Engineering Education and Curriculum as an Extension of Engineering Discourse in the Post-Williams Era.

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ABSTRACT

It is nearly 10 years since the Williams inquiry into discipline of Engineering in Australia. Like its earlier British counterpart, the Finniston inquiry, the Williams report became the landmark in the study of engineering occupation, education and training.The Williams Committee produced a set of recommendations based on intensive inquiry of views, surveys, opinions of the Institutions of Engineers, employer groups, engineering academics, practising engineers, engineering students and the government. The recommendations dealt with the future direction of engineering education in Australia. This paper examines the response of the engineering education providers to one of the recommendations, to enhance the social and management literacy of engineering graduates, and finds that the engineering education providers were by and large bound by institutional cultures and prioritized recruitment often conflicting with the set of recommendations to positively respond to the changing need.

INTRODUCTION

Engineers have contributed to the society well beyond their number.It is well understood that engineering activity plays a crucial role in modern societies in the construction of the social texture and determining economic outcomes in societies.It is thus not surprising that the state has a major stake in engineering. The mechanisms by which the state intervenes in engineering varies according to national cultures and traditions. In European countries such as France and Germany the professions are perceived by the state as an instrument for the provision of public service and maintaining a civic society and thus engineering is an extension of the bureaucracy. The professionalization of engineering in such countries is maintained by the state through the levers of registration and direct control in the provision and nature of engineering education. The guild-type model of professions such as engineering found in english speaking countries such as Britain, Australia and New Zealand places the responsibility of professional education in the province of the professional society or institution. The Institution of Engineers in Australia controls the engineering education through the process of sanctions of courses developed and provided by the higher education sector. The graduates of approved courses meet the membership criteria of the Institution of Engineers. It must be noted that neither the state nor the Institution of Engineers control engineering practice.

The guild type model of of professions would seem on the surface to represent the best basis in developing appropriate engineering curricula to meet the needs of the society and the industry. After all, who is better to decide on epistemology of professional education than the professional practitioner? Despite all this, the need for the Williams Committee reflected the ongoing crisis in engineering education. According to surveys of employers, students and practising engineering graduates there seemed and still is dissatisfaction concerning the nature and appropriateness of engineering education and curricula. The deficit in practical rationality, the gap between engineering education and practice can be attributed to three players in the engineering domain:

- Professional Hierarchies. The most powerful voices and influences in engineering curriculum design within the Institution of Engineers are often furthest removed from engineering practice and are more closely located to engineering academia.

- Structure of Engineering Schools and Faculties. A more practitioner based engineering curriculum cannot be delivered by the engineering education provider because it lacks the essential the essential ingredient, academic staff members who are practicing rather than research engineers. Human resource and University policies implications are found here.

- External. Inadequate input from industry and society concerning the nature of engineering curricula.

IDENTIFICATION OF TENSIONS

The concern that current engineering education is not of best practice has prompted Australian Governments to fund a number of inquiries into engineering and engineering education.In the 1960's Moorhouse identified a crisis in engineering education and placed the root of the problem squarely on the shoulders of the Institution of Engineers. The concerns that Moorhouse identified were rather contemporary in nature; place of engineering as a field of intellectual inquiry, differing expectations of engineering graduates by small and large employers, tensions between broader and specialist knowledge, preparation engineering graduates in non-technical roles,crowded curricula and length of engineering courses, place of pure science and specialist knowledge in engineering curriculum.

In the wake of Finniston inquiry in Britain, the Australian government commissioned Sir Bruce Williams to undertake a comprehensive study into engineering and engineering education in Australia. The terms of the inquiry were based on such questions as: What is engineering? Where is engineering heading? What do engineers do? What is the essential knowledge in engineering? These questions were fettered to both engineering profession and education. The Williams Committee identified number of tensions within the Australian engineering education landscape.

- Appropriateness of engineering courses.Issues of balance between science, technology, management and humanities in engineering curricula.

- Discrimination. Low female participation in engineering education and poor representation of students from certain ethnic groups and lower socio-economic strata in engineering courses.

- Over emphasis on science and scientific research in engineering schools and faculties. Academic promotion was generally gained through the PhD route rather than being awarded on the merit of engineering practice.

- Unconventional educational programs. There was a concern with the institutional inability to develop imaginative engineering curricula which would be more attractive to prospective students. The lack of institutional innovation with respect to engineering curricula reflected poor integration between engineering academia, industry and the community in general.

SPECIFIC RECOMMENDATIONS OF THE WILLIAMS COMMITTEE

Professional engineering education has been a part of higher education landscape in Australia since 1860's. The Williams Committee had to engage the higher education profile. The universities could be grouped into three types according to their time of establishment :

- The State universities established between mid- nineteenth century and the early part of the twentieth century provided opportunity for university engineering education. The engineering faculty members at these sandstone universities concerned themselves with engineering as intellectual inquiry underpinned by scientific principles.The strong principles of platonic rationality combined with scientific principles where single truths could be engaged and contested provided the engineering faculty with the appropriate scholarly credentials that were acceptable to the wider academic community. Polemics aside, many of the engineering faculty members also occupied many senior technical positions in both private and public corporations allowing them to provide a practitioner dimension to the academic discourse.

- The second category of universities were established between the end of second world war and 1960. For distinction purposes I will refer to them as baby boomer universities. The engineering schools and faculties at these universities were able to recruit the first graduates of doctoral programs in engineering. The new PhD's produced a new type of academic, the research engineer. The research influence provided a foundation of science based engineering faculties whose engineering curricula was deeply ingrained with engineering science. The X generation universities established between 1960 and 1987 were not founded to provide engineering education.

- Technological institutes and colleges were responsible for another tier of professional engineering education.These institutions were established from the latter part of the nineteenth century with the purpose to provide vocational and professional education to those interested people who worked during daytime or completed pre-tertiary education via the vocational route. Not being shackled by the mores of academic respectability, these institutional were unashamedly vocationally and practically oriented resembling somewhat the British polytechnics or German fachhochscules. Engineering curricula were designed by state appointed bodies (resembling the European model) and the courses were taught by qualified teachers who were also qualified engineers and by practising engineers. The engineering curriculum placed a strong emphasis on engineering practice rather than pure, applied or engineering science, bearing strong resemblance to the contemporary engineering technology courses offered in United states.By 1991 with the abolition of the binary higher education system these institutions disappeared from the Australian tertiary education landscape, either amalgamating with the established universities or becoming universities in their own right.

By mid 1970's a convergence of the three engineering curricula is observed with the engineering science model clearly establishing ascendancy.

The Williams inquiry was set within broad parameters. The inquiry undertook the study of all engineering education providers in terms of their academic staffprofiles, research and consultancy activities of the staff members, quality of laboratory and research equipment,and engineering curriculum development. Recommendations from the Institute of

Engineers and its various disciplinary components, surveys undertaken by employer groups and university centres for higher education studies were also evaluated by the inquiry. In the summary of its conclusions the Williams Committee presented no less than forty two recommendations.These dealt with areas such as funding of engineering institutions, research, social justice and equity provisions, nature of higher degrees in engineering, size and viability of engineering departments, attractiveness of engineering courses to prospective students. The recommendations constitute a wide field and the scope of this paper focuses to the responses of Williams Committee recommendations concerning improvement of social and managerial literacies among engineering graduates.

The Williams Committee acknowledged the human side of engineering practice. Surveys among employer groups indicated dissatisfaction with engineering graduates skills in social and managerial arenas and suggested that more emphasis be placed in the engineering curricula on humanities, management, and other professional elements and less emphasis on core science. A survey conducted at Melbourne University among senior engineering undergraduates and engineering graduates reinforced the view that greater emphasis in engineering curricula be placed on humanities, management and communication skills. The Institution of Engineers suggested that at least 15% of engineering curriculum be allocated to management subjects. In its conclusion the Williams Committee suggested that:

> *.....There are many Australian employers who do not fully understand this dual nature of technology(the technical and human side). That is also true of many Australian engineers, and their role and skills in this human side of technology if Australia is to lift its levels and rates of improvement of technology*

SCOPE OF STUDY

Six universities were chosen to gauge the response of their engineering schools and faculties to the Williams Committee recommendation concerning increased allocation and attention to subjects dealing with social and management literacies in the engineering curricula.The two sandstone universities are represented by Universities of Sydney and Melbourne. The baby boomer universities are represented by Monash University and University of New South Wales (UNSW), the latter representing an interesting case because its origins lie in earlier technical institution and its eclectic culture has retained some of the components and traditions of its original institution. RMIT University (RMIT) and Victoria University of Technology (VUT) were established in 1991 from largely technological colleges of advanced education.

RESULTS OF THE STUDY

Table 1 lists the percentage of engineering curriculum allocated specifically to subjects that deal with social, managerial and economic literacies.

The results show a mixed bag of trends. Generally courses such as mechanical and industrial/manufacturing engineering whose core values are broadly defined allocate greater percentage of their course curriculum to subjects concerning themselves with social and management literacies than other engineering courses. The nature of the beast. Universities whose histories are anchored in technical education such as RMIT, UNSW and VUT ironically allocate greater proportion of engineering curriculum to non-technical and non-

science subjects than the traditional universities. In this respect,the universities with their historical emphasis on technical education show themselves to be more sensitive to social trends and employer needs. The schools and faculties at these technically based universities broaden the engineering discourse and perhaps place engineering as a mode of real intellectual inquiry closer to what is desired, near engineering practice than the traditional universities whose schools and faculties of engineering closely resemble schools and faculties of science. With one solitary exception - Mechanical and Manufacturing Engineering courses at UNSW - the proportion of subjects in engineering curricula allocated to management and humanities is short of the desired minimum 15% recommended by the Institution of Engineers.

The traditional universities were not particularly sensitive to the Williams Committee recommendations. Slight positive response to these recommendation is observed initially in the faculties of engineering at Monash and Sydney Universities followed by the decline in the emphasis on non-scientific and non-technical components of engineering curricula during the period 1992-1997. Both RMIT and VUT initially reacted positively to Williams Committee recommendation with substantial attention being paid to increasing the non technical and non scientific components in the engineering courses but like in the case of the traditional universities this reaction is tempered during the period 1992-1997. Only the engineering education providers at UNSW continued to respond positively to the Williams Committee recommendation; the proportion allocated to humanities and management subjects has generally been increasing over the whole ten years.

CONCLUDING REMARKS

The response by the engineering education providers to the Williams Committee recommendation would seem to be a knee-jerk reaction, exhibiting little commitment to long term changes in line with the recommendations.It is difficult if not uncomfortable to regard such reactions as superficial. The explanation of responses to the recommendations lies in the terrain of academic inertia. Changes in engineering curricula are successful if they manifest a
shelf life of reasonable length of time, and even more successful if synergy of changes translate into continuous pattern of change. Such a process is sustainable only if embraced by the organisational culture and supported by the academic staff. The faculty of engineering at University of New South Wales with its long standing tradition to engineering practice committed itself to the Williams Committee recommendation. The proportion of time allocated to expand social and managerial literalise within the engineering curricula continued to rise bringing it closer to the minimum proportion recommended by the Institution of Engineers. Here we observe organisational culture and traditions of engineering practice staking its hegemony over engineering curricula without compromising its academic integrity. Engineering faculties within the traditional universities; Monash, Melbourne and Sydney, lacked the technical traditions of UNSW and as a consequence the change had to be initiated and embraced by the academic fraternity. Changes are based upon organisational traditions and the sum total knowledge of its constituent members.The senior academic staff who initiate and implement responses were recruited into the traditional universities because of their scientific and research background and their commitment to certain outcomes made them less than the ideal candidates to embrace the core argument in the Williams Committee recommendation.

The faculties of engineering at the new universities such as RMIT and VUT which though sharing the technical educational history with UNSW adopted the policy in recruitment of staff with strong scientific and engineering research background. The new staff was appointed at a senior and therefore decision - making level and where their attitudes begun to prevail. The replacement of practicing engineers with research engineers (Table 2) shifted the academic texture of the engineering faculties closer to that of the traditional universities. The organisational culture and traditions were too immature or too insecure to prevail the hegemony over the course objectives. A decline in the proportion of humanities and management subject in engineering curricula is observed during the period 1992-1997, a period that also ushered a substantial recruitment into engineering faculties at the new universities of people with research oriented doctoral degrees.

The Williams Committee of inquiry in one of its conclusions placed an emphasis on the importance of engineering practice in engineering curriculum design and recommended part-time engagement of practising engineers by the faculties of engineering. The weakness in such recommendation lies in the fact that part-time faculty members do not generally participate in curriculum design, and the recommendation was conflicting with other signals where the committee of inquiry suggested recruitment be increased through the doctoral path. The underlying assumptions of science based research academic engineering adopted by the Williams Committee not only ensured that some of the committee's recommendation could not be implemented because of competing demands and interests,but such assumptions were not fully validated. Unlike the engineering faculties, the most prestigious professional educational faculties in Australia such as law, medicine, dentistry have not recruited staff through the research criteria and the proportion of academic staff with doctoral degrees in these faculties is less than 30 percent.

Table 1: Proportion of engineering curriculum dedicated to humanities and management subjects.

Name of the Institution	**Engineering Course**	**Percentage Allocation to Humanities and Management subjects in engineering curriculum**		
		1987	**1992**	**1997**
University of Melbourne	Chemical	0.0	3.1	1.1
	Civil	8.5	2.7	3.8
	Electrical	5.5	5.0	3.5
	Industrial/Manufacturing	5.0	6.0	13.8
	Mechanical	5.0	6.0	13.8
	Non-weighted faculty average	**4.5**	**4.2**	**5.5**
University of Sydney	Chemical	0.0	2.0	2.3
	Civil	2.0	0.0	4.7
	Electrical	2.0	1.5	1.8
	Mechanical	3.0	3.8	7.1
	Non-weighted faculty average	**1.8**	**2.1**	**4.0**

Monash University	Chemical	2.0	4.5	3.1
	Civil	3.5	1.6	1.6
	Electrical	3.5	3.0	4.7
	Materials	1.5	2.5	1.6
	Mechanical	4.5	7.2	6.3
	Non- weighted faculty average	**3.0**	**3.7**	**3.5**
University of New South Wales (UNSW)	Civil	9.0	9.0	10.2
	Electrical	3.5	6.5	11.9
	Industrial/Manufacturing	10.0	12.6	17.6
	Mechanical	11.0	12.6	14.4
	Non-weighted faculty average	**8.4**	**10.2**	**13.1**
RMIT University (RMIT)	Aeronautical/Aerospace	9.9	9.6	7.2
	Chemical	6.0	7.0	8.9
	Civil	6.8	11.6	9.4
	Communication, Electronic and Computer	8.6	8.2	2.7
	Electrical	8.0	10.4	1.8
	Manufacturing/ Manufacturing Systems	11.8	13.4	9.0
	Mechanical	9.7	10.0	6.9
	Non-weighted faculty average	**8.3**	**10.0**	**6.9**
Victoria University of Technology (VUT)	Civil and Building	8.3	6.4	5.1
	Electrical	11.4	7.4	5.1
	Mechanical	8.5	15.1	8.3
	Non-weighted faculty averages	**9.4**	**9.6**	**6.2**

Table 2 Academic staff profile in engineering according to qualifications

Institution	**Engineering Area**	**Proportion of staff members possessing doctorates (%)**			**Proportion of staff possessing higher degrees (%)**		
		1987	**1992**	**1997**	**1987**	**1992**	**1997**
University of Melbourne	Chemical	78.6	92.9	92.9	85.7	94.1	92.9
	Civil and Environmental	75.0	77.7	65.0	95.0	96.6	100.0
	Electrical	62.5	77.4	85.7	81.3	88.9	90.5
	Mechanical/ Manufacturing	71.4	71.4	80.0	90.5	87.5	85.0

University of Sydney	Aeronautical	60.0	37.5	66.7	60.0	50.0	88.9
	Chemical	92.3	83.3	85.7	100.0	91,7	100.0
	Civil & Mining	81.5	77.3	84.2	92.6	95.5	100.0
	Electrical	57.7	68.0	85.7	73.1	92.0	100.0
	Mechanical	70.6	100.0	88.2	82.4	100.0	88.2
Monash University	Chemical	82.4	91.1	94.7	82.4	94.4	100.0
	Civil	70.0	70.0	74.3	82.4	87.7	91.4
	Electrical & Computer Systems	61.5	65.5	81.0	73.1	73.1	90.5
	Materials	91.7	94.3	100.0	100.0	100.0	100.0
	Mechanical	62.5	66.7	70.7	81.3	84.4	90.2
University of New South Wales	Civil	69.2	78.0	83.8	97.4	92.7	97.3
	Computer & Electronic	81.5	70.0	67.6	87.0	87.5	85.3
	Electrical	81.5	94.9	97.2	87.0	97.4	100.0
	Mechanical and Manufacturing	83.3	79.2	73.8	92.9	92.5	92.9
RMIT University (RMIT)	Chemical	62.5	75.0	85.6	100.0	100.0	100.0
	Civil	29.4	33.3	32.0	70.6	83.3	76.0
	Communication & Electronic	29.6	41.1	50.0	66.7	82.2	91.7
	Electrical	40.0	75.0	73.7	80.0	91.7	89.5
	Manufacturing	42.9*	20.0	50.0	81.0*	80.0	75.0
	Mechanical	42.9*	50.0	58.3	81.0*	80.0	83.3
Victoria University of Technology (VUT)	Civil and Building	4.3	8.7	18.2	60.9	73.9	86.4
	Electrical	30.8	27.6	56.3	73.1	72.4	90.6
	Mechanical	21.4	40.0	71.4	78.6	80.0	92.8

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Biographical Details

The author after qualifying in science and chemical engineering engineering spent some time in the plastics industry.Since his academic appointment,initially at the Royal Melbourne Institute ofTechnology he completed masters degrees in science and materials engineering while teaching and researching in materials and chemical engineering. He is currently completing a doctoral thesis on epistemological influences in professional engineering education.