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TEACHING AND ASSESSING ETHICS AND SOCIAL RESPONSIBILITY IN UNDERGRADUATE SCIENCE: A POSITION PAPER

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Abstract

Institutional graduate capabilities and discipline threshold learning outcomes require science students to demonstrate ethical conduct and social responsibility. However, neither the teaching nor the assessment of these concepts is straightforward. Australian chemistry academics participated in a workshop in 2013 to discuss and develop teaching and assessment in these areas and this paper reports on the outcomes of that workshop. Controversial issues discussed included: How broad is the mandate of the teacher, how should the boundaries between personal values and ethics be drawn, and how can ethics be assessed without moral judgement? In this position paper, I argue for a deep engagement with ethics and social justice, achieved through case studies and assessed against criteria that require discussion and debate. Strategies to effectively assess science students' understanding of ethics and social responsibility are detailed.

Keywords

Ethics, undergraduate science, social responsibility

Introduction

Among the many changes to the teaching and learning of science that have occurred over the past decade in Australia and globally is an increased focus on learning outcomes other than scientific content. Previously considered part of the latent or hidden curriculum and expected to be acquired incidentally by students as they passed through their rigorous scientific training, such learning outcomes (including communication, team work and ethics) are now specifically stated in the graduate capabilities of all institutions. For example, graduates will be "ethical local and global citizens" (Macquarie University, n.d.); will have "ethical, social and professional understanding" (The University of Sydney, 2004); and "will be able to demonstrate social and ethical responsibility" (Queensland University of Technology, 2009).

Paralleling this development, in 2010, the Australian government commissioned the Learning and Teaching Academic Standards Project (LTAS) to articulate

Threshold Learning Outcomes (TLOs) for several disciplines (Ewan, 2010). The Science TLOs were developed through extensive consultation with the academic community and fall into five categories: (1) Understanding science, (2) Scientific knowledge, (3) Inquiry and problem solving, (4) Communication, and (5) Personal and professional responsibility (Jones, Yates, & Kelder, 2011). Science TLO 5.3 states that graduates will:

> *be accountable for their own learning and scientific work by demonstrating knowledge of the regulatory frameworks relevant to their disciplinary area and personally practising ethical conduct.*

Within the discipline of chemistry, the Australian academic community continued the consultative process in 2012 and 2013 through multiple workshops leading to the expanded Chemistry Academic Standards Statement (Pyke, O'Brien, Yates, & Buntine, 2013). This statement enlarges upon the wording of the TLOs for Chemistry (CTLOs) and specifically includes the following threshold (i.e. minimum) learning outcome for a chemistry graduate:

> *Take personal, professional and social responsibility by recognising the relevant and required ethical conduct and behaviour within which chemistry is practised.* (CTLO 5.3)

An important feature of TLOs, stated at the beginning of LTAS, is that these outcomes can be considered to have been met in a degree only if they have been explicitly taught and assessed (Ewan, 2010). An audit of three undergraduate chemistry degrees from 2011 determined that none of them at that time met all CTLOs (Schultz, Mitchell Crow, & O'Brien, 2013). In particular, CTLO 5.3 was one of only two TLOs not met by any units in the degree at one of the institutions, while it was addressed in only one unit of the degree at the remaining two institutions. Although this is a small sample, this suggests that CTLO 5.3 requires change in a typical chemistry degree to ensure that it is taught and assessed. Consistent with this assertion, a US study recommended ethics to be addressed because it was lacking in first and second year chemistry units at Purdue University (Towns, 2010), and a UK medical degree was also found to be deficient in the learning outcome of ethics (Robley, Whittle, & Murdoch-Eaton, 2006).

However, there is a subtle yet important difference between the wording of CTLO 5.3 and Science TLO 5.3 that has significant implications for the type and extent of changes to teaching that would be required to achieve the TLO. The difference lies in the use of the term *personal and social responsibility* in the Chemistry TLO, which is missing from the Science TLO. A useful way to approach this difference is to use the distinction made by Gibney (2012) between: (a) *microethics*, which includes plagiarism, inaccurate data collection and false reporting; and (b) *macroethics*, which covers much broader issues including war, torture, climate change, and the gap between rich and poor countries. In this paper, the term macroethics will be used to encompass social justice, sustainability, and ethical behaviour in the broadest sense. Microethics in science teaching equates loosely with academic integrity and relates to avoiding plagiarism and data fabrication. Microethical topics are restricted and generally uncontroversial, and are therefore easier to teach and assess (although there can be cultural complexities, such as within plagiarism (Myers, 1998)). Teaching microethics may, however, subvert genuine ethical behaviour because it is possible to maintain a flawless laboratory notebook while, for example, developing chemical weapons (Eriksen, 2002). Gibney (2012) questioned "the manner in which moral standards are restricted and compartmentalized" through a focus on microethics (p. 13) and argues that the focus on microethics at the expense of macroethics leads to a shallow teaching of ethics.

It is useful here to return to the explanatory note for CTLO 5.3, which states that:

> Chemistry graduates will have an awareness of the ethical requirements that are appropriate for the discipline. These may include the importance of accurate data recording and storage, proper referencing (and the need to avoid plagiarism), intellectual integrity, having an awareness of the impact on the environment of their activities, and an appreciation that chemistry can generate new knowledge with benefits and risks to society. It is important that chemistry graduates have some understanding of their social and cultural responsibilities as they investigate the natural world.

Using Gibney's (2012) macro-micro distinction, it can be seen that this explanation of CTLO 5.3 begins with microethical examples, namely data management, academic conventions and intellectual integrity. It then expands to include the impact on the environment and social responsibilities. The inclusion of the latter areas implies that some engagement with macroethical issues should be undertaken to meet the CTLO. In contrast to this, advice in *The Good Practice Guide (Science): TLO 5* produced to assist academics in addressing that TLO, focuses on microethics (Loughlin, 2013) such as academic integrity and compliance with codes of conduct. It thus appears that there is no consensus within the Australian science community over the breadth of ethical instruction that is appropriate for science students, and specifically whether this should go beyond teaching microethics to cover the more complex and controversial terrain of macroethics.

I believe that science teaching should address macroethical issues along with microethics. I have previously argued that there is a moral imperative for chemistry teachers to teach sustainable chemistry and made recommendations as to how this can be achieved (Schultz, 2013). In that project, it was concluded that academics who found intellectual challenge in environmental issues were more able to incorporate sustainability in their teaching. Similarly, engaging personally with macroethical issues will inspire interest from academics and allow them to teach effectively. This position paper explains and provides arguments to support my view.

Why macroethics should be included in science education

Teaching macroethics is critical if we expect the next generation of scientists to behave ethically and be socially responsible. The world faces multiple complex challenges due to climate change, increasing population and shortages of essential resources. Today's students are tomorrow's scientists who will have to deal with these real problems in an ethical manner. As Johnson (2010) contended, "the central problem which surely underpins [the importance of ethics education for scientists] is that ethical issues constantly arise in science, and scientists need to learn how to deal with them" (p. 198).

As explored above, although there is some debate at the level of discipline standards, Australian institutional guidelines in the form of graduate attributes consistently require macroethics to be addressed. As well as the examples previously mentioned, several Australian institutions include statements that require a broader macroethical approach. For example, The University of Sydney (2004) stated that "graduates of the University will... ... be committed to social justice and principles of sustainability" (para. 4.3.4, p. 173) while Macquarie University (n.d.) declared that its "graduates should be aware of disadvantage and social justice" (para. 6) and "be informed and active participants in moving society towards sustainability" (para. 7).

There is also strong, established support for teaching macroethics at the international level. For example, in 1999, the World Conference on Science adopted the *Declaration on Science and the Use of Scientific Knowledge* which stated that:

> The practice of scientific research and the use of knowledge from that research should always aim at the welfare of humankind, including the reduction of poverty, be respectful of the dignity and rights of human beings, and of the global environment, and take fully into account our responsibility towards present and future generations.
> (UNESCO and the International Council for Science, 1999, para. 39)

In her report on that international meeting, Evers (2001) argued for inclusion of macroethical training of scientists as follows:

> Ethical standards for science must be formulated with great care and integrity. ... Asking scientists to be socially responsible in their capacity as scientists presupposes that they possess the relevant competence. The study of ethics should therefore be an integral part of the education and training of all scientists with the purpose of increasing future scientists' ethical competence. (p. 89)

In a follow-up report to the same meeting, Børsen Hansen (2005) expanded the rationale for ethical training by explaining that:

> During their training, scientists and engineers must develop a value system that directs their professional actions in a sustainable and socially just direction. Hence, the teaching of ethics should have this as its overall

> pedagogical ideal. A scientist or engineer acts in an ethical or socially responsible way if he or she does not violate certain ethical principles, and directs his or her research in a sustainable and socially just direction. (p. 5)

In many degrees including information technology, business and law, the inclusion of formal ethical training, including social responsibility and macroethics, has become standard. This aims to prepare students to act as moral agents within their respective professions, both to uphold the integrity of the profession as a whole and to maintain their own personal integrity. Thus, science appears to be somewhat behind other discipline areas in ethical training.

Workshop findings

The issue of the teaching and assessment of ethics within the discipline of chemistry was addressed through a workshop at the Australian Conference on Science and Mathematics Education in September 2013. Strategies for teaching and assessing CTLO 5.3 were shared at the workshop and difficulties were highlighted. The discussion among the 32 participants from 18 Australian universities made it clear that some favoured restricting their teaching and assessment in this area to microethics. Some participants, however, stated that just teaching students not to plagiarise is not enough, and that we should also teach social responsibility.

Four main arguments against the teaching of macroethics to science students at university were advanced at the workshop and have also arisen in informal conversations with colleagues and in the literature. The first is that science educators are not trained as philosophers and are therefore not qualified to teach on philosophical issues. The second argument is that it is not the place of a university academic to attempt to influence the moral development or personal values of undergraduate students. Third, and related to the second point, it is argued that because morals evolve and there is not universal agreement on what values are “right,” we should not attempt to teach ethics but stick to “pure” science, leaving values out of our teaching. Finally, the well-worn argument about finding the time for the inclusion of ethics within a crowded curriculum was also raised.

These arguments are flawed. First, it is not necessary to have extensive training in philosophical theories to introduce students to topical ethical issues in science. A decade ago, the UK’s Higher Education Academy produced a series of *Bioethics Briefings*, the first of which gives several reasons for including bioethics in the biology degree (Willmott, 2004). The advice in that briefing also applies to other scientific disciplines. It explains and provides evidence that it is possible to teach ethics without introducing students to schools of philosophical thought. Nuanced scenarios, preferably taken from real life, can encourage students to think about all sides of an issue, and discussion can be led without any formal philosophical training (Crebert et al., 2011; Willmott, 2004). In this context, it is relevant to note that a survey of staff attitudes and student responses to ethics teaching at the

Australian National University (ANU) (van Leeuwen, Lamberts, Newitt, & Errington, 2007) found that although many staff were reluctant to address macroethical issues, this aspect was considered most valuable by students. As noted above, ethical issues are already successfully taught to non-philosophy students across a range of professions using either case-based reasoning or a mixture of theory and case studies. If necessary, a specialist could be brought in as a guest lecturer for specific ethics topics as is done for other parts of the science degree at many universities. Professional development for academics could be offered to assist their teaching of scientific ethics.

In countering the second argument that we should not attempt to influence the moral development of our students, it must be recognised that the curriculum itself is value-laden (Posner, 2004) and teachers influence students in many ways through all their interactions (Umbach & Wawrzynski, 2005). These interactions can include the transmission of ethical standards when a teacher models appropriate behaviour (Hafferty & Franks, 1994). In addition, there is a major difference between directing students which way to think and teaching them to be able to recognise, analyse and resolve ethical issues they are likely to encounter in their work. The latter influences moral development by providing students the tools to address moral issues and is the aim of ethics teaching.

The weakness of the third argument relating to the transience of moral standpoints is illustrated by the evolution of scientific knowledge, which does not prevent the teaching of science. It is true that morals evolve and it is possible to imagine a future in which our contemporary values appear out-of-date. This is not an argument against opening discussion with students, encouraging them to reflect on contentious issues and giving them tools to guide their decision-making. Progress in ethical standards is itself an interesting topic for discussion and can be illustrated by examples from science such as the use of DDT (Eriksen, 2002), the development of the atomic bomb and the use of biofuels (McGowan, 2013).

The fourth and final argument against the explicit teaching of ethics, which arises whenever new content is to be added to the science degree, is that time with students is already limited and does not permit adding any material to the curriculum. However, an interdisciplinary approach, in which the ethical issues are raised first, leading to the need to understand the science, has been shown to be very effective (McGowan, 2013). In fact, students are expected to retain scientific material better when it is taught in the context of ethical dilemmas because of their higher level of personal engagement; the content is no longer dry but full of real life.

In addition to resistance from academic staff summarised in these four arguments, macroethics may cause difficulties for students. For instance, Johnson (2010) has described the potential focus of students on microethics and explained some of the difficulties that teachers may encounter as follows:

> Related to the differences in culture and norms of the sciences and humanities (and again with the potential to hamper student learning) is the

> inadequate conception some science students hold of what the discipline of ethics is about. For instance, they may regard ethics as constituted by externally imposed rules and regulations; they may conflate ethics and law; or believe the discipline of research ethics exhausts the ethical issues raised by science, so that effective ethics committees may be all that is required to ensure ethical practice in science. (pp. 203-204)

Johnson (2010) went on to suggest that such misconceptions can be corrected through open-ended subjective discussion of real world issues in order to acquire "a sensitivity that allows them to recognise moral issues, as well as situations where values are in conflict" (p. 207).

How to include macroethics in science education

The incorporation of ethical dimensions in teaching is well established because topics such as the use of humans and animals in research, genetically modified organisms and cloning naturally lead to the discussion of bioethics (Beauchamp & Childress, 2009). There have been calls to strengthen the teaching of ethics in medicine (Hafferty & Franks, 1994) and, more recently, in biology (Rappert, 2010) to include more macroethical perspectives.

Griffith University (Australia) has produced a comprehensive guide to teaching ethics and social responsibility that is freely available online (Crebert et al., 2011). This guide contains a plethora of arguments sourced from many disciplines and institutions for engaging with macroethics. Examples of how to do so include inviting industry speakers, presenting multimedia to students, forming focus groups on specific issues and peer review. It includes an comprehensive checklist for designing assessment tasks for ethics with items such as: *How can I keep my own personal ethical values out of the assessment process and remain impartial?* and *Can I undertake to give credit to students whose work I consider to be ethically "wrong"?*

Many participants at the 2013 Australian Conference on Science and Mathematics Education workshop reported in this position paper suggested case studies involving the interrelationship of ethics with economic, environmental and social impacts of a scientific issue as ways to stimulate discussion on ethics. Examples of poor, questionable as well as good ethical conduct and behaviour should be incorporated. A case study approach has been shown to be effective for use in high school (Barden, Frase, & Kovac, 1997) and case studies have also been proposed by others (see, for example, Willmott, 2004) as a way to both teach and assess ethics. However, workshop participants indicated that it is critical for case studies to involve complexities and not be black and white; a view consistent with Gibney's (2012) concern that the real world is far more nuanced and complex than many scenarios developed for students.

Further to this, Johnson (2010) provided an extensive discussion of using role play to develop science students' skills in recognising moral issues and the complexity of ethical debate. Role-playing within case studies can bring a topic to life and allows students to argue for a position without personal involvement.

During workshop discussions, it was noted that not only blatant misconduct should be addressed but also more subtle aspects of professional ethics such as being selective in data reporting and other aspects of scientific fraud (Martin, 1992). Participants suggested a wide range of topical issues as suitable for approaching ethical issues; in particular, it was noted that environmental chemistry (including fracking, biodiesel, construction of industrial facilities) is a topic with many opportunities to teach and assess ethics. Other topics that were suggested for case studies or to stimulate discussion were: (i) advertising claims; (ii) retraction of scientific publications; and, (iii) "dual use" resources such as compounds used to make illicit drugs and chemical weapons.

Attention was also drawn to the *Multiple Uses of Chemicals* website (http://multiple.kcvs.ca) produced through a joint project of the *International Union of Pure and Applied Chemistry and the Organisation for the Prohibition of Chemical Weapons.* This site provides an excellent teaching resource to develop ethical values (IUPAC and OPCW, 2013). It was designed for use in teaching with interactive activities for students to complete alone or in groups and begins with examples of illicit drug use explaining that many chemicals have both beneficial and harmful uses. This leads to a discussion of the development and use of chemical weapons and scientific responsibility.

At the workshop, participants stressed that the relationship between professional practice and ethical behaviour should be addressed explicitly. For example, students could reflect on and discuss whether following a protocol is always acceptable or when they might refuse to perform a task or conduct an experiment owing to ethical considerations. It was agreed that many opportunities to explicitly address ethics within the context of chemistry could be found.

Assessment of ethics

Workshop participants made a number of suggestions as to how ethics might be assessed. One participant, for example, suggested an introductory online quiz on general science ethics for large first year classes although added the caveat that it might be difficult to make it meaningful in this format. Nonetheless, a "tick the box" quiz could be a useful starting point to raise awareness of ethics and their place in the science community. Participation in an online discussion was suggested as an alternative that would allow peer assessment for large classes.

Other suggested assessment items proposed at the workshop were to:

- write a Code of Conduct for chemists.
- prepare a presentation or essay on a compound of current interest focussing on ethical aspects.
- define and give an example of each of:
    - a conflict of interest

  - selective choice of data to fit a hypothesis (such as has been claimed in the climate debate and some drug trials)
  - incorrect attribution of results
  - social implications of results
  - whistleblowing.
- write an essay analysing a given or contemporary ethical issue.
- debate a scientifically relevant, contentious ethical issue such as chemical weapons, euthanasia, immunisation or illicit drugs. Assessment of the debate may be based on team participation and the preparation and delivery of defensible arguments which also meets several other CTLOs.

The previously cited Griffith guide (Crebert et al., 2011) sourced from a variety of disciplines also suggested writing a position paper with the following structure: a description of the issue, identification of stakeholders and how they will be affected, statement of a personal position, argument for the position using a code of ethics and/or ethical theories, and suggested alternative courses of action. A learning journal is also proposed to document moral development, with students expressing their initial standpoint then describing relevant theories as these are learnt during the course, a critical incident and their reflection on how their attitudes have changed over the course.

To assess what might be subjective texts, Hack (2013) has developed and used a matrix for scientific ethics and has shown that its use leads to better performance by students. An extract from this rubric, which focuses on the introduction and conclusion, is shown in Figure 1.

Fail	Pass	Merit	Distinction
7-9 points	10-11 points	12-13 points	14-20 points
The introduction provides background to a topic. Some evaluation and synthesis of key issues and material presented in conclusions.	The introduction provides a brief background to a challenging topic e.g. why is it relevant, and why does it raise ethical issues. The conclusion provides critical evaluation and synthesis of key issues and material.	The introduction provides a brief background to a challenging topic e.g. why is it relevant, and why does it raise ethical issues. The conclusion provides a critical evaluation and synthesis of complex issues and material. Both introduction and conclusion should demonstrate an original and reflective approach.	The introduction provides a brief background to a challenging topic e.g. why is it relevant, and why does it raise ethical issues. The conclusion provides a critical insightful evaluation and synthesis of presented evidence.

Figure 1. Assessment of introduction and conclusion: Rubric for scientific ethics course at the University of Ulster (Hack, 2013)

With modifications to suit the specific assessment task adopted, the use of such an assessment matrix is recommended. It is critical that assessors are impartial in relation to students' own values and only assess whether students engage with the ethical issues using the principles taught in the course (Crebert et al., 2011).

Conclusion

Scientists do not shy away from difficult problems in their research and should, similarly, not shy away from addressing difficult and complex issues in their teaching. The 21st century requires scientists trained to think about the full ethical implications of their work and to make decisions based on anticipated impacts beyond what may occur in the laboratory. Teaching these scientists to consider all sides of a problem and to formulate considered responses is the responsibility of the current generation of academics.

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