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ABSTRACT

ETHICS, ISSUES AND SCIENCE EDUCATION

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For the past two years at NTU, I have been running a fourth year Bachelor of Education course on science issues. The majority of those doing the course are working primary teachers from a variety of backgrounds. The first part of the course consists of the history and philosophy of science, whilst the second part concerns science issues. The reason that I introduced some basic principles of ethics into the course, was so that, as a group, we could try to use some common benchmarks to judge the different issues that students presented to us. This was the starting point and in the paper I will discuss a number of case studies that have aroused some interest and debate. It is hoped that there will be some time for discussion of other scientific issues that colleagues may like to raise.

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INTRODUCTION

B.Ed students at NTU have the option of taking a fourth year course on science issues. The majority of those choosing the course are working primary teachers, and they undertake the course for a variety of motivations. Most have no special interest or aptitude for science and some students have joined the group when courses that they would have preferred had been cancelled. The first part of the course consists of the history and philosophy of science, whilst the second part considers science issues. Although there is a need to look at ethical questions in discussing the history of science (some famous scientists appear to have used fraud and duplicity in their research), the reason that I introduced some basic principles of ethics into the course, was so that, as a group, we could try to use some common benchmarks to judge current issues that students presented to us. In this course students choose one issue that is of concern to them, research that issue and present their findings to the group. I will define a science issue as some aspect of science over which there is genuine disagreement and which is unlikely to be resolved purely on the basis of scientific knowledge. After an issue had been presented to them, the group's next task was to consider it on the basis of a code of ethics, which the group had previously defined and accepted.

ETHICS

The first problem was to obtain some sort of agreement from the class as to what we mean by a code of ethics. In the past, one might have assumed that all members of the group accepted Christian principles, but in a multicultural and multi-faith society this is no longer possible. Rather than spending a large amount of time in constructing a code of ethics I have chosen two examples of ethical codes. One is taken from Australian Kidney Foundation (1992) which states the following principles:-

- 1. Beneficence** *This principle holds that we should seek to promote the good and avoid the harm of others. When attempting to make an ethical decision using this principle we need to ask: will our decision result in greater good or harm for the person?*
- 2. Respect for each person's autonomy.** *Each person has dignity, is entitled to respect from others and should be free to control her/his own life(i.e. self-determination). This is the basis for the 'right to chose' and almost all other rights which people claim.*
- 3. Justice (fairness).** *Three alternative interpretations of this principle exist: No 'special treatment' is possible .-Everyone has the right to equal treatment.-Some people have earned the right to special treatment, for example, those who belong to a disadvantaged ethnic or racial group.*

Generally I found these principles to be helpful in allowing us to decide on the rights and wrongs of particular issues, but on some occasions it was found that principles were in conflict. The second code of ethical principles is taken from notes that I made of a lecture that I attended, by Professor Lea. It includes a similar definition of ethics taken from his paper on ethics and sustainable development, at the NARU Seminar on development in the Northern Territory, which was held in Darwin. It also includes a number of points, which are interesting

to discuss, in considering a code of ethics. I made the following rough notes from Professor Lea's paper:-

- 1) The area of ethics is a minefield being full of rubbery definitions.
- 2) Ethics for life are needed that transcend science; ethical criteria are impossible.
- 3) An ethical concept of development involves:-
 - a) Improving life
 - b) Improving human dignity
 - c) Giving people freedom to make choices
- 4) Practical applications:-
 - a) High degree of commonality across cultures about what is ethical.
 - b) Need for participative planning.
 - c) Value of traditional and local knowledge.
- 5) An ethical approach in planning can be top down or bottom up. Successful approaches involve:-
 - a) Securing rights
 - b) Participatory planning
 - c) Sensible evaluation.

It should be noted that point 3 includes the same basic ideas as in the Australian Kidney Foundation (1992), though they are only a summary of what he said. Professor Lea also pointed out that this general statement about what is ethical, gets a high degree of agreement, but people may agree that certain actions are what they ought to do without necessarily doing them.

One word that comes up frequently is the word "good". Maxwell (1992) believes that we should try to create a good world. What does he mean by this? As will be seen from the passage below, he comes up with the really big issues, which are so big that my course on science issues tries to avoid them, as the solutions to such problems are so complex, that discussion does not appear to make progress. Nonetheless these issues underlie all the smaller issues that we discuss.

If we are to create a more just, peaceful, generally prosperous, democratic and humane world - a good world- the global problems that we will need progressively to solve include the following.

- 1. An end to third world poverty; a more just relationship between First and Third Worlds, including a more just distribution of the world's resources.*
- 2 World-wide elimination of tyranny, whether of the left or right and the establishment of democracy everywhere.*
- 3. The creation of an ecologically sustainable world industry and agriculture; an end to the current massive extinction of plant and animal species through hunting or through destruction or pollution of their natural habitats; an end to the destruction of tropical rain forests; an end to the impending threats of global warming and the destruction of the ozone layer.*
- 4 An end to population growth.*
- 5 An end to war and the threat of war.*
- 6 The creation of more co-operative institutions and social arrangements, both local and global.*

(Maxwell, 1992)

These solutions to global problems may well be founded on sound ethical principles, which might achieve a high degree of agreement, but they are not easily achievable because people don't always do what they ought to do (as Professor Lea pointed out). Our first major lesson in

this sphere is then to attempt only those issues where we can have some major influence and where individuals can act to bring solutions closer. If too many big issues that appear not to have solutions are discussed, then the discussions may become unreal and the debates mere talk-shops.

Can ethical codes be constructed by us as human beings? Or can they only come from a deity? People disagree fundamentally about religious matters, so a large measure of agreement can usually be reached by using a code of ethics, since such codes usually contain no principles that contradict those of established religions. However in these discussions, little can be taken for granted. For example, a recent series of articles in the New Scientist during April and May 1992 (Issues Nos 1815 to 1821) dealt with ethics and the way we treat laboratory animals. One reply (Ryder, 1992) deduced a code of ethics on the basis of our kinship with animals. A reaction to this reply from a clergyman introduced ethical cats and mice to counter this suggestion stating that, in his opinion, codes of ethics cannot come from below us, only from above us (Foster, 1992). That is, the ethical code of cats permits them to kill and eat mice. Ainsworth (1992) agrees with Foster in general, but feels that a minimal satisfactory ethical principle is not to inflict pain on another creature, whilst Alberry (1992) simply inverts the argument by hypothesising that some creature from outer space has landed on earth and is about to carry out experiments on us. We have to use moral arguments to persuade it to desist.

Related concepts and synonyms are common in this area, so that it is often difficult to determine whether speakers are making points based on the same assumptions or on different assumptions. Ethics, values education moral education and religious education are all terms in common usage with different connotations. For the classes that I teach, I have felt that, because we live in a multicultural society with a variety of religious beliefs or none, there is a possibility of getting a measure of agreement on a code of ethics where there is little possibility of reaching a common religious position. However this is not an area where there are single solutions: for example Nichols (1990) argues the case of modern scientific advances in reproductive technology from a religious point of view, whilst Gillam (1990) considers the same issue as a social issue. Malcolm (1989) looks at the overall place of values and ethics in the educational context of science and technology. A feature of considering issues is that issues are often complex and involve interdisciplinary study. Issues are more often related to the biological sciences than to the physical sciences: in fact, Kelly (1990) sees biology as an ideal vehicle for teaching ethical principles

"Ethical principles have long been associated with biological phenomena.....ethics should be taught as a part of biological education, within a framework of history, futures study, training in clear thinking and the development of empathy"

Without getting into an argument about where ethics should be taught, it is certainly now considered an essential of science education. Presumably better education about what is ethical in science, whilst scientists were at school, might have led to fewer reported cases of scientific fraud. So, one might see the study of a number of cases of fraudulent science as a starting point for a unit on ethics in a science course. We might then look at a number of cases of ethical issues in biology, chemistry and physics

ISSUES IN BIOLOGY

Biology has a large number of possible issues, such as transplantation (Australian Kidney Foundation, 1992), human reproductive technology (Charlesworth, 1989), euthanasia (Elliott, 1992; Nowak, 1992), Aids (Mann & Tarantola, 1992; Barnett & Blaikie, 1992) etc. I will spend

a little time in providing some discussion and a few useful additional references in each of these areas.

(a) Kidney transplantation. Two years Tonti -Phillipini came to Darwin and gave a series of fascinating talks on this topic. He is a professional ethicist and I must admit that before hearing him speak, I did not realise that it was a profession, let alone a profession that is expanding rapidly. He was interesting in that he suffers from a kidney defect himself, and continues on dialysis in spite of being offered a kidney transplant, because he believes that relatives of the deceased person whose kidneys are to be used for a transplant are often pressured unethically to sign their permission to allow the doctors to start the operation. He said that he personally would not accept a transplant until these procedures had been improved.

Swazey (1987) in a poem that she quotes from Sapperstein(1971) indicates what it is like to be on dialysis and I quote it again with the same purpose in mind.

The Travenol salesman wears glasses and a dark suit:

"Do you take this machine

In sickness and in health

Till death do you part?"

I do.

Reclining

On the nausea-green hospital chair:

Below me children, playing in the street;

Above me old men, dying of coronaries.

I am

The final essence of the technological age,

Flesh conjoined with plastic, vessels with steel,

Coils, alarms, twisted tubing turning scarlet

Deep within the machine dark blood

Mixing with the fluid, cellophane-separated, plugged in and turned on.

Dear God

Purify me.

Sapperstein, 1971

The Australian Kidney Foundation (1992) has produced a really excellent package which is a very good class resource for discussing the issues involved in organ transplantation. Charlesworth's (1989) book (reviewed Palmer, 1991) is a good introduction to the area of ethical issues relating to transplants, human reproductive technology and euthanasia.

(b)Recently the "New Scientist" published a number of articles on euthanasia. Euthanasia has not been a question taken up in the course that I teach, probably because we try to make the course relevant to their teaching situation. They are all primary teachers and may not feel the topic relevant to their pupils.

(c) "The Higher" published a number of articles on Aids, some of which are included in the references. Similarly the topic of Aids has not been a topic my students have chosen in the past two years, probably because they would prefer not to teach the topic at a primary school level.

ISSUES IN PHYSICS

In physics the number of obvious cases of ethical issues is smaller, but the construction of various technologically useful artefacts varying from ships to dams gives a wide variety of complex issues to consider. The case study chosen as an example here is that of dams. It is

probably best to consider some particular dam or dams, which is local or about which the students have some special knowledge. One needs to consider the reasons for building dams and perhaps some of the physics behind their construction. If it is a local dam it may be possible to get some detailed information for students to consider. Ethically students will be very sympathetic to the idea of building dams for power generation, because they save on the use of fossil fuels and do not appear to add to the burden of greenhouse gasses. Also dams can serve other purposes, such as to improve fishing or navigation. In a recent article, Bartlett (1992) points out one major issue of the operating policy at the Glen Canyon Dam on the Colorado River in Arizona. Because of variation of demand for electricity, there are evidently large daily fluctuations in the level of the river downstream, which causes severe erosion problems and can make leisure-time boating hazardous for tourists. However if the dam were closed and its generating capacity replaced by a conventional coal-fired power station, then there would be additional atmospheric pollution and the emission of carbon dioxide. Bartlett writes:-

"Our students need to be aware of these conflicts, they need to develop their own ethical standards for dealing with particular conflicts, and they need to think about the long term task of dealing with the growing frequency and severity of these conflicts in the future."

Dams have been built for a variety of reasons, and have at different times and places caused a wide variety of problems. Teachers might well like to explain to their students that many dams, particularly those built in the developing world have not delivered to those countries anything like what was expected.

In Nigeria, for example, the Kainji Dam on the River Niger fell a long way short of providing the power that was promised, because the planners grossly overestimated the amount of rain that would fall in the area, due to inadequate data. Also the dam is filling up with silt to a greater extent than expected and has probably caused the spread of river blindness to a wider area than before. In other words the benefits have been less than predicted and the costs have been considerably greater. Thus if evaluated in advance on projected benefits, the decision to build the dam may well have been sensible, but in terms of what was actually achieved, probably no project or a much smaller project, would have made better economic sense and would have saved considerable human suffering.

Other examples of problems caused by particular dams might be the washing away of parts of the Ghanaian and Togolese coastlines caused by the construction of the giant Akonsomba hydro-electric dam in Ghana (Bourke, 1987). The occurrence of infection of local people with waterborne parasitic diseases such as schistosomiasis and onchocerciasis (river blindness) have increased markedly. The project displaced 64,000 people, and although new villages were built to house them, there was considerable social disruption, which meant that many of those moved were transformed from being independent farmers to being dispossessed and dependent on the state for support. In Sarawak, Malaysia, the Bakun hydro electric seems very likely to cause similar disruption to produce much more electricity than is needed by Sarawak (Mohun & Sattaur, 1987). In India the huge Narmada dam, now partially constructed, is in trouble with the World Bank admitting it has fallen short of its own guidelines (Miller, 1992). Goldsmith and Hildyard (1986) have written a book detailing the problems caused by a number of the world's dams.

ISSUES IN CHEMISTRY

In Chemistry I like to consider the metal lead, its uses and its toxicity and the issues that arise from this. Here I will list some issues that arise but perhaps when teaching, some sort of concept map, drawn after a brainstorming session, may help to tease out all the issues. Some issues might be:-

(a) Lead may have been the reason for the decline and fall of the Roman Empire (Emsley, 1987). Emsley also makes a good case for it being the cause of the decline of the British Empire. The article shows lead to have been a common accidental ingredient of both the Roman diet and the British diet up to the end of the 19th century. The issue is now to ensure that people in developing countries or the poorer suburbs of developed countries do not get too much lead in their diets.

(b) To illustrate the issues currently involved with lead pollution Appendices 1 & 2 are provided. Appendix 1 uses AARNET as a source of material to discuss and this explains the problems of lead pollution in a number of third world countries. Appendix 2 gives some US newspaper references to lead pollution. These articles indicate that the major source of lead pollution is lead tetra-ethyl, with lead glazed pottery, lead pipes, proximity to industrial plant using or manufacturing lead, lead paint etc being contributory factors. Lead slowly poisons individuals who ingest it or breathe in polluted air. Lead damages the intelligence of children and to a lesser extent, adults. It is only removed from the body very slowly through excretion. It was found that athletes training by running long distances in crowded cities were a group at risk, though in developed countries this risk has been reduced, due to the introduction of unleaded petrol (Vines, 1992).

(c) A final lead case study is the harmful effect that lead weights, used in fishing have on swans in UK rivers. These weights can cause death and suffering in swans in a number of very unpleasant ways and is an obvious area where a little ethical thought would do some good.

POSSIBLE METHODOLOGIES

A variety of methodologies may be used to make the teaching of issues in science one of the more interesting parts of the course.

Gillam (1990) advocates the use of the benefit /harm approach. In this she uses a grid drawn up by members of the class to decide the balance of harm and benefit to the individuals involved. The grid consists of a single sheet of paper for each issue, with the issue stated at the top of the page, and five columns which are "Those involved", "benefits", "rating: 1-10", "harm/costs" and "rating: 1-10". To use the system fully, some weighting needs to be given to each item and then the total costs and benefits can be totalled. This is cumbersome in class but is in fact a simplified version of the technique of cost /benefit analysis.

One can have students make short plays which groups will perform in front of the class. This could be a play, such as a play about famous scientists, and the ethical decisions that their work involved. At Exeter, in the United Kingdom, a theatre company in association with a group of science teachers wrote a play about genetic engineering and *in-vitro* fertilisation set in the future (Somers, 1992), which formed the basis for student discussions in a number of local schools. A variation on this is role play where a situation regarding a hypothetical decision to be made [in this case the question of which of four possible recipients should receive a kidney transplant, (Crisara, 1990) which is to be decided by a committee whose characters have been briefly indicated in advance].

One can explain an issue and ask a class to take sides. They actually physically move across a line from one side of the classroom to the other, to indicate what they think. Further information is then given in stages and people can move backwards and forwards as each additional piece of information causes them to change sides or not. At the end the number of people on each side of the line represents the balance of class opinion.

Generally I find it very helpful in teaching issues to keep a file of articles relating to a large number of commonly discussed scientific issues, so that students have a place where they can start in preparing an assignment on a particular issue.

CONCLUSION

In schools the consideration of a code of ethics, when teaching science can be a valuable part of the course, and in the author's view should be included at appropriate points in the curriculum in order to ensure that the curriculum is balanced and humane. Furthermore, the 1989 Australian Education Council, which consists of State, Territory, and Federal Ministers of Education, agreed upon a set of national goals (The Hobart Declaration) and item 6j of the declaration states that we should "*develop in students a capacity to exercise judgment in matters of morality, ethics and social justice*". The above paper contains some suggestions as to how this might be achieved in school science curricula.

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APPENDIX 1

Article obtained from:- Kenny Bruno Not getting the lead out, AARNET transmission, sci. environment: item 5607, Friday, 18 October, 1991.

NOT GETTING THE LEAD OUT

Kenny Bruno

In Mexico City, the world's most polluted and populous city, 4 million cars pump approximately 32 tons of a potent neurotoxin into the air every day. Across the Pacific, in Jakarta, Indonesia, cars belch a ton and a half of the same poisonous substance into the air every day.

The toxin is lead from tetraethyl lead (TEL) gasoline additive. The result is every parent's nightmare and society's most sickening failure: lead poisoning, an illness that can destroy the health and mental development of children. Despite the U.S. phase-out of leaded gasoline, which began in 1975, U.S. companies are still exporting highly toxic TEL gasoline additive to developing where its use is not restricted." Today, *we have one gasoline for the rich countries, and another, deadlier gasoline for less industrialised countries,*" says Mario Epelman, a physician with Greenpeace's Latin America Project.

As a result, says David Schwartzman, professor of geology at Howard University, *"children in the Third World continue to be subjected to a poisonous assault from high lead gasoline."* With the use of cars growing in developing countries, Schwartzman says, lead levels in gasoline and air are so high that *"we can reasonably expect childhood lead poisoning to reach truly epidemic proportions in many Third World cities."*

There is frightening evidence that Schwartzman may be right: Dr. Jerome Hriagu, a research scientist with the Canadian National Water Research Institute, recently performed roadside dust analyses in Nigeria which showed as much as 6,000 ppm of lead. By comparison, in the United States paint is considered hazardous to children at 600 ppm of lead.

Harvard Medical School neurobiologist Dr. Stephen Rothenberg's long-term study of maternal-infant lead levels has revealed that some umbilical cords at Mexico City's National Institute of Perinatal Development contain enough lead to cause neurological damage. In Alexandria, Egypt, where gasoline contains extremely high concentrations of TEL and air lead levels are often double the European Community's (EC) recommended limit, central nervous system dysfunction has been discovered among traffic controllers. In Buenos Aires, Argentina, air lead levels have been measured at 3.9 *grams per cubic meter in the daytime, and 1.7 grams per cubic meter at night, according to Epelman. The EC's recommended limit for a 24-hour period is 1 gram per cubic meter.

Lead's toxic effects are compounded by problems symptomatic of developing countries. *"Because of the narrow streets and overcrowding in urban areas, because of the prevalence of contaminated dusts both indoor and outdoor, because of poor nutrition and health, poor hygienic conditions and the preponderance of pregnant women and children, the populations of developing countries are much more susceptible to the hazards of environmental lead contamination,"* explains Nriagu.

Debate has raged for decades over the source of childhood lead poisoning. While gasoline additive is not the only source of 80 to 90 percent of all environmental lead contamination, according to North Carolina epidemiologist Dr. Carl Shy who studied the problem for the World Health Organisation. In the U.S., study after study after study has shown correlations between exposure to gasoline lead and high blood lead levels.

In Mexico, where blood lead levels are among the highest in the world, the problem is compounded by the centuries-old practice of using lead salts for pottery glazing. But with Mexico using almost seven percent of the world's TEL in its cars, many suspect gasoline lead as a major culprit as well. Earlier this year, Dr. Eduardo Palazuelos of the American British Cowdry Hospital and three colleagues from Mexico City's Public Health Department finally documented this suspicion: children who live near busy streets have higher blood lead levels and are more likely to suffer neuropsychological and behavioural impairment.

If putting lead in gasoline is, as Dr. Shy has written, "the mistake of the twentieth century, *"why is so much of the world still doing it?"* The answer is technical, political, and, most of all, economic.

TEL was invented and first marketed in 1924, when the U.S. auto industry was at a crossroads. The choice was between relatively small, efficient engines relying on higher grade gasoline, and larger, high compression engines requiring TEL, an octane boosting additive. The first 18 months of TEL production, in 1924-25, were telling: At least eight workers died and at least 300 others were poisoned from exposure to lead fumes at Du Pont's Chambers Works, New Jersey plant. (Twelve years later, in 1936, the company explained in its annual report that the lead poisoning deaths were the *"slow and gradual toll humanity has always paid, and perhaps must always pay, for the conquest of new ground."*)

In response, more stringent workplace regulations were imposed, but experts continued to warn of public health consequences from TEL use. Dr. Alice Hamilton, one of the country's foremost experts on lead at the time, doubted that the public could be protected from widespread dispersion of lead into the environment. She said, *"You may control the conditions within a factory, but how are you going to control the whole country?"* Her

arguments seen persuasive now, but a heavy propaganda assault from industry -- Ethyl, for example, proclaimed TEL "a gift from God" -- carried the day and industry began widespread marketing of TEL. By the 1970s, its world consumption reached 350,000 tons per year (270,000 tons in the U.S. alone), making it one of the largest volume chemicals produced. Air lead levels in U.S. cities reached staggering levels, and dangerously elevated blood lead levels in children became common.

But as lead's threat to health became more widely documented, as modern gasoline refining techniques and alternative octane boosters became available, and as catalytic converters became required in cars, leaded gasoline virtually disappeared from Japan, Canada, Australia, and the United States. Worldwide, the TEL market is declining by about 10 percent annually; however, much of that decline is in Europe. Most of the rest of the world still relies on leaded fuel. And they buy the lead additive from the big three TEL manufacturers - either U.K. - owned OCTEL, U.S. - owned Ethyl (whose lead manufacturing plant is in Canada), or U.S. - owned Du Pont's joint venture with Penex - TEMSA - in Mexico. (OCTEL and Ethyl sell TEL all over the world, while TEMSA markets its TEL in Mexico and the rest of Latin America.)

The manufacturers justify the continued marketing TEL with an arrogant denial that leaded gasoline cause damage to children. Floyd Gottwald, CEO of Ethyl, claims that "*no conclusive scientific evidence has ever linked the use of lead in gasoline to human health problems.*"

While almost no one outside the industry agrees with Gottwald, the fact is that the removal of lead from gasoline requires capital investment for refinery modernisation and higher operating costs. Joel Schwartz, senior scientist at EPA, estimates that it costs two and a half to three cents more per gallon to use unleaded gas and still produce high octane fuel. Thus, the poorer the country, the more likely it is to continue to use leaded gasoline.

But the benefits of removing lead make those three cents a gallon seem unimportant. In the U.S., the decline in the use of leaded gas has had "a fantastic effect on children," according to long-time lead researcher Dr. Sergio Piomelli, a hematologist at Columbia's Children's Hospital. Before the phaseout of lead, 30,000 out of 100,000 New York City children tested had elevated blood lead levels; after the phaseout, only 1,500 out of 100,000 had similarly high blood lead levels.

Convinced by the success of North America's switch to unleaded, some countries in Latin America are now beginning to look at measures to stop the lead attack on their children. Mexico, with perhaps the worst problem in the hemisphere, has reduced the lead content of its gasoline drastically since 1980. In Argentina, Greenpeace's Epelman has called on the government to prohibit the import of TEL and other hazardous products, and has put together a plan for the phaseout of leaded gasoline by 1996. Epelman calls his country's adoption of leaded gasoline technology "a tragedy," but is hopeful because there is no technological impediment to the phaseout.

* Note that these and subsequent figures should probably be expressed in microgrammes per cubic metre

APPENDIX 2

Rick Crawford AARNET NEWS, 19 October 1991 sci. environment: 5641

Crawford referenced above gives a number of references to lead poisoning from US sources.

"California finds that lead may affect 1 of 5 children". New York Times v140 (Tue, Sept 3, 1991):B8(N), C10(L)

"Lead and your kids; public-health officials say lead is the No. 1 environmental threat to children - whether they live in public housing or neat suburban homes" - Waldman, Steven. (Cover Story) Newsweek v118, n3 (July 15, 1991):42

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