Engineering PhDs: how many has Australia produced?

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ABSTRACT: Doctoral degrees are the highest of the qualifications awarded by Australian universities, and the PhD is the most common of these. The Australian PhD is a relatively recent phenomenon, with the first three being awarded as recently as 1948, and the first in engineering in 1951. This article tracks engineering PhDs awarded in the first 60 years of the PhD in Australia, and reports on the distribution of these by gender, citizenship status, and type of university attended. Nearly 10,000 PhDs in engineering have been awarded and, in recent years, typically about 20% of these are awarded to women, and nearly one-third are awarded to overseas fee-paying students. About 12% of all PhDs awarded between 1948 and 2007 were in engineering, meaning that engineering ranks fourth after science (34.2%), arts/humanities (22.8%) and health (13.5%). Engineering PhD graduates are now being produced by a wider range of universities. In 1988, Australia's major research universities were responsible for 83% of engineering PhDs, but by 2007, the proportion was about 64%.

Keywords: PhD, doctoral graduations, engineering PhDs, Australian graduates, overseas students

INTRODUCTION

The PhD is a research degree and one of several postgraduate-level qualifications offered by Australian universities. As currently defined in the Australian Standard Classification of Education (ASCED), *the Doctorate by Research provides a significant contribution to knowledge and understanding within a particular field, and to the application of knowledge within that field. The majority of the programme, usually about two-thirds, is undertaken as an original research project* [1].

The Australian PhD is a recent phenomenon, especially when compared with its namesake in much of the rest of the world. Quoting from the Australian Vice-Chancellors' Committee (AVCC) publication *The Progress of Higher Degree Students* (1990), *The introduction of PhD courses in Australia resulted from discussions in the Faculty of Science of the University of Melbourne. The Dean had approached the Vice-Chancellor in October 1944 and had informed him that most faculties supported its introduction …By 1946 Melbourne had published its rules and three of its candidates (including two women) were awarded the degree in 1948. By 1949, all Australian universities were offering the degree* [2].

Statistics on the PhDs awarded in Australia are available, and arguably, they are readily available. However, they have to be extracted with considerable labour from myriad reports from a range of organisations. Over time, the Australian Bureau of Statistics (ABS) and its predecessor, the Commonwealth Bureau of Census and Statistics, and various mouthpieces for the university sector, such as the Commonwealth Tertiary Education Commission and the 'education department', known its current guise as the Department of Education, Employment and Workplace Relations, have had the responsibility for statistics on universities. University statistics have always been fairly reliable, and these days, universities are required to submit extensive data files on student enrolments, staff and course completions. The current Act that enforces this is the Higher Education Support Act (2003), Subdivision 19E, 19-70 [1].

For reasons best known to the authorities responsible for collating university statistics, the scope of what was collected and reported varied from year to year. Some years the university awarding the degree was not reported; other years, it was the gender of the recipient, *et cetera*. The definition of *discipline* has also varied over the years, but fortunately, this has had no impact on engineering; *engineering* has always been *engineering*. Other areas are less simple to track across the years, because some of them have *migrated* from one defined field to another. Information technology is one such example. It had been included in the same category as *science* for many years, until it was granted its own *field of study* from 2002.

The period from 1988 has seen more detailed information being available, primarily because the education department of the day distributed computer software to universities that simplified the task of data checking and submission.

PHD COMPLETION STATISTICS

In the first 60 years of the PhD (1948-2007), Australian universities awarded a total of 82,841 PhDs [3]. This number is the best available figure obtainable from published sources. Of these, about 9,816, or 11.8%, were in engineering.

Table 1: PhDs Awarded: Australia 1948-2007 by study field.

Year	Agriculture	Architecture	Arts, Law, Creative Arts	Business & Commerce	Education	Engineering	Health	Science	Total
1948-1967 - No.	140	4	378	26	12	167	154	1,320	2,201
%	6.4%	0.2%	17.2%	1.2%	0.5%	7.6%	7.0%	60.0%	100.0%
1968-1987 - No.	964	66	2,966	651	464	1,767	1,677	7,457	16,013
%	6.0%	0.4%	18.5%	4.1%	2.9%	11.0%	10.5%	46.6%	100.0%
1988-2007 - No.	3,199	650	15,562	4,032	4,399	7,882	9,314	19,588	64,626
%	5.0%	1.0%	24.1%	6.2%	6.8%	12.2%	14.4%	30.3%	100.0%
Total - No.	4,303	720	18,906	4,709	4,875	9,816	11,145	28,365	82,841
%	5.2%	0.9%	22.8%	5.7%	5.9%	11.8%	13.5%	34.2%	100.0%

Source: Dobson (Unpublished), from a range of sources [3].
Notes: From 1948 - 1961, *year* = calendar year.
*From 1962 to 1968, *year* = 1 August to 31 July. From 1969 to 1985, *year* = 1 July to 30 June. From 1986 on, *year* = calendar year. Various minor adjustments have been made to compensate for these changes.
*Between 1983 and 1986, official statistics did not report degrees awarded by study field. Figures represented in Table 1 for those years have been apportioned according to the average distribution by study field in 1982 and 1987.

Table 1 demonstrates a number of matters clearly. First, there has been an explosion in the number of PhDs awarded over the past 20 years. In the first 20 years, Australian universities awarded 2,201 PhDs, 2.7% of the total. The middle 20 years saw the awarding of just over 16,000 PhDs, or 19.3%. The period from 1988 to 2007 has seen 64,626 PhDs awarded, 78.0% of all those awarded in the Australian PhD's first 60 years. In fact, the real explosion has occurred over the past 10 years, during which time almost 55% of all Australian PhDs were awarded.

A number of explanations could be put forward to explain this growth and pattern of growth, and these are likely to include:

- the increase in the number of institutions permitted to award PhDs from the late 1980s. This came as a result of the so-called *Dawkins Reforms* of 1988/1989, which transformed a number of teaching-only colleges into PhD-granting universities;
- the rapid expansion in the number of university students, particularly international students, also since the late 1980s;
- the fact that universities now offer PhDs in study fields that were not previously taught at university level, such as nursing; and
- what might be described as credentialism, whereby more and higher qualifications are now required in many sections of the labour market.

Within the PhDs awarded, Table 1 also reveals that PhDs in Science have been predominant, but the proportion of Science of the total has steadily declined. Of the PhDs awarded in the first 20 years of the degree, 60% were in Science. In the 60-year history of the Australian PhD to 2007, 28,365 Science PhDs had been awarded, making up over one-third of the total. PhDs in Arts, Law and the Creative Arts have been the second most common to be awarded, amounting to 22.8% of all PhDs awarded between 1948 and 2007.

Engineering PhDs have grown steadily over the life of the Australian PhD, and by 2007, the 9,816 PhDs in Engineering represented 11.8% of all PhDs awarded. This ranks Engineering fourth, after Science and Arts, and Health, which has awarded 13.5% of all PhDs awarded over the life of the degree.

Earlier it was mentioned that circumstances meant that more detail was available for the period from 1988. By then, university statistical reporting had become predominantly computer-based, and in the early days of personal and desktop computers, universities reported statistical data in the form of unit-record data files on floppy disks [3]. However, various changes in data collection methodologies, and some of the classifications meant that plotting change over time is not necessarily a simple matter. For instance, the study field classification changed from 2001, meaning that comparisons before and from 2001 have to be undertaken with extreme care. Fortunately, these changes had only a minimal impact on Engineering, for which it is possible to produce an accurate time series.

Figure 1 shows the steady growth in the number of PhDs awarded in Engineering between 1988 and 2007 (vertical bars, left-hand axis) and the proportion of all PhDs awarded made up by awards in Engineering (line, right-hand axis). As can be seen, in 1988, 105 PhDs were awarded in Engineering, but in recent years, the annual number has climbed to almost 800. Over the same period, there has been considerable fluctuation in Engineering's proportion of the total. The average over the whole 20-year period has been 12.2%. However, the current trend is that the relative proportion of PhDs in Engineering has been increasing since the new millennium.

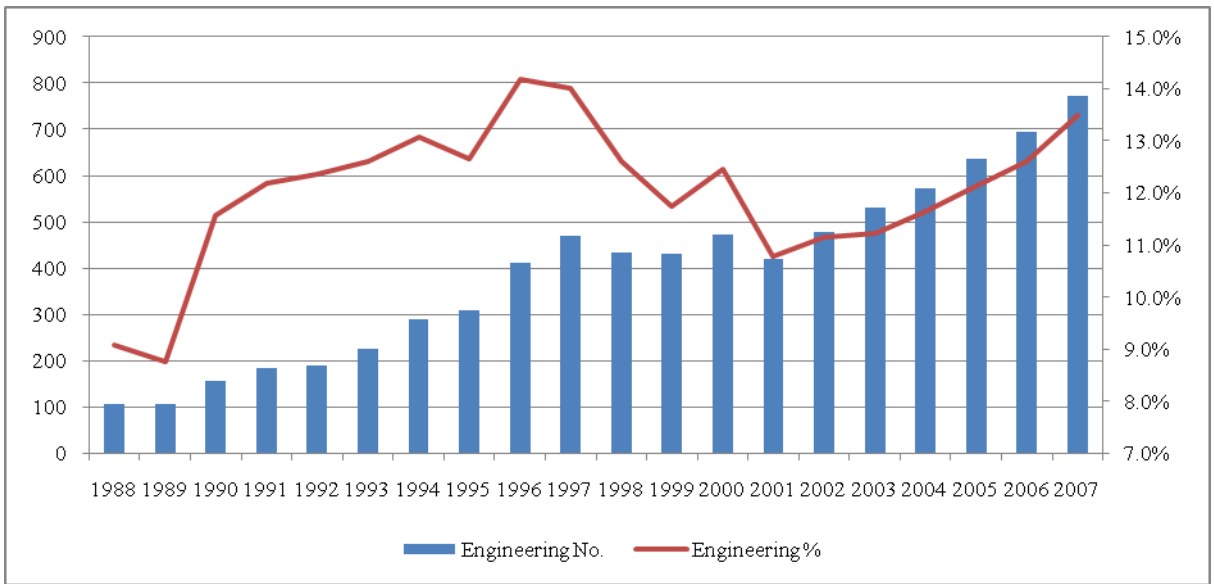

Figure 1: Number of PhDs awarded in Engineering; proportion of all PhDs awarded.

Table 2 presents more detailed information on the number of Engineering PhDs awarded. The overall number has increased from 105 in 1988 to 772 by 2007.

Although women are generally over-represented in Australian higher education (55% in 2007, [4]) they are considerably under-represented in Engineering. However, the presence of women in the PhD graduating classes in Engineering is higher than it is at the bachelor level. Women typically make up around 16% of bachelor degree course completions in Engineering, yet since the early twenty-first century, they have comprised around 20% of those to whom PhDs in Engineering were awarded [4].

Overseas students, most of whom pay full-cost fees in order to study at Australian universities, have increased in number over recent decades. By 2007, overseas students comprised about a quarter of Australia's 1,000,000+ university students, and about 6.8% of those were enrolled in Engineering courses [5]. It is no surprise, therefore, to see that overseas students now make up a substantial proportion of all PhD graduates in Engineering. Although the high representation of overseas Engineering PhD graduates of the early 1990s has not been challenged in recent years, Table 2 shows that in 2007, overseas students made up about one-third of all PhD awards in Engineering. It is likely that some of these PhD graduates remain in Australia and become members of the upper echelons of the engineering profession, but it is equally likely that many return to their countries of origin. To the extent that this is true means that labour market planners must factor in this loss of highly-qualified technologists. The rosy picture painted by the fact of Australia producing nearly 800 Engineering PhDs a year has to be qualified if around 250 of these leave Australia once they have graduated.

Finally, Table 2 examines the extent to which Australia's major research universities are responsible for PhD graduations in Engineering. Academics from Australia's self-designated *Group of Eight* (Go8) universities earn most of the competitive research funding, author most of the scholarly publications, and likewise tend to supervise more PhD graduates than other universities. In 2006, these eight (out of Australia's 35 multi-disciplinary universities) earned 69%

of all research funds, were responsible for 52% of all publications, and enrolled 27% of all PhD students [6]. Looking at PhD graduations in Engineering, it can be seen that in 1988, universities that are now members of the Go8 were responsible for nearly 83% of these, but by 2007, their proportion had declined to about 64%. This is an indication of the expansion of postgraduate capacity in engineering and technology in Australia's other universities, surely a good sign for the nation.

Table 2: PhDs awarded in engineering: Australia 1988-2007. Total, female, overseas students and Group of Eight Universities.

Year	Total No.	Female No.	Female %	Overseas No.	Overseas %	Go8 No.	Go8 %
1988	105	8	7.6%	9	8.6%	87	82.9%
1989	106	4	3.8%	22	20.8%	91	85.8%
1990	157	10	6.4%	60	38.2%	125	79.6%
1991	185	19	10.3%	61	33.0%	147	79.5%
1992	188	24	12.8%	73	38.8%	154	81.9%
1993	226	23	10.2%	104	46.0%	178	78.8%
1994	288	25	8.7%	122	42.4%	213	74.0%
1995	308	38	12.3%	111	36.0%	227	73.7%
1996	412	52	12.6%	122	29.6%	289	70.1%
1997	469	57	12.2%	142	30.3%	319	68.0%
1998	434	73	16.8%	113	26.0%	276	63.6%
1999	430	66	15.3%	114	26.5%	260	60.5%
2000	472	78	16.5%	118	25.0%	286	60.6%
2001	419	80	19.1%	98	23.4%	240	57.3%
2002	478	80	16.7%	99	20.7%	297	62.1%
2003	531	112	21.1%	109	20.5%	298	56.1%
2004	571	112	19.6%	151	26.4%	345	60.4%
2005	636	127	20.0%	185	29.1%	373	58.6%
2006	695	133	19.1%	208	29.9%	437	62.9%
2007	772	157	20.3%	253	32.8%	493	63.9%

CONCLUSION

The aim of this article was a modest one: it intended to do no more than report on the number of the most highly educated engineers that have been produced by the Australian university sector since the awarding of the first Australian PhDs in 1948. This article is probably the first time that the total number of Engineering PhDs produced during the life of the Australian PhD has been stated. At time of writing, the total will have topped 11,000, with nearly 10,000 in the first 60 years since the PhD was first offered in Australia.

The past 20 years have seen about 10,000 PhDs awarded in Engineering. Although this sounds like a large number, and one that might be sufficient for Australia's knowledge economy, it must be remembered that over 28% of these PhD graduates were overseas students, and may have been lost to Australian labour markets.

AUTHOR NOTE

The statistics used in this article have been drawn from the author's yet to be published: *Doctor, doctor! An enumerated history of the PhD in Australia* (Working title). Statistics for that work were drawn from a range of sources, including the Australian Bureau of Statistics, the Commonwealth Tertiary Education Commission, and the Federal Education Ministry in its many guises.

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BIOGRAPHY

Dr Ian R Dobson was a career administrator, predominantly in strategic planning and statistical analysis. In his formal career he held posts at RMIT, the University of Melbourne and Monash University, between 1971 and 2005. Since then, he has been a freelance researcher, editor and consultant. He has had about 60 papers published in scholarly journals and is editor of the Journal of Higher Education Policy and Management and the Australian Universities' Review. His PhD was on access to higher education, social mobility and higher education equity policy. He spends much of his time in Finland, and his currently working on a research project on the academic profession with the University of Helsinki. He also has links with the L H Martin Institute for Higher Education Leadership and Management at the University of Melbourne.