At last count: engineering undergraduates in 21st Century Australia

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ABSTRACT: The number of enrolments in undergraduate programmes in engineering has grown at more than the national average this century. The main areas of enrolment growth in Australian higher education have been of women and overseas students, and the latter group has been particularly relevant in the case in engineering. The analysis undertaken for this article is based on statistical data from the ministry responsible for Australia's tertiary education. However, women remain underrepresented in engineering programmes, and there is a risk that the high proportion of overseas students means that Australia is *exporting* engineering talent at a cost to the development of its own knowledge-intensive labour force.

INTRODUCTION

This article provides a summary of undergraduate enrolments in the first decade of the 21st Century. In particular, it presents an examination of enrolment patterns at Australian universities, focusing on programmes leading to qualifications in the *Engineering and Related Technologies* field of education (described hereafter in abbreviated form as *engineering*). Enrolments in university programmes have increased rapidly over the past 20 or so years, part of the international trend towards the *massification* of higher education. The concept of massification was first described by Trow, referring to the change in higher education systems from ones that catered for the *elite*, to ones that admitted many students who had previously been excluded [1][2].

In 1990, Australian institutions had about 485,000 enrolled students, of which about 84% were in undergraduate programmes [3]. By 2010, the number had increase to more than 1.2 million, with undergraduates making up about 73% [4]. The reason for the change in composition of the student population was a reflection of the expansion in enrolments by fee-paying overseas students, many of whom enrolled in postgraduate degrees, mainly coursework degrees at the Master's level [5][6].

The data used here were drawn from the *do-it-yourself* UCube statistics system made available by the Australian federal government ministry responsible for higher education. Currently, the Department of Innovation, Industry, Science, Research and Tertiary Education fills this role. The data period selected for analysis is 2002 to 2010. Analysis of enrolments in time series from before 2002 produces misleading results, because prior to 2002, the methodology for counting student enrolments was different [6][7]. The change in methodology added something like 19% to the number of students in the system [6]. UCube can be accessed at http://www.highereducationstatistics.deewr.gov.au/.

ENGINEERING AND THE REST: ENROLMENTS IN THE 2000s

Undergraduate programmes include Bachelor's and Bachelor's (Honours) degrees, and several types of undergraduate diplomas. Whereas it used to be possible to analyse these undergraduate sub-groups separately, this is no longer the case with the UCube system described above. *Undergraduate*, therefore, is as specific as it is possible to get. However, most undergraduates are enrolled in Bachelor's degrees, more so in engineering than several other fields of education. Table 1 summarises undergraduate programme enrolments for selected years between 2002 and 2010. The table shows enrolments divided into fields of education, with the so-called *STEM* fields/disciplines of science, technology, engineering and mathematics shown separately from the others. The STEM fields are considered to be the major drivers of economic growth in society, and there is perpetual concern within most developed Western economies that too few STEM graduates are being produced to keep some economies viable into the future [8][9].

The statistics that can be obtained from the Australian higher education system do not map exactly with what are generally considered to be *STEM* fields of education. Arguably, not all of the programmes offered as *Agriculture, Environment and Related Technologies* (*agriculture* hereafter) are STEM, and some of the programmes offered under the *Health* field of education possibly do represent *science* or *technology*. However, much of the teaching within *Health* is in nursing programmes. As with any set of statistics, there are imperfections.

Engineering is a major component of the STEM fields, and the reason for aggregating fields in this way is to show that growth has been stronger than the other STEM fields, but less strong than some other non-STEM fields. Table 1 shows the actual decline in undergraduate enrolments in agriculture (which declined by almost 2,000 undergraduates between 2002 and 2010), and *Information Technology* (which had 23,434 fewer undergraduates by 2010). By contrast, there were 13,420 more student undergraduate students enrolled in programmes in the *Natural and Physical Sciences* (+23.4%) and 16,400 more engineering undergraduates, an increase of 33.0%. It can be calculated from Table 1 that engineering's proportion of all enrolments in the STEM disciplines increased over the period from 28% to 36%, but that overall STEM enrolments declined from 26% to 20% of the total.

Engineering undergraduates are a small proportion of all undergraduates, but their relative presence has been consistently higher than 7% this century and they represented 7.4% of all undergraduate programme enrolments in 2010.

Table 1: Undergraduate enrolments by broad field of education - 2002, 2005, 2008-2010.

						Growth	
	2002	2005	2008	2009	2010	No.	%
STEM Fields:							
Agriculture #	14,149	12,272	11,034	11,654	12,250	-1,899	-13.4%
Engineering +	*49,648*	*50,207*	*57,439*	*61,429*	*66,048*	*16,400*	*33.0%*
Information Technology	57,454	44,045	33,168	33,622	34,020	-23,434	-40.8%
Natural and Physical Sciences	57,360	61,515	62,295	65,485	70,780	13,420	23.4%
Sub total	178,611	168,039	163,936	172,190	183,098	4,487	2.5%
Other Fields:							
Architecture and Building	14,709	16,255	18,511	19,737	20,699	5,990	40.7%
Creative Arts	46,642	51,169	61,189	67,087	69,830	23,188	49.7%
Education	60,632	64,233	64,684	66,150	67,650	7,018	11.6%
Health	74,204	83,021	109,038	117,047	125,289	51,085	68.8%
Management and Commerce	161,855	181,168	217,102	230,733	238,714	76,859	47.5%
Society and Culture	155,187	158,066	168,038	177,139	188,665	33,478	21.6%
Other	138	91	799	1,139	1,102	964	698.6%
Sub total	513,367	554,003	639,361	679,032	711,949	198,582	38.7%
Total - Course enrolments §	691,978	722,042	803,297	851,222	895,047	203,069	29.3%
Total - Students §	640,208	665,257	743,411	790,341	833,390	193,182	30.2%
Engineering % of Total Course Enrolments	7.2%	7.0%	7.2%	7.2%	7.4%		

Agriculture Environmental and Related Studies

+ Engineering and Related Technologies

§ Some students are enrolled in more than one programme simultaneously, such as students concurrently enrolled in a law degree and an arts, commerce or science degree. Therefore, the number of programme enrolments exceeds the number of students. Most engineering students, however, enrol in a single programme.

ENGINEERING UNDERGRADUATES: MORE DETAIL

Growth in enrolments in higher education programmes has come from two principal sources: the expansion in the number of women and the growth in the number of overseas students. Women have been in the majority as university enrolees since 1987 [4], in which year they represented 50.1% of all students. Taking 2010 figures from UCube, the proportion of women had increased to 56%. Over the period since women represented the majority gender, that is 1987 to 2010, the number of female students has increased by 236%, compared with the relatively modest increase of 179% in the number of men.

Overseas students have also increased in number, and all but a few are required to pay full cost-recovery tuition fees, and Australian higher education quickly became dependent on these students as an income stream, particularly in light of the consistent decline in the funding per student provided from government sources [10].

Table 2 examines growth in the first decade of the 21st Century of students enrolled in undergraduate engineering programmes. Looking first at the gender distribution, it can be seen that approximately 2,000 more women were enrolled in 2010 than had been in 2002, but even if this represents an increase of about 25%, the proportion of women of total engineering undergraduates declined, from 18.3% to 17.1%. Among men, the number grew by over 14,000, or 34.3%.

Engineering has often been noted as a discipline not favoured by women, and it is clear that with such an extreme underrepresentation, potential talent is wasted. Among the reasons for this phenomenon are that secondary school and university-age women perceive engineering, and other STEM fields, as male dominated and unsympathetic environments. Absence of suitable female role models has also been cited as a reason for this gender imbalance [11]. Many studies and reports have examined these themes, and many countries now have specific programmes in place to increase the attractiveness of the STEM disciplines. Anyone interested in pursuing these issues further could start by referring to the genSET Web site http://www.genderinscience.org/, or the Society of Women Engineers http://societyofwomenengineers.swe.org/, among others.

Growth in enrolments by overseas students was strong. The number of domestic students increased by 7,788, or 19.5%, but this was out shadowed by overseas student enrolment expansion of 8,612, or 89.2%. During the decade, the proportion of overseas students increased from 19.4% to 27.6%. Overall growth of engineering undergraduates was 33.0%.

Table 2: Undergraduate engineering enrolments by gender and citizenship status - 2002-2010.

	Female	Male	Female % of Total	Domestic	Overseas	Overseas % of Total	Total
2002	7,678	41,970	18.3%	39,998	9,650	19.4%	49,648
2003	7,771	43,099	18.0%	39,716	11,154	21.9%	50,870
2004	7,546	43,196	17.5%	38,962	11,780	23.2%	50,742
2005	7,334	42,873	17.1%	38,214	11,993	23.9%	50,207
2006	7,470	43,945	17.0%	39,008	12,407	24.1%	51,415
2007	7,923	46,597	17.0%	40,788	13,732	25.2%	54,520
2008	8,407	49,032	17.1%	42,633	14,806	25.8%	57,439
2009	8,935	52,494	17.0%	45,154	16,275	26.5%	61,429
2010	9,668	56,380	17.1%	47,786	18,262	27.6%	66,048
Increase - No	1,990	14,410		7,788	8,612		16,400
Increase - %	25.9%	34.3%		19.5%	89.2%		33.0%

The patterns explained with respect to Table 2 can be seen more clearly in Figure 1, which extends Table 1 by examining gender and citizenship status simultaneously. It is clear that growth in enrolments by male overseas students has been the greatest, and that although there has been growth in female numbers (whether of domestic or overseas students), it is clearly lagging behind expansion in enrolments by men. The two lines represent the proportion of domestic and overseas women compared with total enrolments of domestic (broken line) and overseas students (unbroken line), respectively. These should be viewed against the right axis. Given the world-wide push for an increase in the number of women in engineering as one way of expanding the STEM labour force, the flatness of these lines is disappointing. The proportion of undergraduate engineering enrolments made up by women has declined from 14.9% among domestic students, and from 17.8% among overseas undergraduate engineering students. Of the increase of about 2,000 of the number of women enrolled in undergraduate engineering programmes, nearly 600 were domestic students, and nearly 1,400 were overseas students.

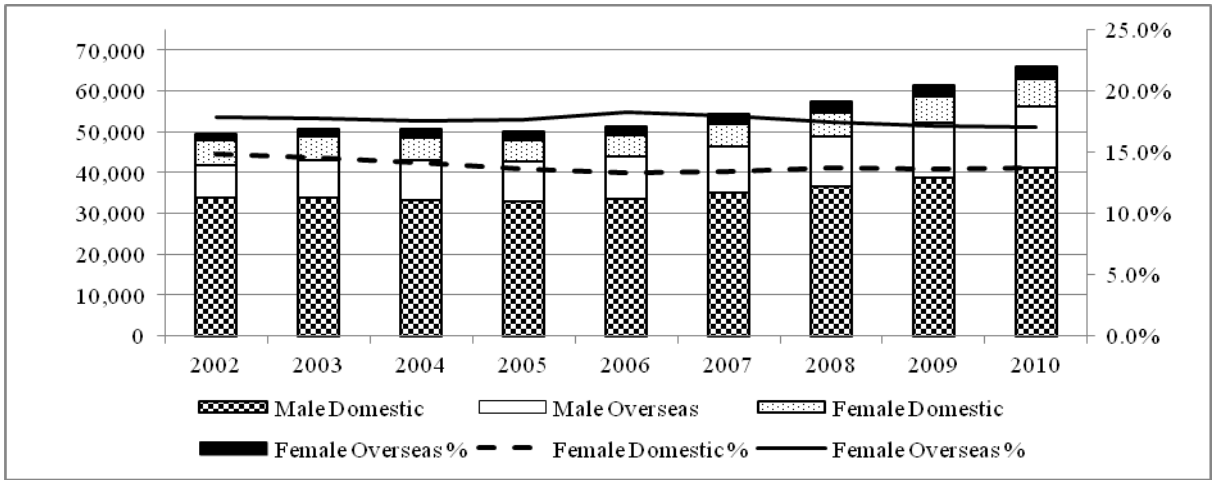

Figure 1: Undergraduate engineering enrolments - 2002-2010 by gender and citizenship status.

As a final *test* of the strength of engineering and the potential for likely continued growth, Table 3 and Figure 2 show that undergraduate enrolments of both commencing and continuing are in the ascendency. As suggested by the name, *commencing* enrolments are those by students just starting a programme, usually in the first year. Typically undergraduate engineering programmes offered by Australian universities last for four years, so the most usual circumstance is for a student to *commence* the programme and, then, *continue* in it for at least three more years. As such, measuring commencing enrolments constitutes a *leading indicator*; a continued upward trend in programme commencements indicates that students are still attracted to those programmes. In situations where there is declining interest, the proportion of commencing students declines, usually leading to an eventual decline in total numbers.

Table 3 shows that commencing enrolments in undergraduate engineering programmes did slide back a little in 2004, stabilised in 2005 and, since then, have expanded each year. Stronger growth was shown between 2007 to 2008 and 2008 to 2009. Under such circumstances, total enrolments in undergraduate engineering programmes will continue to rise.

Table 3: Undergraduate engineering enrolments by commencing and continuing students - 2002-2010.

										Growth	
	2002	2003	2004	2005	2006	2007	2008	2009	2010	No.	%
Commencing Students	15,057	15,297	14,665	14,619	15,184	17,027	17,350	19,283	20,681	5,624	37.4%
Continuing Students	34,591	35,573	36,077	35,588	36,231	37,493	40,089	42,146	45,367	10,776	31.2%
Total	49,648	50,870	50,742	50,207	51,415	54,520	57,439	61,429	66,048	16,400	33.0%

Figure 2 maps commencing, continuing and total undergraduate enrolments in engineering across the decade. The definite growth trend from 2007/2008 suggests that there is still plenty of student demand for engineering. The gap between the lines representing commencing and continuing enrolments gets wider over the time, because programmes take several years to complete.

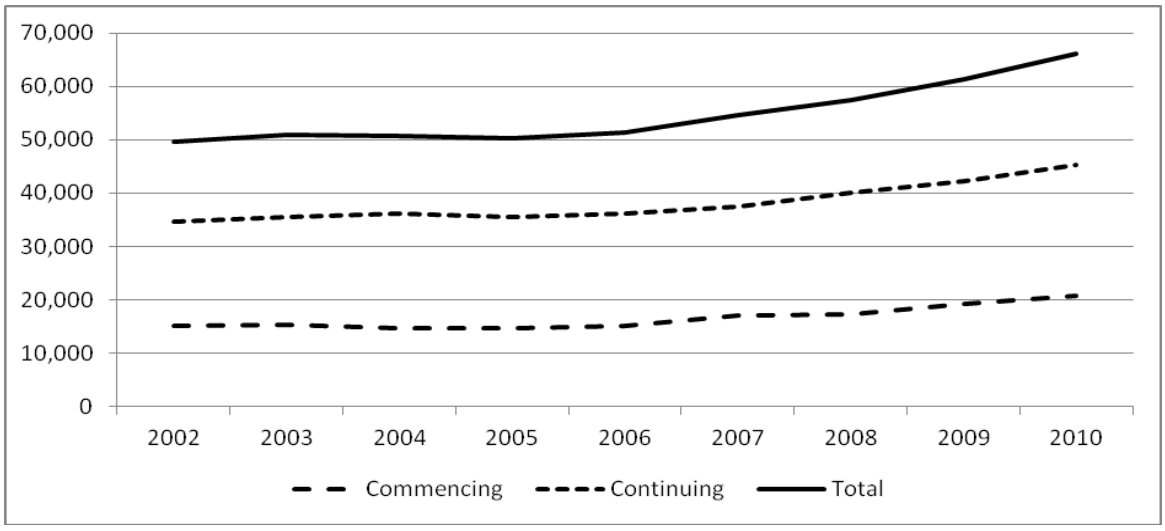

Figure 2: Undergraduate engineering enrolments by commencing and continuing students - 2002-2010.

CONCLUSIONS: THE FUTURE

Interest in undergraduate engineering in Australia appears buoyant, with the growth in undergraduate enrolments between 2002 and 2010 (33.0%) exceeding the growth in enrolments overall (29.3%). In particular, undergraduate engineering is faring well compared with other STEM fields of education. In fact, numbers of undergraduate enrolments in *Information Technology* and agriculture have declined over the decade. Enrolments in undergraduate programmes in the *Natural and Physical Sciences* also increased (+23.4%), but this growth was less vigorous than for engineering.

The fact that there is an upward trend in commencing enrolments is a positive sign for engineering in Australia, and on the surface, producing such a large number of qualified engineers would seem to be a good thing. However, an increasing number of engineering undergraduates are overseas students, and it is possible that some of the Australia-produced engineering talent is *exported*. In fact, a considerable number of engineering graduates gain Australian residency status on the basis of their Australian engineering qualifications. In 2009, 1,144 engineers (all levels) were visaed under the Employer Nomination Scheme [12].

Engineers play an important part in boosting Australia's workforce in the knowledge economy, so it is important that strong demand to undertake engineering remains. It is clear from the low proportion of women enrolled in engineering programmes that efforts should be made to improve engineering's image in order to tap into this potential source of demand.

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