SUSTAINABILITY, ENGINEERING, AND AUSTRALIAN ACADEME

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The engineering profession, including engineering academics, still has a long way to go in reconciling our present approaches to technology with the competing demands of economic development, social equity and sustainability. After reviewing some of the problems associated with the term "sustainability," and the limited progress made so far in Australia in coming to terms with the challenges it poses, this paper goes on to record and then reflect on the current processes of change in engineering in Australia, and in particular to discuss how Australian academics have attempted to deal with the issues. Experiences at the University of Technology, Sydney, are used to illustrate initiatives being developed to broaden the discourse of engineering to assist and encourage future engineers to take a role in framing as well as solving problems. The paper argues that broadening the discourse so that engineers expect to work cooperatively with those in other disciplines on the problems of development, equity, and sustainability is essential for the future of engineering education. It is also a prerequisite for these issues being addressed effectively.

INTRODUCTION

Technologies conceived and developed with sustainability and equity included among the design criteria are an essential part of practical moves towards sustainable development. My own personal and professional concerns are centered on the aspects of this process concerned with engineering practice and engineering education and the ways they both need to change to support moves towards sustainability.

Engineers have key roles in wealth creation and in innovation. However, the way they work is limited by the current discourse of their profession. This discourse emphasizes problem solving, but fails to include responsibility to involve the community in framing the problems. It does not even give engineers a role in framing the problems they are expected to address.

The education of technical professionals draws, often unconsciously, on the prevailing discourses surrounding science, technology, and society. As I have discussed elsewhere, shortcomings in discourse formation have limited the effectiveness of engineering education in making students aware of the social impacts of their chosen profession and in preparing them to deal with these impacts. Engineering education needs to encourage engineers to appreciate the social, economic, political, and environmental effects of the technologies they develop. Change is certainly occurring in engineering education in Australia, and at quite a rapid pace. It is imperative, however, that we take time to reflect on some of these changes, especially in terms of how the discourse itself allows and supports them (Johnston, *et al*., 1995a, 1995b, 1996).

Sustainability is one issue which is increasingly claimed to be shaping engineering education in Australia, but a great deal of confusion about sustainability is also evident. There is clearly a need to explore the shared understandings (if any) which inform this development, to examine the extent to which they are based on pedagogic or other arguments, and to determine precisely how sustainability is to be integrated into professional engineering education. This paper is an attempt to contribute to that process.

SOME DEFINITIONS

There is not a consensus on the relationships between technology, economic development and sustainability, or even on the significance of the most commonly used term in this area, "sustainable development." The Macquarie dictionary, the standard Australian reference, defines sustainable development as: "economic development designed to meet present needs while also taking into account future costs, including costs to the environment and depletion of natural resources." This definition raises as many questions as it answers. In economically developed countries, are we actually talking about "needs" or "wants"? Even where environmental costs are taken into account, this will not necessarily prevent the destruction of a particular environment or habitat, although it will be less likely to happen in an offhand or uninformed way. Public visibility and accountability are important drivers.

Cuello Nieto and Durbin (1995) discuss approaches to the concept of "sustainability." These approaches vary widely. Some see sustainability as vitally

important, and as being about maintaining the integrity of nature's processes, cycles, and rhythms. In this biocentric view, human life is seen as only a part of the whole system of life, and a major focus is on saving Planet Earth, avoiding catastrophes that would seriously damage the earth's ability to regenerate itself. More human-centered approaches focus on maintaining the quality of human life, and are more prepared to trade off the interests of other species. At the other end of the spectrum are those who regard technological development as problematic and see sustainability simply as a utopian idea, even a reactionary myth.

Cuello Nieto and Durbin go on to show that "sustainable development" is an equally contested term, with a variety of emphases and interpretations. Part of the difficulty is in the differences in environmental objectives between developed and developing countries. Some economists in developed countries see no insuperable difficulties with sustainable development. However, in emphasizing the substitutability of one resource for another, their approaches play down the significance of the uniqueness of localities and life forms.

In developing countries, the issue is more of people meeting their basic needs, and sustainable development is about economic productivity being maintained, regardless of social upheavals and population growth. This implies that poor people must be involved in meeting their own aspirations, in turn requiring political changes at local, national, and international levels. The importance of political issues is demonstrated by the experience of non-government aid organizations like APACE (Appropriate Technology for Community and the Environment) in the Solomon Islands, which shows that political and social climate is just as important to village development as getting the technical matters right (Waddell, 1993).

In this confusion of views, it is not surprising that official and semi-official bodies have tended to look to the Brundtland Report (UNCED, 1987), a practical document which sought to develop realistic inter- governmental policy approaches to sustainability and sustainable development. It called for overriding priority to be given to "needs," particularly the essential needs of the world's poor.

One major contributor to the sustainable development debate in Australia warns that national policy development may accept "the traditional frameworks of

business activity, the priority of economic goals over environmental goals, and the primacy of existing social or political structures, institutions and goals" (Beder, 1996, p. xvii). Beder goes on to question whether, under such circumstances, ecologically sustainable development (ESD) is an oxymoron, or even a Trojan horse, since, if the ESD rhetoric comes to be interpreted as meaning that development generally is and will continue to be "sustainable," this may give the green light for unfettered development. The issues have not been adequately explored in a systematic way in the public debate on sustainability, perhaps partly because we have not yet learned to express the problems concretely enough for the general public to follow. We may need to invent something like a "tree index," to give a practical measure of how many extra "international standard trees" it would take to absorb the fossil fuel carbon dioxide which typical Australian lifestyles generate.

Part of the reason for a very limited critique of notions of sustainability is that, as suggested above, there has been little real questioning of the expectation of continuing growth. This is not too surprising, given a global industrial capitalist economy predicated on growth. As long as growth can be assumed to continue indefinitely, questions of equity may not be seen as urgent, since the "trickle down" theory suggests that improvements will eventually reach the poor. Trickle down theory may well be a comfort to the affluent in both rich and poor countries. If, however, depletion of resources is recognized as a major limitation, and the need for an end to growth is accepted, social equity rapidly emerges as critical. This puts the issues sharply into the political sphere, for which engineers have not traditionally been adequately prepared and where they are commonly uncomfortable. Changes in engineering education need to address this situation too.

AUSTRALIA AND SUSTAINABILITY

By 1991 Australia had made a promising start towards developing sustainability policies in a broadly consultative way. The official government approach at the national level was based on the detailed analysis of specific industry sectors, and provided a solid base for policy development (Commonwealth of Australia, 1991). Unhappily, the process did not lead to practical policy outcomes. The conservation groups involved believe that this was because the process was undermined by the federal bureaucracy. Neither the

previous social democratic nor the current conservative national government has provided practical leadership on sustainability issues. The refusal to address the issue of greenhouse gas emissions is perhaps the most dramatic example of this failure. At a national level, neither the potential for international opprobrium, nor arguments that efficiency savings would significantly exceed costs, seems to carry sufficient weight so far.

The picture at State level is somewhat brighter. For example, the reform of the electricity generation industry in New South Wales has led to more sustainable options being made available by particular energy suppliers. For a modest premium, customers in some areas can choose to purchase power from environmentally friendly sources. Methane gas given off by garbage at landfill sites is being collected for use in electricity generation. Cogeneration, and moves towards using gas turbines rather than coal fired units, are making a contribution. Attention is also being paid to increasing the efficiency of electricity consumption as well as generation. Such successes should not, however, be read as real political commitment to sustainability.

The difficulties need to be acknowledged. Australia is a dry continent, with more than one third of the country receiving less than 200 mm mean annual rainfall, and less than one third receiving more than 500 mm. The Murray/Darling river system is the fourth largest in the world, draining one seventh of the continent, but its outflow into the sea is a trickle across a beach, a few hundred millimeters deep and a few meters wide. Hydro-power potential is therefore rather limited. The larger sites which are both economically and environmentally acceptable have already been developed. So have some sites which generated considerable opposition. Wind and solar power offer real possibilities, and photovoltaic cell research at the University of New South Wales leads the world. However, turning promising research outcomes into innovations has not generally been done within Australia. In any case, Australian research and development spending has historically been low, particularly in the private sector, probably reflecting the relatively small size of locally owned firms and the tendency for overseas-owned firms to do their research in their home countries. Concessional government financing schemes can play an important role in assisting local firms to establish the international profile necessary to operate on a commercial scale, but in the recent climate of budget austerity, policy movement has actually been towards a reduction in this sort of support (Bygraves, 1996).

Australia is a major exporter of primary energy products. Our major energy reserves are in coal, natural gas, and uranium. This presents some dilemmas relating to sustainability which go to the heart of the sustainability agenda. What attitudes should we adopt to exporting fossil fuels to our neighbors like Indonesia and Thailand? Coal burned in thermal power stations produces greenhouse gases and contributes to rises in sea level. Should we refuse to export it? How much responsibility should be accepted, respectively, by the buyers and the sellers of such fuels? Despite significant energy and other resource costs in mining, milling, and building the nuclear power plants to use it, uranium may reduce greenhouse emissions. However, the potential disasters associated with its use cannot and should not be ignored. Nuclear power generation demands a very high level of technical infrastructure and is only suitable for large scale centralized electricity production, so it does not generally address energy needs at the village level. Several promising photovoltaic initiatives for rural areas in Indonesia, India and the Philippines, which would have addressed these needs, have been delayed or cancelled as a result of recent changes in Australian government policies (Bygraves,1996). Elsewhere in our region of the globe, the Pol Pot approach, of rejecting technology, turned out to be even more appalling.

ENGINEERING AND SUSTAINABILITY

Some of the issues may seem simple, but acceptable answers to them will not be. Engineers will need to play central roles in developing acceptable technical solutions, where these are what is required. Educating a new generation of engineers who recognize the importance of sustainability and are able and willing, in cooperation with people from a variety of other disciplines, to grapple with them, is a major challenge for engineering educators around the world. Such engineering graduates are needed for the wider discussions which will eventually define what needs to be done. They will have an essential role in ensuring that, where technical goals are eventually set, they are technically sound and realistically achievable. Without such engineers, sustainability will indeed be a cruel myth.

Within the technical community in Australia, in practice the terms "environmentally friendly" and "sustainable" have commonly been used as if they meant the same thing. In the author's view, this reflects the fact that the local discourses of engineering education and engineering practice have generally been

rather narrowly technical, with political, social, and cultural aspects of engineering largely ignored.

The focus of debate so far has been on what, in common with many engineers, I call "no regrets" options, such as increasing efficiency and reducing waste outputs. They are "no regrets" because adopting them actually reduces costs or increases the profitability of operations. The move towards "cleaner manufacturing" is an important example. Such options ought to be introduced regardless of environmental and sustainability concerns, yet even acceptance of these changes cannot be taken for granted. A promising recent development is the sponsorship of some demonstration projects in these areas by Australian state and national environmental protection agencies.

The more difficult policy areas are those where sustainable approaches may actually cost more to implement than our present ones. The currently popular political rhetoric, based in economic rationalism, is to reduce the role of government and to lower taxes. "Smaller government" is asserted to leave taxpayers with more money in their pockets, but it also makes it more difficult to implement and maintain socially and environmentally desirable projects like pleasant and effective public facilities, including transport. It may also reduce the level and effectiveness of desirable government planning and control. The associated reduction in the social wage leads us into situations of "private affluence and public squalor," situations which reduce the conviviality of society. This rhetoric also tends to substitute "standard of living" (rate of consumption of resources) for "quality of life" (satisfaction of human social and other needs), and makes the idea of reducing resource consumption more difficult to promote.

Of course, even if most of the world can be convinced that sustainability needs to be embraced—and the attitudinal change is probably as radical as that associated with the historical abolition of slavery—without a parallel acceptance of the importance of equity considerations, the outcomes will not necessarily be positive. Generosity and enlightened self-interest do not universally characterize powerful decision makers. The outcomes could well consist of variations on "buying a place in the capsule for me and my descendants." Wars for access to scarce resources are not unknown.

I personally do not see how engineering educators can do anything but try

to proceed in good faith, and with optimism about the inherent goodness of human nature, but we do need to keep our eyes open. The perspectives individual participants bring to these debates are shaped by their own background and experiences, and affect the way they formulate and address questions of sustainability. My own situation is that, as a design engineer turned mechanical engineering academic, I became interested in the politics and economics of development. In 1975 I spent a year on secondment to the government of a developing country, Papua New Guinea, grappling with the problems of rationalizing the importation and provision for technical support for mechanical and electrical equipment, including motor vehicles. On my return to academia I introduced an elective subject, Appropriate Technology, which encouraged engineering students to explore criteria for and implications of technological choices. I encouraged students to look at Australian issues in a new and different way, to locate them within a global perspective which took account of development, technical and social equity concerns.

In 1980 a group of us introduced a new core subject, Engineering and Society, into the Mechanical Engineering degree. The subject was a broad exploration of the history of engineering, its social location, the significance and roles of engineers, and the socialization and acculturation of engineering professionals in modern Australia. We have also used it to encourage students to think in a positive and structured way about ethical and futures issues (McGregor, 1995). The subject led in turn to a textbook which critically explored these issues (Johnston, *et al.*, 1995a). This background has informed my interest in the philosophy of technology (and more specifically of engineering) and the beginnings of an analytical approach to long-term questions of sustainability.

As I have been to some extent a pioneer in this area of engineering education in Australia, I am very much aware that many people see technology, and engineering in particular, as part of the problems, rather than as an essential element in grappling with them. There are elements of truth in both perspectives. When we look closely at engineers and the technologies they develop, we find pressures acting in two different directions.

The first is their role in innovation, bringing new products, services, processes and systems into commercial being. New products and services create new jobs. There are important questions as to whether innovation increases or

reduces social equity and demands on resources. The answers commonly depend on the design criteria. There are important roles here for tough and informed customers and regulators, to ensure that design outcomes are as sustainable as is realistic with the technologies available, and that effort is focused on developing these technologies in the direction of sustainability.

A second role for engineers has been to increase the productivity of labor. Broadly, this means some combination of reducing the number of jobs and increasing output. We have the potential to ensure that the basic needs of all the people of the Earth are met. Engineers have been very successful at increasing productivity (although not necessarily in sustainable ways). Increased productivity means either that the same amount of goods or services can be produced by fewer workers (so, unless we are prepared to reduce working hours, some will be laid off), or that the same number of workers can produce more (implying increased resource consumption). A problem here is that equitable distribution of products is essentially seen as a political question, and therefore one which lies outside the discourse of engineering (which is centered on production). Given that wages are the major mechanism for distribution of the benefits of production to workers,increased productivity has the potential to increase social inequality and/or consumption. Neither outcome is supportive of sustainability.

Engineers have generally been happy to accept and recognize the first of these roles although, as discussed elsewhere (Johnston,*et al*., 1996), a major limitation of the current discourse of engineering is that engineers expect to solve the problems, but not to frame them. The second role is a much less comfortable one. Some of our students (and colleagues) refuse to acknowledge it, but it is critical to sustainability.

Three recent developments illustrate how attempts are being made within Australian engineering and academe to incorporate the wider community debate on sustainability into our engineering education discourse. I believe our experience may well be a microcosm of how sustainability issues are being teased out, interpreted, adapted, and assimilated in many other discourses, particularly those related to technology and to the economy, in many other parts of the world; they may serve to highlight widespread deficiencies and equivocations, as well as providing some examples of genuine efforts to grapple with the issues.

NATIONAL REVIEW OF ENGINEERING EDUCATION IN AUSTRALIA

If one looks first of all to see what support has been given to sustainability by the engineering profession in Australia (an example, if you like, of the Technology/Sustainability nexus), a significant element in the recent discussion has been the National Review of Engineering Education. Initiated in late 1994, the review was sponsored by the three major professional and educational groups—the Australian Academy of Technological Sciences and Engineering (ATSE), the Institution of Engineers (Australia) (IEAust) and the Deans of the Australian Faculties of Engineering—and supported by the national government.

The review was timely, in that there were recognized problems in engineering education, and a need for leadership to help to decide on and implement significant changes. In fact, a real crisis seems to have been emerging. As mentioned above, professional engineering education in Australia has been criticized over the last decade as being too heavily oriented towards engineering science and too little concerned with professional development issues—there is a widespread perception that engineers (and other technologists) are not interested in the social impacts of their work. This has resulted in, or at least coincided with, a sharp drop in interest by university entrants in practically all disciplines associated with the physical sciences. Demand by school leavers for entry to engineering undergraduate courses has declined steadily over recent years; in 1996 most engineering schools lowered their entry requirements and still failed to attract enough new students to fill the allocated places. The National Review of Engineering Education was intended to present recommendations aimed at reversing this decline.

The urgency of the present debates on engineering education has also been sharpened by cuts to basic funding for universities in Australia (effectively 10 to 20 percent over the next few years) and by the fact that this problem is not limited to Australia. In much, although not all, of the English-speaking world, engineering and engineering education are under challenge and are seeking to redefine themselves in ways which are more inclusive and more deliberately engaged with broad social and environmental concerns. To cope with these challenges, Australian universities simultaneously have to broaden the appeal of their engineering courses, reduce the cost of running them, and prepare for international competition from other providers of education in flexible and

distance modes. Much was expected of the first Exposure Draft for public comment (IEAust, 1996a) which appeared in August 1996. It met with a very critical reception.

Despite its limitations, the draft included a major recommendation that the concept of sustainability must be recognized as central to engineering practice, and that consideration of sustainability issues should permeate engineering education at all levels. The definition of sustainability used in the draft was one previously adopted by the Academy (ATSE). While it provided a realistic starting point for discussion and subsequent action, this was rather a minimalist definition, drawn essentially from the Brundtland Report. Rather than focusing strongly on issues such as equity, biodiversity, or the maintenance of natural capital, it stressed the desirability of sustainable development in terms of "meeting the present needs of humanity without compromising the ability of future generations to meet their own needs," and implied that this could only be achieved in a socially, economically, and ecologically sustainable environment. It went on to comment in its Guiding Principles for Sustainable Development and Engineering Education:

—Engineering education has to prepare young engineers to accept sustainability as a basic design requirement for the development of products and processes and as a basic policy criterion for future industrial developments; it has to provide the older generation of engineers and scientists with a reformation process in order to adjust to a technology that is in harmony with the environment and to adapt the profit principle to this situation.

—Sustainability involves many disciplines, hence there is a need to broaden the horizons of conventional engineering education. It is therefore necessary to introduce environmental science into the conventional engineering curricula as part of the current subjects; expand the basis for conventional engineering education by introducing relevant subjects from other disciplines such as the social sciences, environmental architecture, economics, law, and environmental politics; introduce life cycle analysis and design as the basis for sustainable engineering practice; adapt conventional economics and traditional systems analysis and ensure that the future is not devalued and inter-generational equity is preserved, as well as consider moving from a technological to a knowledge/information based economy (ATSE, 1996).

The Australian Academy (and hence the National Review of Engineering Education) also accept that:

—There is a very important need to move beyond just environmental engineering and science and it is necessary to provide for a consideration of political implications and the social impact of sustainability.

—In many practical situations non-technical and non-scientific factors dominate the final outcome of developmental decisions. Engineers and scientists have to be trained to face up to this by an exposure to social and political sciences as part of a broader educational base. The capacity of communication in a social and political environment has become a vital factor if engineers and scientists want to remain relevant in society (ATSE, 1996).

—Independently of the National Review, the Academy also encouraged attention to ecologically sustainable development (ESD) issues in undergraduate engineering courses throughout Australia by running an e-mail / world-wide-web survey of the percentage of such courses devoted to ESD issues. Linked to the survey document on the web was the statement quoted in part above.

So what does all this really signify? My own view is that, given the general recognition that engineering education has very real problems, the review was desperately looking for solutions and seized on sustainability as a possible lifeline. The rationale for this is not hard to discover; in fact the University of Technology/Sydney/Engineering Faculty (and the author) furnished some of the arguments. We believe that a focus on sustainability will be expected by an increasing proportion of potential engineering students, particularly students with less traditional approaches to the profession. This includes students who expect that problems and issues will be situated in their broader contexts; and we are targeting women in particular.

Byrne (1993, p. 16) discusses the widespread perception of science and technology as male areas. She notes that three aspects of this perception have been highlighted in the literature:

1. The perception of science as a male area by adolescents and young adults which filters young females out from an unconditioned choice).

2. The actual male-dominance of science and technology in terms of the participation of teachers, learners and producers.

3. The construction and design of science in disciplines on a paradigm seen as male, patriarchal, and instrumental (which is described by some as creating an inappropriate teaching/learning environment for females and many males).

In our UTS engineering promotional literature and in our annual Women in Engineering seminars, which are aimed at encouraging female senior school students to consider careers in engineering and applied science, the most recent themes have been Appropriate Technology and Engineering for a Sustainable Future. The feedback has indicated that they have been well received, and the review acknowledged this.

However, in the way it took up some of these arguments, the National Review may well have done a profound disservice, not only to the pro-sustainability camp, but also to the engineering profession as a whole, which it claims to represent. This is because it failed to analyze sustainability (or most other issues, for that matter) in any depth. Instead, what was presented in the Draft Exposure Report looked suspiciously like lip service and platitudes. This was one reason why the draft was so disappointing; unless it was extensively rewritten, solutions to the crisis in engineering education would need to be found elsewhere.

Of more immediate relevance to this paper, however, the real danger was not that the report might trivialize or stifle the debate on sustainability, serious though this outcome would be. It was rather that the engineering profession itself needs to demonstrate the ability to present well-reasoned, cogent positions on sustainability. As I have argued above, engineers really are necessary to make sustainability work—however reluctant they and the rest of the community may beto accept the need for their contribution.

The final version of the report (IEAust, 1996b) was in fact extensively rewritten from the Exposure Draft, on which it was a very significant improvement. Even so, the lack of continuity and coherence in the review process itself did tend to show through in volume 1, the report itself. This formal report

was significantly enriched by the material in volume 2, which included summaries of the work of the task forces, the ATSE Report on Engineering Education and Sustainable Development mentioned earlier. Volume 2 also included the excellent National Position Paper for Women in Engineering, developed in parallel with the review process. This position paper summarizes for me the sorts of cultural changes which need to take place in engineering education and practice to underpin sustainable practice, changes which I believe have been encouraged by many aspects of the review process, particularly the extensive consultation and discussion it encouraged.

REVIEW OF THE ENGINEERING FACULTY AT UTS

While the National Review was under way, it is perhaps not surprising that we at UTS were looking closely at our own backyard. In 1996 our Engineering Faculty was the subject of a seven-yearly internal Developmental Review. I will discuss briefly some of the changes we are making, changes which have been shaped to some extent by these two review processes. I will also explore some of the understandings these processes display of the discourse of engineering and, in particular, how we will take up issues of development, social equity, and sustainability. This discussion should help to bring into sharp focus some of the approaches being adopted "on the ground" and to illustrate the complexities of incorporating sustainability issues into academe.

The faculty review was carried out by a small invited team of people, mostly from outside the university. The team included, as an international member, Eleanor Baum, the Dean of Engineering at Cooper Union, a small but distinguished university in New York. Professor Baum was recently president of the American Society for Engineering Education and chaired a U.S. inquiry into engineering education. The review panel was chaired by a retired vice-chancellor (university president), and included two experienced engineers from Australian industry as well as an associate dean from another Faculty at UTS.

A factor which made our review particularly timely was that the faculty leadership had for some time been developing a restructuring proposal to eliminate the division into three undergraduate schools and to implement a single, faculty-wide, undergraduate degree program. We were keen to remove the artificial barriers between the undergraduate courses across the faculty, and to

refocus early stage teaching on generic aspects of engineering. Among the objections raised to the latter change was the question as to whether the different engineering disciplines in the faculty did in fact share a common intellectual core. This is a question which goes to the heart of the problem as to whether there is a common discourse of engineering. The author is part of a group which reached some preliminary positive conclusions, presented at the 1995 Society for Philosophy and Technology conference (Johnston, *et al.*, 1996). We are continuing to explore these issues.

The next step was that, during the later part of 1996 and the first half of 1997, all the undergraduate programs in the faculty were reviewed and the syllabuses for most individual subjects rewritten, for progressive introduction from 1998. The new engineering undergraduate degree structure has a common core across the faculty of mathematics, engineering science, and professional orientation material. There is also a generous allowance for electives, freely chosen from programs across the university (and even outside it). Individual degree programs are distinguished by Field of Practice material in specific disciplinary areas including Civil, Computer Systems, Electrical, Environmental, Manufacturing, Mechanical, and Telecommunications Engineering.

The author's view (which is not universally shared in the faculty) is that an essential direction for change in the work of the faculty must be towards a focus on sustainable futures. My input to the review process has been as a change agent among staff and I have specifically sought to generate support for a greater focus on sustainability. It is my strong desire that, for example, Environmental Engineering should be available in combination with any of the other majors.

Why are we making such extensive changes? Partly for educational reasons, to reduce overloading in the present programs and to increase students' responsibility for their own learning. The other main reason for the changes is that they should allow the faculty and the university to survive the planned government funding cuts which I mentioned earlier. In the change process we will be looking to substantially reduce face to face teaching and to move towards more flexible and student-driven learning approaches. However, one may well then ask: where, among all these rather pragmatic considerations, can one discern a philosophical commitment to sustainability? Am I, myself, just an engineering academic who is prepared to use sustainability as a convenient peg on which to

hang some quite unrelated decision-making? Are we, at least partly in the name of sustainability, taking all sorts of actions which cannot be shown to be grounded in any sort of genuine belief in sustainability, or even to arise logically from the fact that there is a recognition (at least on the part of some engineering academics) of the need to make all the academic programs in the new structure responsive to the need for engineering to focus on sustainability? In other words, is sustainability once again being seen as the solution to a quite different set of problems?

Interestingly, while most of my colleagues are generally comfortable with using the term "sustainability" in our promotional activities, we do not feel that its inclusion in our formal degree course titles would be particularly attractive to our potential student intake. Instead, we use the term "environmental" to indicate our broader and more sustainable approach. In the new faculty structure there is a scholarly and research grouping of staff whose academic interests center on environmental engineering. In practice they come mostly from what was the School of Civil Engineering. They share a focus on waste water and its treatment, and on handling solid waste. For Mechanical Engineering, the sustainability emphasis will need to be mainly in areas like combustion and air pollution, cleaner manufacturing, and the minimization and appropriate handling of solid waste. Attention to energy and other resources and their efficient utilization moves the focus more towards sustainability. Cleaner manufacturing, efficient use of energy, and the use of renewable energy sources are all relevant to Electrical Engineering, which already has a strong research, development, and commercialization focus on high-efficiency electric motors, using rare-earth permanent magnets.

A shift in title, to include Environmental Engineering, has already proved popular. In 1994, Civil and Environmental Engineering was offered for the first time at UTS; the incoming group had a particularly high matriculation performance, and 50% were female. Subsequent groups look like stabilizing at around one third. This compares very well with the average across the more traditional offerings of the faculty, around 8% to 10% of females. Cynical male academics may be more impressed by these numbers issues than by cogent arguments based on broad policy issues.

However, this does reinforce two points I raised earlier, viz. the contested nature of the term "sustainability" and the lack of engagement with and

understanding of it. Engineering discourse has apparently failed to distinguish properly between the two terms. Whenever we use "environmental" to stand for all the positive and untroubling aspects of sustainability, we are making it more difficult to achieve a shared set of understandings within our own discourse, let alone in a wider context.

How ought sustainability issues actually be addressed in curricula across our restructured Faculty of Engineering? Should they be included as part of most or all of the subjects offered, or be treated in special subjects? In my view, both approaches need to be used. Sustainability has to be a consideration in every subject, and it also needs to be recognized as a specific issue in its own right. As the ATSE statement quoted above recognized, for this approach to be effective, students will need to be encouraged to take a broad approach to problems, rather than focusing narrowly on the technical issues. Our graduates will need to be politically astute enough to adopt and implement principled as well as technically well-founded approaches. Where necessary and appropriate, they will need to be able to convince both colleagues and employers that their approaches to framing and solving problems make good sense. A major challenge in all this is that they must still be able to solve the technical problems well. Finally, to labor my point somewhat, they must accept their responsibility for ensuring that sustainability will work for society as a whole. If we can achieve this, in the short term we can certainly live with calling such programs Environmental Engineering. It is encouraging to note that many of the best students in these courses are already pressing for the programs to become more focused on sustainability.

ESTABLISHING AN INSTITUTE FOR SUSTAINABLE FUTURES AT UTS

The third development which I would like to mention here is that in 1996 UTS established an Institute for Sustainable Futures. The published objectives of this institute are to:

1. undertake and promote scholarly activity and research. . . towards the identification of sustainable futures;
2. foster public debate on issues relating to sustainable futures for Australia and the world;
3. conduct research and consultancy work concerned with improving the quality of life of all social groups in

ecologically and socially sustainable ways;

4. advise on the development of curricula at UTS to ensure that UTS graduates are alert to issues of economic, social and ecological sustainability.

The vision for the institute is for it to become a leading Australian research center on sustainability issues. It is also seen as having a major role in support of networking and inter- and multi-disciplinary cooperation across the university in pursuit of its objectives. His perceived ability and willingness to encourage such cooperation was an element in the selection of its Foundation Director, Mark Diesendorf.

This development raised some very interesting broad issues about technology and sustainability. While a handful of staff in the Engineering Faculty at UTS could legitimately claim to have helped create the right climate of opinion and to have laid essential groundwork for the formation of such an institute, it was in fact championed by two individuals in the senior leadership of the university—a social scientist, and a science educator—and its new director was originally a mathematician. The whole process has been a deliberate effort both to broaden the debate about sustainability itself, and to encourage other professional discourses represented within academe to start to take serious note of sustainability issues.

An initiative which may help to build constructive and fruitful relationships between the Institute for Sustainable Futures and the rest of the university, and in particular with the Faculty of Engineering, is a new interdisciplinary subject,Technology, Society, and Change. Originated and championed by engineering staff, it has been adopted as an undergraduate elective, available across the university from the beginning of 1997. The institute has taken over responsibility for the subject, which is assessed as one quarter of a student's academic load for one semester. The material to be taught in Technology, Society, and Change, consists of three modules, each of which examines and illustrates the interdependence and tensions between society, technology, and change and will address one or more of the following questions in relation to their topic:

—How have different societies come to define and deal with risk? How are cost and benefit of society's risks determined? Who defines them; who

benefits, and who pays the cost?

—How have different societies valued and defined social justice? How are the tensions between technological and communal interests understood?

—How have different societies perceived progress? How have these perceptions shaped their past? How might they shape their future?

—How have different societies valued and striven for the sustainability of life on earth?

Initially the subject is an elective, but after experience is gained, it seems likely to be incorporated in the core of some programs. There were some interesting difficulties and sensitivities associated with the introduction of this subject, partly attributable to unsatisfactory experiences academics have had with subjects taught by outsiders who presumed to critique their specialist areas, and partly, in my view, reflecting the difficulty practitioners have in coming to terms with the fact that, in practice, no discipline is value-free. One Faculty (not engineering) has asked that the unit exploring the social implications and applications of techniques associated with its disciplinary area be rewritten; it also initially rejected the subject as an elective for its own students.

Engineering Faculty approval for the new subject was far from unanimous. One concern expressed was that critiques from outside the discipline would be seen by students simply as confrontational, and rejected by them. Such tensions are always likely to be associated with the introduction of interdisciplinary subjects. Just where such a subject (which approaches sustainability in a very different way) will eventually be perceived by engineering students as belonging is still a moot question. An important challenge will be for the academics involved in the subject to have a critical appreciation of the discourses of their own disciplines and be able to explore them constructively with a broad group of students.

CONCLUSION

This was initially a "work in progress" presentation and I am very conscious that I am still working through many of the issues. I have explored here

the way sustainability, engineering, and academe are currently interacting in Australia. I have looked particularly at what has been happening in my own faculty and university, both as a microcosm of the overall scene, and because I have the most detailed insight into it. I believe that the initiatives being taken within the faculty and across the university will not, on their own, solve the problems of moving towards sustainability, but they have started to raise awareness of the importance and urgency of the problems, and to give shape and focus to the ways in which we can move forward. For engineering students and staff they also encourage recognition of the need for engineers to be as involved in framing the problems as they are in solving them. They are immensely important in the discourse formation, without which further real progress is unlikely to occur.

One important part of the process of engineering education in general will be to offer subjects which allow students to explore the present and potential roles of their profession in improving society's record on sustainability. In doing so they will become more outward looking and try to address problems of the invisibility of engineering in public policy debates. Such debates are generally couched in terms of "science" and technology, with no specific recognition, let alone acknowledgment, that key roles in any real moves towards sustainability will need to be played by engineers and engineering. One expectation from more broadly educated and outward-looking engineering graduates is that they will be able to participate more effectively in the wider community debate about sustainability, including political discussions about framing the problems to be solved, as well as being involved in their actual solution. At present, engineers tend to accept relatively minor roles and responsibilities in setting the criteria for the projects they undertake, in fact, with the trend towards increasing product liability litigation, the rhetoric is changing from "engineers produce solutions" to "engineers offer options and alternatives." As long as the main driver for innovation in our capitalist society is the desire to make a profit, and as long as product criteria are framed in terms of marketability rather than sustainability, we will continue to have a long way to go.

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