Remembering not to forget why there are so few women in engineering: the Women in Engineering Program, UTS 1981-

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***Abstract*:** *This is a brief account of the experience of leading an equity and advocacy program over a decade which saw a major reform of engineering curriculum. The reform was promoted by reorganisation of the faculty and an investment in team teaching and staff development, and communicated by re-making the image and representation of engineering so as to attract a broader audience. The women in engineering movement nationally was a critical catalyst for change in engineering education. These reflections are intended to be useful to practitioners and educators as engineering enrolments are down; the long-predicted skill shortage bites; women continue to leave engineering, and climate change finally now has a place on political agendas. They are also prompted by the designation of 2007 by Engineers Australia as 'Year of Women in Engineering' and by the commissioning of a review of changes since the far-reaching recommendations of the National Review of Engineering Education of 1996.*

Introduction

In 2006, the Women in Engineering initiative at UTS celebrated its 25 year anniversary with a diverse group of alumni, academics, engineers and educators and representatives of industry and professional organisations. This was an occasion to acknowledge the sustained efforts of faculty and co-ordinators of the initiative at UTS across three fronts: to communicate creatively to girls about engineering and its links to everyday life and to an interesting and worthwhile career; to reform the curriculum and teaching and learning, and to critically engage with current engineering practice and its social, economic and environmental dimensions (Holland and Kanga, 2007).

Whilst the event marked the journey of many individuals and celebrated the decades-long collaborative project of communicating, demonstrating, teaching and leading young people through their development as undergraduates and to graduation and professional life, there was also a nagging paradox.

If so many had worked so hard for so long, why was it that enrolments into engineering had climbed so slowly after the first decade, and then plateaued and fallen, and why was it that women were continuing to leave the profession after only ten or so years in engineering? This brief account will address this paradox and serve as a reminder of why it is so important 'to remember not to forget why there are so few women in engineering' in Australia if there is to be a renewed commitment, based on a credible and coherent strategy, and backed with resources to reverse the trends.

As a member of a generation raised on the elixir of change, one of the possibilities as we graduated was to take part in 'changing the system from within'. Two of the three paradigmatic patriarchal professions in which the stakes were very high were law and engineering.

The law and its practice in Australia has certainly been feminised in past decades with the numbers of female law graduates now at 68.8%, and a recent appointment of a second woman to the High Court. At the same time, many significant bids for reform of the profession have been defeated, and the day to day workings of legal practices, particularly large firms, are characterised by a strict regime of billable time and long hours. As one consequence, the number of women achieving partnership is just 20% (Merritt 2007). As a resource for the

redress of social and economic injustice and serious environmental impacts, there have been landmark legal challenges and victories in Australia, including Mabo, and the recent successful challenge by a student to state planning processes that means that the environmental impacts of coal burning are required to be taken into account in the environmental assessment of coalmines (ACJP 2007).

The engineering profession in Australia was also energised by the new social movements, and many members took a stand against contested projects, including the damming of the Franklin river in Tasmania, and uranium exports, and large infrastructure with negative impacts on communities, environment, and 'opportunity costs' of extinguishing more sustainable longer-term solutions. However, by the late 1980's, the engineering profession and the outdated rhetorics of 'progress' had lost public confidence in Australia and the western world, after many contests over development and environment, and the rise of a new participatory politics. This shift was recognised by the Review of Engineering Education in its discussion of community perceptions (IEAust 1996).

As enrolments by the 'best and brightest' (and 92% male) students, for whom engineering had been a degree of first choice, were in decline, national inquiries were held to analyse and propose solutions to the problem. There were projections of the damaging consequences for the nation if trends were to continue. The Williams Review of 1988 recommended that the proportion of female students in engineering education should increase from 7% in 1986 to 20% in 1997 (Williams 1988). This was timely in terms of the ongoing feminist project to remove discriminatory barriers in public education, and state and federal programs to promote retention of girls in maths and science and opportunities for women in traditionally male technical trades and vocations.

At the then New South Wales Institute of Technology, (NSWIT), academics in civil engineering sought to redress the low rate of female enrolments and set in train the initiative that led to a dedicated women in engineering unit. This allowed the recruitment of new female staff, including engineers and specialists from other fields, such as communications and maths education, who responded to the opportunity and produced activities, resources and an award-winning film to communicate creatively with girls. With so many cultural and educational factors supporting the new mantra 'Girls can do anything', female enrolments in engineering began to move and more than doubled nationally from 4.6% in 1983 to 13.1% in 1994 (Lewis and Harris 1995).

By the mid-nineties there was a marked slowing of the rate of growth of female enrolments in engineering and Lewis claimed that if this were to continue, it would be 2055 before there would be parity between males and females in engineering (1995).

Remaking the engineering curriculum

At UTS in this period, there was intensive experiment and innovation in curriculum in the electrical and mechanical engineering courses, which took new approaches to teaching and learning, and worked to situate engineering in social and historical contexts and problematise it in relation to the principles of sustainable development. New texts were being developed to support teaching a critical approach to sustainable development in engineering and science courses, including Beder (1993, 1998) and Johnston *et al* 1999, and Diesendorf and Hamilton (1997). The National Committee for the Advancement of University Teaching (CAUT) Grants scheme promoted research and innovation in tertiary education and supported the development of resources for teaching engineers, including decision-making for sustainability (Harding 1998) and introductory study in engineering design (Roberts *et al* 1995).

The inclusive classroom was promoted by publication of resources such as *Gender in the Engineering Curriculum* (Moxham and Roberts 1996) and fine-grained study of engineering classrooms such as by MacLean *et al* (1996) and by many submissions to the IEAust and Australian Council of Engineering Deans (ACED) commissioned, National Review of Engineering Education (IEAust 1996).

At UTS Faculty of Engineering, the source of much of the energy for change in education, where there had been a sustained commitment to gender outreach since 1981, the Faculty was restructured from schools to a matrix of discipline-based groups and course-based programs. The undergraduate course was redesigned, using a set of graduate attributes, to promote interdisciplinarity and to attract a greater diversity of students (Parr *et al* 1997). The design of the new course was guided by mechanisms including 'a learner-centred curriculum and management format' justified by educational research, contemporary trends in engineering practice, acknowledgement of the cultural diversity of the student body, and the educational and student-centred commitment of an 'influential minority of staff' (Bryce *et al* 2002).

The new course was to promote personal, academic and professional development of students as *lifelong learners*, capable of working in teams and literate in sustainable design and anticipatory approaches to impacts and their minimisation. Inclusivity was one of the objectives of a strategy to induct engineering staff into team teaching of the new mandatory interdisciplinary core subjects and particularly into the high contact first year subject, *Engineering for Sustainability*. This approach drew together engineers, with non-engineering academics and academic language and literacy specialists from the English language and academic literacy support ELSSA Centre. The Women in Engineering Program fixed its flag to the mast of the new course, and reoriented from networking nationally to outreach and communicating the advantages of studying engineering at UTS.

WiE UTS selling the 'New Engineer'

Championing engineering to girls and young women as a challenging and engaging course which could lead to a worthwhile and socially valuable career, with the opportunity to 'make a difference', was made easier by the innovation in the undergraduate course. The Women in Engineering Program was outwardly oriented, in terms of outreach and giving voice to the 'New Engineers' to attract and inspire young people (eg Beder 1998), but with a primary identification with the Faculty at UTS as being in the vanguard of long-awaited change in engineering education..

The Program was sustained by a permanent position, a dedicated space and a small annual budget. The staff complement was increased in 1997 with the recruitment of a science educator who founded Community Outreach as spin-off from WiE, which networked with secondary teachers and produced engineering resources for the high school curriculum and student-led school activities for course credit. Strategically, the Program became closely aligned with the new undergraduate engineering course and participated in the remaking of the image of engineering and creative representation of the possibilities and directions to which choosing engineering at UTS might lead.

In this period there was a feminisation of the face of engineering courses – with the increased budgets allocated to marketing in an increasingly competitive higher education *market*. Marketing media, mainly print-based, with use of video and limited radio and cinema advertising, projected an energetic and appealing *experiential* image for engineering which featured lots of young women. This change of image for engineering courses has been one impact of the first recommendation of the National Review of Engineering Education: 'engineers must receive a broader education and be drawn from a wider range of backgrounds' (IEAust 1996). At UTS, the two strengths to communicate to young women were the academic integration of industrial experience, or internships, which were to be recognised by a Diploma in Engineering Practice, and the new interdisciplinary core of subjects throughout the degree which were compulsory for all students. Access to industrial experience or internship had long been a deciding factor for students who chose UTS over other shorter engineering courses, while the redesign of the course and its emphasis on interdisciplinarity and with sustainability as a central theme, was expected to increase its appeal and relevance to a greater diversity of young people, including women.

Finding the challenge in change was the theme for the Third Women in Engineering Forum in 1996, and this well captures the experience of higher education and at UTS engineering since the mid 1990's. Significant changes have included increases to HECS charges for public university places, the contraction of Commonwealth funding of higher education from 60% in 1996 to 40% in 2007, an increased reliance on fee paying international places at UTS, and the introduction of full-fee local places.

In terms of recruitment, and the academic profile of engineering, key industrial changes - since discontinued - increased opportunities for women, for example by enabling career paths for previously terminating tutor positions, and by the restriction of fixed term contract employment by the Higher Education Contract of Employment Award of 1998 and conditions for conversion to continuing employment. A program of re-entry scholarships for women led to the recruitment of engineers into the Faculty who had taken time out to raise families. The introduction of enterprise bargaining, and the HEWRRS legislation (Higher Education Legislation Amendment (Workplace Relations) Requirements) Bill 2005, has served to industrially discipline the sector. More recently, the introduction of Voluntary Student Unionism and its impact on resourcing of student services, has seen a major shift in the campus life of many universities (Cohen 2007).

The leadership of the Faculty at UTS also changed as senior figures moved on, became adjuncts or retired. The disciplinary orientation of the leadership changed over the life of the Women in Engineering Program from mechanical, civil, electrical engineering and to civil engineering. This had been the field that had initiated focussed outreach to women in 1981 and had seen significant growth in women's participation and celebrated their achievement in civil engineering. With respect to broader changes, the School of Civil Engineering had generally rejected the case for replacing the Faculty's school structure with an open matrix of groups (by engineering fields) and programs (by courses), and the redesign of the undergraduate engineering course (O'Loughlin *et al* 1996).

The endurance of the UTS Women in Engineering Program through an era when many similar initiatives were closed down, can be attributed partly to the support of senior faculty who were leading curriculum reform, several of whom were WiE alumni. In addition, there was a strong tradition of voluntarism by academic and technical staff in the Faculty which had sustained women in engineering outreach and hands-on activities for schools. It also adopted the shape of a 'small target' with a small budget. The university itself had a strong equity profile, and the Equity and Diversity Unit championed WiE, including to the Equal Opportunity in the Workplace Agency in its determination of the university's status as an 'Employer of Choice for Women'. The Program was able to double its resources in 2001 by taking on the industry-sponsored School Speakers Program, developed at Swinburne University. Such new partnerships, and others with professional bodies offering women in engineering scholarships, lent recognition and moral support to the Program in an increasingly pressured era. They extended the environment for the Program and for women students, with increased opportunities for internships and graduate employment and to participate in industry events, seminars and awards, and to connect with organisations working for sustainability and social justice.

The new industry and university sponsored Sydney Women in Engineering & IT (SWIEIT) Speakers Program funded the recruitment of a second part-time co-ordinator, and enabled Women in Engineering to have collective identity and to 'punch above its weight'. The Women in Engineering Program attracted press coverage as one of the few remaining such initiatives and received two UTS Human Rights Awards in 2004 and 2006 for services to women.

So much for *survival* – what did the Program deliver for schools, students and graduates?

With the currency of 'volunteer points' and course credit for a Professional Service Project devised by Community Outreach, and the support of the student Engineering Society, Women in Engineering was able to take a comprehensive approach to its outreach to schools, links to first year orientation and mentoring and to student experience of the new course, and student support. The SWIEIT Speakers Program extended outreach about choices in engineering and IT to an additional 1000 students each year and its team structure connected women undergraduates from two faculties with professional women in computing, software, IT and telecommunications from the sponsoring companies.

The Program was closely linked to undergraduate teaching and the new interdisciplinary core which began with *Engineering for Sustainability*, a subject which benchmarked academic literacy, oriented new students to their choice of engineering as a degree, and related engineering practice to the principles of sustainable development. Students divided their time between individual work and group projects. They were introduced to critical perspectives on technological change, including comparison between the 'taken-for-granted' assumptions of technological determinism and evidence of the 'social

shaping of technology', and required to test these ideas in a case study. They explored the ethical risks of group work, and researched a sustainable innovation linked to the theme of their chosen module.

Just as the Program was receiving support from industry partners and professional bodies, including the Sydney Women in Engineering Group of Engineers Australia, which reformed in 2005, it began to gain some significant press coverage. Two critical articles were: firstly in the AFR in March 2005, one in which Julie Mills, chair of the National WiE Committee of Engineers Australia linked the decline in engineering enrolments by women to the axeing of university programs of outreach and support, and in a second feature in BRW in 2006 looking at the rate at which women were exiting from IT, journalist Kath Walters claimed that the debate about the national shortage of skilled workers had a 'blind spot' about gender (2006). By being included in these stories, the Women in Engineering Program at UTS was linked to both university outreach and enrolments and to broader, industry and economic outcomes, a connection which was accepted by external partners and sponsors and was motivating their support for university equity programs in non-traditional fields for women. With 2007 designated 'Year of Women in Engineering', by Engineers Australia there has been demand for stories about women engineers in universities and industry. The Program has been able to draw attention to the contraction of funding at all levels of public education, the cutting of WiE initiatives and the outdated and discriminatory conditions, including long hours work cultures, that persist in many workplaces according to both research and reporting by interns (eg Lebihan 2007). The continuing low rate of retention of women in the engineering profession can be explained in part by research findings commissioned by Engineers Australia (Ayre 2001) and conducted by APESMA (2007). Surveys of women members seven years apart have found that they give the same two reasons for considering leaving the profession: lack of flexibility in workplace conditions and 'workplace culture'- the prevailing values and conduct in the workplace (Lewis *et al* 2007).

Remembering not to forget

Systemic 'culture change' in engineering education, in the profession (Fawcett and Roberts 2001) and in the engineering workplace, still needs to be the guiding metaphor for an effective strategy to redress the low participation of young women in engineering education and to retain women in the profession beyond their late twenties. This needs to be in tandem with a reinvestment in public education at all levels. The primary and secondary sectors need increased resourcing of basic infrastructure, and to support the professional development of teachers in maths, sciences and engineering, and, importantly, a more contemporary and engaged appreciation of technology and technology practice by career advisers and teachers in humanities and economics. The projected shifts in Australian higher education towards a binary system of research, and teaching-only universities have changed the climate for innovation in teaching and learning and the standing of academics engaged in this work and related scholarship. This may be redressed by the contribution of Carrick Grants, founded in 2004 to advance university teaching and learning, informed by values which include ***Inclusiveness:*** *by assisting the development of networks and communities which support higher education staff who have a direct impact on the advancement of learning and teaching.*(Carrick Institute).

The 'deficit model' that focuses on changing young women to 'fit' engineering and related courses is discredited (See eg reporting of research from University of Toronto, medicalnewstoday.com 5 October, 2007). Firstly, females now achieve better outcomes than males in the New South Wales Higher School Certificate, and are more likely than male peers to earn a university degree or diploma and to be represented in the professions (NCESM and AMP 2007). Secondly, the transformation of the curriculum, together with a learner-centred teaching practice represents the educational preparation that both employers and many students themselves are seeking (Scott and Yates 2002) and aligns with community expectations of access to planning and decisionmaking about environments, health and technology change. It is still the most promising opportunity for energising engineering education and preparing young people for creative and collaborative roles and the leadership of socio-technical systems innovation that is needed for the future.

Recent trans-European research into factors influencing women's decision-making about engineering courses, found that visible interdisciplinarity of subjects early in the undergraduate curriculum was a significant factor (Sagebiel and Dahmen 2006). Despite the continued confirmation of the value of

interdisciplinarity, both for the recruitment of women, and for the preparation of young engineers, it is becoming a casualty of cuts and 'integration into invisibility'. Despite key recommendations of the National Review of Engineering Education of 1996 (1,3,4), and related requirements for the accreditation of engineering courses, innovative interdisciplinary undergraduate subjects for early and later stage undergraduates which pose challenges and raise questions about technology and futures and choices for engineers and community, continue to meet with unreflected prejudice and an all-too familiar 'boundary riding' about what is properly 'engineering' content.

The frustration of long-term researchers and advocates with leadership and policy in technology education is captured well by Catherine Lang and co-authors in relation to falling female enrolments in ICT fields:

If…young women studying information and communication technologies…are at an age when they are vulnerable to evaluating themselves negatively even when they are high achievers, have less background experience of computers and less computer confidence from an range of previous gendered experiences at home and school, learn better in a learning centred rather than a performance centred classroom, prefer the socio-technical contextual curriculum over the abstract…then why are these findings consistently ignored? Despite numerous studies replicating each other, why are the needs of these women pedagogically ignored? (Lang, Lewis and Mackay 2006).

Workplace conditions, including inadequate provision of maternity and carer leave and access to part-time work, and workplace culture, continue to be the main factors women cite as affecting whether they will leave the engineering profession in Australia. Research into the formation of professionals indicates that flexible conditions are now sought after by men as well as women (Reed *et al* 2003). Their adoption would be a strategic advantage for companies and organisations when the national unemployment rate is at a low of 4.3% (*Sydney Morning Herald* 9 August 2007). Research by the Workplace Research Centre at the University of Sydney has found that recent industrial changes have had negative impacts on pay and conditions for working women (van Wanrooy *et al* 2007).

Women in Engineering initiatives at UTS have been motivated by the need to increase the participation of women in the design of technology, systems and social futures, and access to a skill set linked to economic independence and security. The Program has been able to link outreach which communicates a broadened notion of engineering to young women, with experiment and innovation in the curriculum and extra-curricular activities for student engineers that build team skills, tolerance and confidence. It has drawn support from progressive organisations and companies which prioritise increasing the participation and retention of women, and raised the profile of professional women engineers, who otherwise have low visibility in engineering education. In combination, the low proportion of female engineering faculty and lowered rates of recruitment in higher education, mean that students meet few women engineers during their course (EDU UTS 2004).

These are just some of the reasons why, in Engineering Australia's 'Year of Women in Engineering', at UTS we have claimed that '*every year* is for women in engineering', and why the review of the changes since the recommendations of the National Review of Engineering Education, '*Changing the Culture:Engineering Education into the Future'* needs to ensure that academic, professional and industry leaders as well as policy makers, *remember not to forget why there are so few women in engineering*. This mnemonic might resonate more if linked to performance indicators.

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