courses that are more readily associated with day-to-day or public interests, particularly in the biological sciences, were much more likely to include a range of ethical categories within their courses. Perhaps students are also more likely to ask questions about ethical issues in such courses.

The findings of this study mirror those of the UK survey (Willmott et al., 2004) in that apprehension is felt by science lecturers in presenting ethics to undergraduate students. Reasons given for not including more ethics were lack of training or resources and the crowded curriculum. However, the apparent mismatch between ANU science students' comments about the value of discussing a range of ethical categories, and the common perception from science teaching academics that overt ethical discussions were not important to their courses (with the significant exception of academic honesty) is an area that we wish to pursue further.

The current study has involved a preliminary investigation of student responses regarding science courses with declared interests in ethics, along with a pilot survey of staff coordinating a small sample of undergraduate science courses. While we are keen to broaden this investigation to include a representative sample of all undergraduate and postgraduate science students and the teachers of science courses, this current investigation has already provoked some responses from our colleagues. One interesting outcome is that the survey stimulated the interest of teaching staff as to how they could incorporate more ethics of science into their curriculum. One lecturer commented '…[this survey] made me think about [ethics] being important. Do I need to be better informed? Not about academic honesty but perhaps about other aspects [of ethics]'. Several other lecturers made similar comments.

This study covered only 16 of the 242 undergraduate courses offered in 2007 by the ANU College of Science. A more detailed survey of all lecturers within the College of Science is planned, along

with interviews of a representative sample of staff. Further exploration of students' perceptions of ethical issues is about to commence with a view to probe any connections between formalised in-course discussions of ethical categories and the development or alteration of conceptions of science ethics. Questions at the heart of this future investigation include: Should overt discussion of a range of ethical categories form a part of the education of every science student? What does this look like for a mathematics, physics or chemistry major student? If we suppose that ethical attributes should form a part of the skill set of graduating students, we need to investigate what this means for the education of science undergraduates beyond the current experience.

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