Multidisciplinary education and research in science, technology and engineering to underpin environmentally sustainable development

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Abstract

Environmentally sustainable development (ESD) will be achieved by harmonising socio-political and economic goals with technologies and systems that are focussed on minimising environmental impacts. Universities have key roles to provide education for professionals working in ESD and related research.

The paper describes how the University of South Australia is addressing ESD in education and research in the technological areas concerned with urban and regional planning and the implementation of physical infrastructure in built environments. The paper argues for multidisciplinary approaches and shows how a university can be an exemplar of environmentally sustainable operation.

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Introduction

Most nations, regions, and cities envision economic development as the key to attaining and sustaining desired levels of prosperity, health, and security for their people. Nevertheless, modern *homo sapiens* has, through the agricultural, industrial, and now globally-interconnected post-industrial, knowledge-based economic development, imposed progressively greater strain on all facets the natural environment (Pimm, 2001). Critical environmental changes, such as atmospheric greenhouse gas increases, soil degradation and desertification, fresh water depletion and biodiversity reduction on land and in the oceans, are matters of everyday debate. The era of cheap fossil fuel energy, the key driver of economic development, may be near its end (Heinberg, 2003). Arguably, understanding how environmentally sustainable development (ESD) can lie alongside economic and social development is increasingly important for policymakers and professionals responsible for the development and implementation of physical and biotechnical systems and products.

The advances in science and technology that will continue to underpin economic and social development and improvements in population health through well- engineered products, services, and infrastructure need to be applied with ever greater sensitivity and understanding of their impact on the natural and human environments. Since knowledge and understanding lie at the heart of intelligent action and decision-making, education and research are critical to ESD, and the world's universities have a special responsibility and opportunity to lead.

The University of South Australia (UniSA) has incorporated sustainability as a key theme in its academic profile and operational practices. The paper describes, in particular, how UniSA is developing and implementing the ESD theme in its education and research programs for technological professions that are responsible for planning and implementing the physical infrastructure of the built environment: civil engineering, planning, etc. An element of these developments is multi-disciplinarity: we anticipate better outcomes though through collaborative work among disciplines than through strictly disciplinary approaches, while acknowledging the importance of the latter to advance specific expertise. The paper concludes with some examples of how the university is underpinning ESD through improved practices in energy, water and waste management, and new building design.

South Australia and the University of South Australia

South Australia is a state of 1.5 million people within the Federation of Australia. The state has a diverse and progressive economy based on mineral resources, agricultural products, wine production, defence and electronic industries, manufacturing, arts and tourism and increasingly, international educational services. It is politically and socially stable, and most of its inhabitants enjoy high quality lifestyles. Nevertheless, the state operates with an ecological footprint (Loh, 2002) that is about four times the global mean value.

The state's critical long-term environmental problem is that its water supply from the inland river system is compromised by the results of extensive up-river farming irrigation in other states. The recognition and solution of this, and related land degradation problems are the subjects of systematic national action. Within South Australia there is considerable community support and specific government targets to significantly improve water re-use

and conservation, and to reduce energy, built-form and transport footprints (SA Government, 2004). Achieving such outcomes requires professionals to ensure, build, and maintain a high- quality built environment as well as encourage appropriate economic use and preservation of the natural environment.

The State's three universities support the economy and society through their education programs and research, although the Federal government provides most of the public funding for these activities. The University of South Australia (UniSA) is the youngest and largest of the three with approximately 32,000 students. About 10,500 of these are non-Australians, of which 7,000 are studying programs in countries outside Australia, predominantly in the Asian region.

The university has three parts to its mission:

- **Educating professionals** in the sciences, engineering and technology, built and natural environments, the health professions (other than medicine and dentistry), teacher education, social work, business and management, and journalism and creative arts.

- **Creating and applying knowledge** through research programs in selected areas and mostly in collaboration with industry and community stakeholders. UniSA has won national and international prominence in materials science, industrial and applied mathematics, pharmaceutical science, satellite communications systems, intelligent manufacturing, transport and planning, environmental modelling and remediation, social and economic science and sustainable tourism.

- **Serving the community** through work with the professions, and local, national, and international communities.

The university's coursework programs develop graduates with generic "graduate qualities" of discipline knowledge, communication skills, problem-solving, teamwork, and individual work capacity, understanding of ethics and international practice, and skills for life-long learning.

Since the mid-1990s the senior management team has undertaken strategic planning with its staff and external stakeholders to ensure that its academic profile (coursework programs and research) is positioned and its resources (staffing and infrastructure) are disposed to meet future needs and respond to changes in demands of local and international students, employers and industry partners. Two such exercises are relevant to the present discussion.

The university examined research priorities for science and technology in 1999, nominally with a horizon of 2015. The outcome is represented as "four pillars", as shown in FIGURE 1. Three of them, information and communication technology, materials and manufacturing, and health and biological sciences, were already well established. The fourth, environmental sciences, was assessed to be an emerging area in which we had scope to build much greater expertise. The model has assisted us to consolidate our expertise within the pillars themselves, and improve collaboration between the pillars to underpin emerging research areas, such as health informatics, and intelligent manufacturing. A similar exercise in the social sciences enunciated pillars in 2001, and the extended model has since contributed to the development of cross-disciplinary research programs across the whole university.

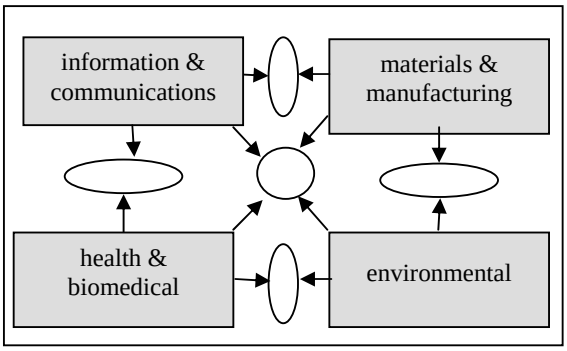

FIGURE 1 THE FOUR PILLARS OF UNISA'S SCIENCE AND TECHNOLOGY PROFILE INDICATING POTENTIAL

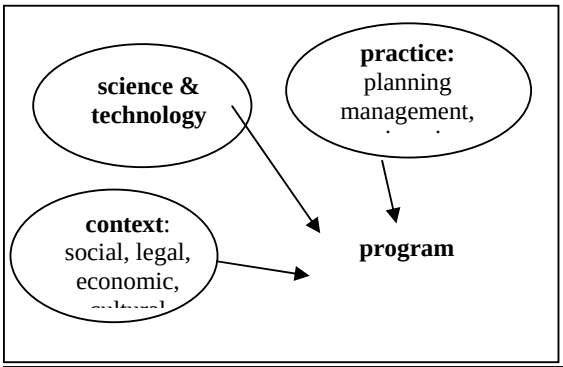

Figure 2
THREE DOMAINS OF DISCOURSE CONTRIBUTING TO MULTI-DISCIPLINARY EDUCATION AND RESEARCH PROGRAMS

The author uses these models to express how contemporary education in professional technological areas, such as engineering, and applied research, legitimately draws on three "domains of discourse:" the underlying science and technologies, the socio-economic context, and methodologies of practice, as depicted in FIGURE 2.

A university-wide planning activity in 2002 determined that the future academic profile should have an increasing emphasis on sustainability, healthy lifestyles. and modeling and managing complex systems. Here, "sustainability" embraces the so-called triple bottom line of economic, social, and environmental sustainability. These themes will be progressively embedded into the education programs that prepare professionals for practice, and will be developed in new programs, as described below.

Academic Structures and Coursework Programs in Areas of Sustainable Environments and Infrastructure

The university provides undergraduate programs for the professions that underpin the built environment: architecture; civil engineering; geoinformatics and surveying; construction

management and economics; environmental management; and urban and regional planning. The university also runs undergraduate programs in aspects of the natural environment: ecology, geology, and park conservation management. These largely separate programs characterise the disciplinary-specialised paradigm of the latter half of the 20th Century.

The need for specialisation can certainly be justified by the expectations of the community for specialist expertise built on the exponential growth of scientific knowledge, and deeper insights and interpretations of human behaviour, operating as both individuals and organizations. The public increasingly demands to be involved in decisions that affect its communities – especially in issues that affect the built and natural environment – and demand progressively higher levels of performance and accountability from governance boards and individuals in both private and public sectors. Discipline and professional specialisation provide much of the necessary assurance of competence. But interactions are also required between the professions to solve the many problems of environmentally sustainable development. Members of each professional area need to understand their working interfaces with others, and that working together can produce better outcomes than may otherwise be possible.

After an extensive and consultative review process in 2002-03, it was decided to create a single School of Natural and Built Environments from 2004 that encompasses most of the disciplines listed above. This, we believe, creates a much stronger academic foundation for coursework and research programs in areas of environmentally sustainable development. FIGURE 3 indicates the principal current and potential linkages between the disciplines within and outside the school, based on work undertaken by the review. Linkages take several forms: collaborative research; a core course provided by another discipline; or a collaborative program of courses from several disciplines.

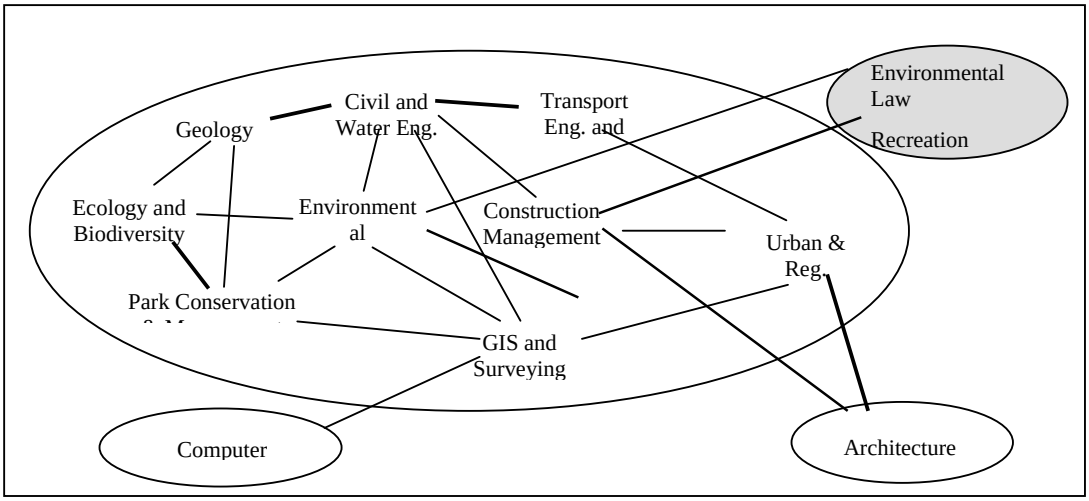

FIGURE 3 MAJOR EXISTING AND POTENTIAL LINKS BETWEEN DISCIPLINES IN UNISA'S SCHOOL OF NATURAL AND BUILT ENVIRONMENTS, AND SELECTED EXTERNAL LINKS TO OTHER SCHOOLS

With this structure, our intention is to develop coursework programs that equip graduate professionals with greater mutual understanding among their disciplines, in order to improve the performance of the multi-disciplinary teams that ultimately work on almost all major physical infrastructure projects and environmental planning issues. Such program changes will not be easily won, however. Program and course overlaps and potential program synergies must be identified and evaluated. Long-held perceptions of disciplinary differences must be explored and resolved, and trust and respect must be built among staff members. The latter point is particularly important since we hope to produce graduates – "new professionals" – who will ultimately bring their own expertise to operate on genuinely difficult problems in sustainable environmental planning and development. We want them to be able to understand and respect the genuinely held disparate perspectives of others on their team and in the communities they serve. Multidisciplinary project work with stakeholder engagement provides opportunities to bridge the educational divides that certainly exist between science, engineering and design, and social science and humanities approaches to knowledge and practice.

A good academic structure is desirable but is not sufficient to ensure good education in the sustainability issues relevant to any particular professional discipline. We have four approaches. Firstly, principles of sustainability are introduced early, particularly in courses that develop students' understanding of the scope, focus and methodologies of practice of their chosen profession. For example, the engineers can be introduced to sustainability with reference to the Engineers Australia Code of Ethics that includes clauses on sustainability and ethics. Secondly, we provide specific courses on technical ESD topics, such as embodied energy in buildings, and water resources management. Thirdly, we make extensive use of design projects within the curriculum that give students the chance to work directly on ESD topics. One particularly rich area of activity has been the industry-supported development of a solar-powered commuter car as a joint effort among industrial design students, engineers, and mathematicians. Fourthly, we are working towards implementing a number of interdisciplinary courses that form core or elective courses within a number of the programs.

We are also examining the development of courses in ESD that would be attractive as electives for all undergraduates, particularly those studying in non-technological ESD related professional areas. These courses will include a mix of economics, social-science and scientific and technological material presented without advanced mathematics.

Further, we are developing a framework for postgraduate courses and programs in environmental management with specialisations in environmental law and management, green economics, remediation, renewable energy, water, transport, planning and architecture and construction. Several elements of these specialisations already exist as short-courses for professionals working in government and industry, locally and internationally. They draw on expertise in the technological research areas described in the next section, and from the university's Hawke Institute for Sustainable Societies (Hawke Institute, 2004)

Collaborative and Multidisciplinary Research in Areas of ESD

In parallel with the coursework program development outlined above, the university is engaged in initiatives to develop a number of centres of expertise that can contribute to ESD through basic and applied research. These research centres operate across disciplines and work closely with industry and government agencies to address critical areas. They

provide research degrees, undertake contract research and consultancies, and develop and deliver short courses. Several are partners in national cooperative research centres, and undertake international projects. Three initiatives are outlined below.

Institute for Sustainable Systems and Technologies

Four well-established research centres in transport planning and engineering, sustainable energy, agricultural machinery design, and industrial and applied mathematics have recently come together to form an Institute for Sustainable Systems and Technologies with the mission "*To develop systems and technologies that will sustain ecosystems, facilitate social and economic development while optimising the use of natural resources, minimising waste, emissions and other environmental consequences and reducing cost"* (ISST, 2004). The formation of this institute has already shown how research collaboration between its parts can produce ultimately more sustainable solutions than would be likely otherwise, through, for example, taking established expertise in embodied energy modelling towards integrated design and assessment of comprehensive sustainable development.

Centre for Environmental Risk Assessment and Remediation

The second example is the university's Centre for Environmental Risk Assessment and Remediation (CERAR, 2004). Formed in 2003, this centre links expertise in bio- and geo-chemistry, contaminant chemistry, microbiology, ecotoxicology, environmental engineering and hydrogeology with environmental law and management to undertake research on human and ecological risk assessment and remediation of contaminated environments. Its research has demonstrated that bioavailability assessment for human health risk characterisation is more important than total contamination levels, since the contaminants present in a soil, dust, or food only pose risk to environmental and human health if the contaminant is available for uptake by receptor organisms.

CERAR researchers are now working closely with environmental regulators to transfer these findings into policies for adoption at the national level, with clear health, social and economic benefits to long-term sustainability. The CERAR team works closely with industries that operate with high concentrations of potential contaminants. One of their international projects addresses the cycling of naturally occurring arsenic from soil and water to cultivated crops in Bangladesh and Australia.

Short Courses

Thirdly, UniSA has several research and short-course programs in the area of water sciences and related systems. These encompass the management of irrigation and water law, as well as the technical domains of urban water re-use, waste water treatment, and the safe conversion of organic materials in food industry waste streams into hydrogen and value-added products such as biodegradable plastics. As in the other ESD related research areas, these activities have strong industry and international links. They are coordinated within the recently inaugurated SA Water Centre for Water Science and Systems, with significant funding from the South Australian Water Corporation.

The University as an Exemplar of ESD and Community Engagement

UniSA is committed to intelligent use of technologies in its operations. While the emphasis of this commitment has been to use information and communications technologies to deliver student-centred education and support efficient management processes, it is also committed to good environmental practices in its management of energy, water, and waste. Energy savings have been achieved throughout the university through automatic timer control of lighting and air-conditioning systems. Almost all paper is recycled, and electronic distribution is used for all business papers, and students' assignment submissions. Increasing numbers of staff are adopting essentially paper-free practices, using the campus-wide wireless internet. Recycled water is used for watering university grounds where possible. The university has also recently concluded a major new buildings program which required stringent ESD demands on the architects. A new library extension has a particularly strong ESD specification, and its operation will be the subject of energy use monitoring studies.

Being an exemplar of environmental sustainability also resonates well with prospective students, and the community. Over the past decade university engineering students have worked with secondary school and technical college students on the successful development and operation of a solar powered car. The university has also been directly involved in several applied research projects in energy and water systems and management in the local community. There is increasing scope for such work in line with the increasing community and political interest in ESD.

Conclusions

Modern societies rely on good infrastructure, supported by a wide range of professions, whose members must be ever mindful of their responsibilities to the community, and increasingly to principles of environmental sustainability. Universities should undertake leadership roles through their responsibilities to educate for the professions and undertake relevant research. This paper has focussed on the technological educational, research, and community outreach activities in ESD being undertaken at the University of South Australia, which has a university-wide commitment to sustainability. The university's approaches are likely to be increasingly successful as they embrace multi-disciplinary approaches to ESD that engage the sciences with social and economic professionals.

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