



Australian Government
**Department of Education,
Science and Training**

Audit of science, engineering & technology skills



S U M M A R Y R E P O R T

J U L Y 2 0 0 6



Australian Government
**Department of Education,
Science and Training**

Audit of science, engineering & technology skills | July 2006



S U M M A R Y R E P O R T

ISBN: 0 642 77625 3
0 642 77627 X (online)

© Commonwealth of Australia 2006

This work is copyright. It may be reproduced in whole or in part for study or training purposes subject to the inclusion of an acknowledgment of the source and no commercial usage or sale. Reproduction for purposes other than those indicated above, requires the prior written permission from the Commonwealth. Requests and inquiries concerning reproduction and rights should be addressed to Commonwealth Copyright Administration, Attorney General's Department, Robert Garran Offices, National Circuit, Barton ACT 2600 or posted at <http://www.ag.gov.au/cca>



A MESSAGE FROM THE MINISTER

Australia's productivity and success in the highly competitive global market is increasingly reliant on science, engineering and technology (SET) skills. Our abilities in research and development, innovation and discovery are dependent upon the availability of suitably skilled scientists and engineers.

The SET audit is a reflection of the commitment of the Australian Government toward research, development and innovation. Through *Backing Australia's Ability, Our Universities – Backing Australia's Future* and a number of other initiatives, the Australian Government is committed to providing support to develop Australia's SET capacity.

Our capacity to train young people to produce the next generation of scientists and engineers is also reliant on our current capability in SET. A broader question for the Australian Government, state and territory governments, industry groups and the research community is how we develop, maintain and foster the supply of relevant skills to meet industry, research and community needs.

Against this background, the *SET Skills Audit* was commissioned by the Australian Government to examine trends in the demand and supply of these skills in Australia and the factors affecting this balance.

The report raises a number of issues: skills shortages in many engineering and some science disciplines; a static or declining proportion of participation in the enabling sciences and advanced mathematics in schools and in post-school settings; concerns about the quality of science education; and the increasing need for SET graduates to have enabling and cross-disciplinary skills. The report will inform Government consideration of these issues.

I am pleased to release this overview report and believe it will provide a sound basis for further examination of these issues in consultation with key stakeholders.

Julie Bishop

Minister for Education, Science and Training

July 2006



CONTENTS

Executive Summary	ix
1 Introduction	1
2 Public and private sector demand for SET skills from industry, the research community and education providers, both now and into the future	3
2.1 Past and current trends in Australian SET employment	3
2.2 Projected annual job growth and replacement demand for skills in Australian SET industries	6
2.3 Skill needs for specific industries	10
3 The supply of SET skills from all training and education sectors	17
3.1 Participation in SET study	17
3.2 Quality of students studying SET	26
3.3 Engagement with SET	28
4 Demand for SET skills compared to supply of SET skills	31
5 The success of the education sector in meeting existing skill needs and responding to emerging needs	37
5.1 Education and training	37
5.2 Investment in research and development (R&D)	39
5.3 Building research capacity to support research excellence	39
5.4 Building collaboration and linkages	40
5.5 Raising community awareness of and engagement in SET	41
5.6 Enhancing SET teacher quality and numbers	41
5.7 Other areas for action	42
6 The long and short-term trends in the emigration and immigration of SET graduates and the impact on Australia's SET skill base	43
6.1 Australia's SET capacity compared to other countries	43
6.2 International factors influencing the availability of Australia's SET skills	45
7 Conclusions and Next Steps	49
7.1 Summary of audit findings	49
7.2 Challenges	50
7.3 Next steps	51
7.4 Related Material	51
APPENDIX A: Steering Committee members	53
APPENDIX B: ASCED 2-, 4- and 6-digit classification system	55
APPENDIX C: ABS correspondence of pre-2001 6-digit Field Of Study codes to post-2000 ASCED 4-digit Field of Education groups	59
References	61

LIST OF TABLES

Table 2.1:	Persons employed with engineering qualifications by industry, Australia, 2004–05	4
Table 2.2:	Persons employed with natural & physical science qualifications by industry, Australia, 2004–05	4
Table 2.3:	Employment growth for SET between 1996–97 and 2004–05 and projected employment growth for SET between 2004–05 and 2012–13, expressed as per cent of total growth, by 4-digit ASCED code	5
Table 2.4:	Levels of annual replacement demand and new employment growth between 1995–96 and 2003–04 and projected levels of replacement demand and new employment growth between 2003–04 and 2011–12 for SET occupations by ASCO code	7
Table 2.5:	Current vacancies in SET occupations by level	12
Table 3.1:	Potential supply of SET skills from schools	18
Table 3.2:	Percentage of Year 11 and 12 students participating in science, mathematics and technology across different university career destinations	19
Table 3.3:	Supply of SET skills from the vocational and technical education sector	19
Table 3.4:	Supply of SET skills from the higher education sector	22
Table 3.5:	Enrolments in undergraduate programmes for science and engineering 4-digit ASCED course groups across domestic and overseas students from 1989 to 2004	24
Table 3.6:	Enrolments in post-graduate programmes for science and engineering 4-digit ASCED course groups for domestic and overseas students from 1989 to 2004	25
Table 3.7:	UAI/TER at quartile percentile rankings, students who accepted offer by selected field of education – 2004	27
Table 3.8:	Top reasons influencing subject choice and reasons for interest/disinterest in science (S), mathematics (M) and technology (T) subjects by cohort and student interest level	29
Table 4.1:	Total demand increase and supply from education for science professionals	33
Table 4.2:	Total demand increase and supply from education for engineering professionals	34
Table 4.3:	Total demand increase and supply from education for engineering trades	35
Table 6.1:	Proportion of higher education graduates by field of study, Australia compared to the OECD, 2003	44
Table 6.2:	Sources of finance for research and development and performance of research and development by sector, Australia compared to the OECD and China, 2003	45
Table 6.3:	Net flow of persons from migration, for selected occupations, permanent and long term movements, 1998–99 to 2002–03, as a percentage of 2001 stock	46



LIST OF FIGURES

Figure 2.1: Unemployment rate in Australia, 1978–2005 (trend series).....	10
Figure 2.2: Recruitment difficulty rating for engineering-related occupations (per cent).....	13
Figure 2.3: Typical length of time spent on recruiting engineering-related occupations (per cent)	13
Figure 2.4: Main sources of employees in SET-related occupations (per cent)	14
Figure 2.5: Consulting engineering industry study; rating of level of recruitment difficulty (per cent)	15
Figure 3.1: Factors influencing career choice for the three cohorts surveyed: Year 10 students, Year 11 and 12 students and School Leavers	30
Figure 4.1: Labour force status of persons aged 15 and over with Bachelor Degrees or Higher Qualifications in Civil Engineering by period since qualifying.....	32



EXECUTIVE SUMMARY

The skills and abilities of our population are a key resource for Australia's continued prosperity. Science, engineering and technology (SET) skills are vital, as they provide the basis for an innovative and globally competitive workforce. The development of these skills contributes to the development and growth of industry and research sectors and, in turn, the growth and productivity of the economy.

The Australian Government provides extensive support for SET in Australia. The *Backing Australia's Ability (BAA)* initiative was introduced by the Australian Government in 2001, to promote science and innovation. The initiative was the largest (\$3 billion over the 5 years 2001–02 to 2005–06) and most comprehensive set of measures ever put in place by any Australian Government in support of science and innovation. In 2004, the Prime Minister announced the *Backing Australia's Ability – Building our Future through Science and Innovation* package. This package builds on the initial 2001 BAA investment and together these packages constitute a ten year, \$8.3 billion funding commitment stretching from 2001–02 to 2010–11. BAA represents a commitment from the Australian Government to pursue excellence in research, science and innovation through three key themes: the generation of new ideas (research and development); the commercial application of ideas; and developing and retaining skills.

However, the adequacy of SET skill supply is an ongoing concern for Australian industry, governments, and the scientific research community and gaps in SET skill supply have been identified. This concern is shared by many Organisation for Economic Cooperation and Development (OECD) countries, which are experiencing declines in the SET share of higher education enrolments in their countries, coupled with a seeming decline in youth interest in SET study and careers.

The audit of SET skills was initiated by the (then) Minister for Education, Science and Training, The Honourable Dr Brendan Nelson, MP in October, 2004. The aim of the audit was to investigate the adequacy of supply of these skills by examining trends, both in demand from industry and the scientific research community, and in supply from all education and training sectors. The audit also considered the impacts of migration on the supply and demand of these skills and the factors influencing trends in migration.

It should be noted that the audit has not involved examination of Australia's health or ICT skills issues. Skills issues in these fields have been examined concurrently by the Productivity Commission (health skills) and the Department of Communication, Information Technology and the Arts (information communication technology skills).

The audit was informed by a comprehensive consultation process involving meetings and discussions with key stakeholders, as well as written submissions and reviews of relevant literature. Analysis of existing research on supply and demand of SET skills; a study by The Allen Consulting Group on international demand for Australia's SET skills; a survey on youth attitudes towards science, mathematics and technology study and SET careers; and an industry survey on current and future demand for SET skills, together with a series of industry studies for industries reliant on these skills, all formed an integral part of the audit process.

The audit found that the proportion of domestic students in SET study across all education and training sectors has remained static or declined in Australia over the past decade. This was particularly apparent for enabling sciences, which include advanced and intermediate mathematics, physics and chemistry.

In contrast, overseas students constituted an increasing proportion of enrolments and completions in Australian SET courses at the undergraduate and postgraduate level at Australian universities, helping to ensure the sustainability of some courses. The result of the downward trend in domestic school enrolments and vocational training and higher education SET commencements/enrolments and completions is a decreasing pool of applicants for SET positions in industry and the scientific research sector.

Feedback from audit submissions and consultations undertaken as part of the audit highlighted a perception among industry and the vocational and technical education and higher education sectors that many students leaving school were ill-prepared for tertiary study and employment in SET fields. There was also a strong perception that Australia lacks sufficient suitably qualified secondary school science teachers, which impacts adversely on student engagement in SET.

There was also a concern in consultations and submissions about a lack of quality SET careers advice. Negative community perceptions of careers in SET industries and the research sector were also reported as having had an effect on young persons' perceptions of SET careers. The perceived benefit of SET study in schools, and the number of students considering SET careers, is relatively low compared to some other high profile areas (e.g. medicine, law).

The audit found that international migration may also impact on the availability of SET skills in Australia. In recognition of the fact that SET skills are in demand, the European Union, the USA and the BRIC countries (Brazil, Russia, India and China) are developing policies aimed at retaining their own SET skills base and attracting overseas SET-qualified staff. Although there was a net inflow of skilled persons to Australia between 1998 and 2003, the increasing emphasis and associated expenditure on Research and Development (R&D) by Organisation for Economic Cooperation and Development (OECD) countries may result in a net outflow of Australia's SET skills in the future.

A comparison of projections of demand for skills by the Centre of Policy Studies from Monash University (Monash) until 2012-2013 to supply projections from higher education and vocational and technical education suggests that the present supply of non health related SET skills from domestic and overseas sources appears adequate to meet Australian industry and research SET skill needs. However, labour demand projections are

based on historical data, and may not reflect recent, planned, or potential developments in the resources sector, infrastructure development and renewal or defence materiel needs.

Australia's labour market is currently very tight, with the low unemployment rate (approaching 5 per cent) reflecting strong employment growth in many industries. As a result, employers are likely to face recruiting difficulties. Recruiting difficulties are likely to be intense for low paid jobs or where employers have adverse reputations or jobs are located in remote or rural areas.

As a result, *sectoral labour supply* issues were evident, particularly in respect to engineering skills. There has been strong recent growth in demand for some SET skills, reflecting growth in the resources sector, defence needs and infrastructure development and renewal. This has led to significant recruitment difficulties with respect to certain SET skill sets, particularly in engineering disciplines, and in sciences such as earth sciences, chemistry, spatial information sciences and entomology. In the finance sector, as in other industries, recruiting difficulties exist in respect to high level mathematical and statistical skills.

The audit industry survey indicated that employers are having considerable difficulties in recruiting engineers in comparison to recruiting in other skill sets. This survey also indicated that recruiting periods in engineering disciplines are longer than for non SET skills. The industry study on consulting engineers confirmed this concern, despite increasing industry attempts to recruit in international markets. Similar concerns were evident in submissions to the audit and in audit consultations.

The consulting engineering industry study also drew attention to substantial recent salary movements in engineering professions, a further indicator of recruiting difficulties. Increased salary pressures are also reflected in recent increases in salaries for graduate engineers. This has led to more frequent salary reviews in the consulting engineering industry. Consulting engineer industry study participants expressed concern that skill capacity constraints are causing difficulty in relation to engaging in emerging business opportunities.

One factor adding to these recruitment difficulties is the extent of wastage from employment in SET occupations. Some people with SET qualifications go on to work in related occupations, e.g. management roles. However, a significant proportion of people with SET qualifications do not work in SET related occupations. This proportion tends to increase with time, post qualification.

The audit also found significant challenges in meeting future SET skills requirements. Similar issues were reflected in the 2005 Department of Employment and Workplace Relations publication, *Workforce Tomorrow*, which suggests population ageing has the potential to cause skill shortages in many occupations, including SET occupations.

Participation in SET careers will be influenced by the ageing of the SET workforce; a decline in the number of school leavers from 2010 onwards as a result of demographic change; the low profile of SET careers; limited community awareness of the benefits of investment in the sector; and concerns about the adequacy of funding with respect to student places and teaching infrastructure for education and training providers.

Projections produced by Monash, based on historical data, suggest replacement demand for SET skills (i.e. demand that arises from staff turnover, movements and retirement) is likely to be greater than new demand for skills as a result of economic growth over the projection period to 2012.

Capacity will be constrained by competition for skilled workers due to the high level of international demand for SET skills, difficulties in keeping pace with growth and technological change occurring in SET industries, the availability of adequate infrastructure to support SET in universities and concerns about support for research careers. The audit provides a valuable evidence base for further consideration of practical solutions to meeting Australia's current and future SET skills needs.

The audit findings present Australia with challenges. The audit suggests Australia cannot be complacent about SET skill formation. It is vital that Australia has the skill sets to facilitate continued development of knowledge intensive industries. On the other hand, the audit findings provide an opportunity to better develop SET skill sets in demand by the scientific research community and by industry in consultation with key stakeholders.

Challenges in building Australia's science, research and innovation capacity for the future include:

- Improving information about and awareness of SET and SET career opportunities among students, parents, industry and the community to encourage growth in the number of school students studying SET and aspiring to SET careers.
- Facilitating more rapid SET skills acquisition by existing workers, apprentices and new entrants to the labour market to meet demand in a responsive way.
- Improving the capacity of the education and training system to deliver high quality SET courses. An adequate supply of well qualified science and mathematics teachers is a key to success.
- Continuing to ensure that Australia has an adequate stock of scientists, engineers and technologists in Australia, including through emigration and immigration of SET graduates, to meet the skill needs of industry and the scientific research community.
- Enhancing the understanding of SET career opportunities among early to mid-career researchers and working with the public and private research sector to provide rewarding career paths for young researchers.
- Continuing Government and industry reforms to ensure that flexible employment practices are in place to facilitate the long-term supply of skilled SET workers.
- More effective staff retention strategies (especially for older workers), to reduce attrition of qualified SET workers either to retirement or to other occupations.
- Ensuring quality infrastructure is in place to support SET training and research.

In meeting these challenges, there will be a need for ongoing consultation with all the relevant stakeholders to ensure that practical solutions are developed to best meet Australia's SET skill needs now and into the future.



INTRODUCTION

Australia's future prosperity rests in the skills and capabilities of its people. While the rest of the world is a significant source of ideas and technologies, a country like Australia cannot rely on a strategy of passive absorption to maintain strong productivity performance. In order to benefit from this knowledge, countries need to have well trained scientists, a technologically capable workforce and active engagement in cutting edge research. Science, engineering and technology (SET) skills are therefore necessary to enable Australia to perform successfully in a highly competitive global market.

There is considerable evidence in Australia and in other Organisation for Economic Cooperation and Development (OECD) countries of the contribution science and innovation make to productivity and growth in modern economies, as well as to improved social and environmental quality of life. Silicon Valley in the United States, along with the recent developments in India and China, for example, all demonstrate how the existence of a skilled workforce can transform an economy. A high performing science and innovation system contributes to the development of new businesses, jobs growth, environmental sustainability and social well-being.

Australia's scientific and engineering capacity depends on the availability of suitably skilled scientists and engineers to meet industry and research needs. Sufficiency of SET skills within the economy depends on a number of factors: supply from education and immigration; demand levels as influenced by economic growth (including the evolution of new industries and expansion of private and public sector research and development); and wastage rates through emigration, retirement and skill losses to other industries.

The Australian Government demonstrates its commitment to science and innovation through longer-term funding support. The *Backing Australia's Ability – An Innovation Action Plan for the Future* and *Backing Australia's Ability – Building Our Future Through Science and Innovation* initiatives, announced in the 2001–02 and 2004–05 Budgets respectively, represent a commitment of an additional \$8.3 billion over 10 years to 2010–11. Additionally, *Our Universities: Backing Australia's Future*, a reform package announced in May 2003, lays the foundation for a ten year vision for Australian higher education. The latter will see more than \$2.6 billion of additional Australian Government funding being invested over five years through an integrated policy framework based on four foundation principles: sustainability, quality, equity and diversity.

Together, the *Backing Australia's Ability* initiatives and existing funding for ongoing science and innovation programmes amount to a total investment in science and innovation by the Australian Government of about \$53 billion over the same period.

However, Australia's recent strong economic growth has resulted in a substantial increase in the demand for skilled workers including persons with science, engineering and technology skills. Strong growth in demand for SET skills has led to labour supply issues in many SET occupations.

Industry and the scientific research community have therefore become concerned that the supply of SET skills are not adequate and will not be adequate to meet Australia's needs in future. The aim of the audit of SET skills was to examine trends in demand for SET skills by industry and the scientific research community compared to supply of these skills from the education and training sectors including schools, vocational and technical education and higher education in Australia. The audit also examined gains and losses of SET skills through migration and factors influencing trends in migration.

The audit involved the Department of Education, Science and Training (DEST) undertaking extensive analytic work during 2005, together with broad consultation with and submissions from key stakeholders, an industry survey on current and future demand of SET skills, a series of industry specific studies and a survey on youth attitudes to SET study and career choice. DEST also commissioned The Allen Consulting Group to undertake an investigation into international factors influencing the availability of Australia's science, engineering and technology skills to feed into the audit. A comprehensive literature review was used to inform the audit process.

The audit was overseen by a high level Steering Committee comprising representatives from industry bodies, the science and school communities, learned academies, and higher education and vocational and technical education (VTE) sectors (see Appendix A). The Committee was chaired by DEST.

The audit report generally excludes discussion of the demand for information communication technology (ICT) and health-related skills in SET, as these were the subject of separate Department of Communications, Information Technology and the Arts (DCITA) and Productivity Commission reviews respectively.



PUBLIC AND PRIVATE SECTOR DEMAND FOR SET SKILLS FROM INDUSTRY, THE RESEARCH COMMUNITY AND EDUCATION PROVIDERS, BOTH NOW AND INTO THE FUTURE

Demand from industry for skilled employees is comprised of two basic components: demand that arises due to economic growth and/or the emergence of new industries and technology leading to the creation of new jobs that did not previously exist, referred to as ‘new’ demand; and demand that arises from staff turnover, movements and retirement, referred to as ‘replacement demand’.

New demand can be difficult to estimate for two reasons. First, labour market projections are based on historical data and may not fully reflect current labour market conditions (e.g. recent strong growth in Australia’s resources sector). Second, innovation and technological change frequently results in the creation of new occupations and substantial change in the nature of existing occupations, which may not be well reflected in existing occupational classifications.

Knowing which industries and emerging technologies will require skilled workers, which industries and occupation areas are growing and the level of skills they require can help provide the knowledge needed to implement successful skill development policies. The audit examined past and current trends in Australian employment, projected employment growth and subsequent demand for skills in Australian SET industries and skill needs for specific industries.

2.1 Past and current trends in Australian SET employment

Australia has a substantial SET skills base relative to overall employment, with around 13.5 per cent of employed persons possessing SET qualifications. This compares reasonably well with many OECD countries. OECD data from Eurostat indicated that in 1998 between 15 and 20 per cent of the population of Denmark, Germany, France, Ireland, Luxembourg, the Netherlands and the United Kingdom held science and technology related qualifications.

The employment of persons with SET qualifications is dispersed across all industries in Australia. Persons with professional, associate professional and trade level engineering qualifications, for example, are widely employed across the Australian economy, as shown in Table 2.1. This includes employment of around 90,000 professional engineers and 10,000 engineer managers. Likewise, persons with qualifications in Natural and Physical Sciences are employed across all occupations in Australia (Table 2.2).

Table 2.1: Persons employed with engineering qualifications by industry, Australia, 2004–05

	Number (000's)	Proportion by industry (%)
Agriculture, etc.	30.3	2.8
Mining	30.3	2.8
Manufacturing	231.6	21.4
Utilities	21.6	2.0
Construction	143.9	13.3
Wholesale trade	59.5	5.5
Retail trade	162.3	15.0
Hotels/hospitality	19.5	1.8
Transport/storage	69.3	6.4
Communications	28.1	2.6
Finance/insurance	16.2	1.5
Business services	130.9	12.1
Government administration/defence	44.4	4.1
Education	23.8	2.2
Health/community	26.0	2.4
Cultural/recreational services	18.4	1.7
Personal services, etc.	28.1	2.6
Total	1082.2	100.0

Source: Centre of Policy Studies, Monash University, 2005.

Table 2.2: Persons employed with natural & physical science qualifications by industry, Australia, 2004–05

	Number (000's)	Proportion by industry (%)
Agriculture, etc.	6.1	3.1%
Mining	4.5	2.3%
Manufacturing	15.6	7.9%
Utilities	2.2	1.1%
Construction	5.5	2.8%
Wholesale trade	6.7	3.4%
Retail trade	12.6	6.4%
Hotels/hospitality	3.0	1.5%
Transport/storage	5.9	3.0%
Communications	3.4	1.7%
Finance/insurance	7.9	4.0%
Business services	35.3	17.9%
Government administration/defence	14.8	7.5%
Education	36.9	18.7%
Health/community	24.3	12.3%
Cultural/recreational services	6.3	3.2%
Personal services, etc.	5.9	3.0%
Total	197.4	100.0%

Source: Centre of Policy Studies, Monash University, 2005.

Considered by field of education, in the ten years from 1996–97 to 2004–05, growth in employment was relatively high for the science and agriculture sectors and relatively low for the engineering sector, as illustrated in Table 2.3. This trend was driven by high levels of employment growth in environmental studies, other natural sciences and biological sciences, low levels of employment growth in electrical and electronic engineering (less than 5 per cent), negative employment growth in mechanical and industrial engineering and automotive engineering and moderate levels of growth in the remaining fields.

However, projected employment growth by field of education is lower for agriculture and natural and physical sciences for the period 2004–05 to 2012–13 than was the case for the period 1996–97 to 2004–05.

Employment growth for persons with engineering qualifications is projected to be higher from 2004–05 to 2012–13 than was the case between 1996–97 and 2004–05, reflecting anticipated growth in resources and infrastructure developments.

Table 2.3: Employment growth for SET between 1996–97 and 2004–05 and projected employment growth for SET between 2004–05 and 2012–13, expressed as per cent of total growth, by 4-digit ASCED code

ASCED Field Category	Employment Growth 1996–97 to 2004–05 (%)	Projected Employment Growth 2004–05 to 2012–13 (%)
Environmental studies	97.3	44.7
Forestry studies	61.3	44.0
Fisheries studies	83.3	40.9
Other agricultural & environment	242.9	37.5
Horticulture & viticulture	72.9	34.5
Agriculture	26.7	31.7
Total Agriculture	56.8	36.2
Physics and astronomy	33.0	49.6
Biological sciences	70.3	33.8
Other natural sciences	36.7	33.8
Mathematical sciences	52.1	32.5
Chemical sciences	5.4	28.6
Earth sciences	-11.9	26.2
Total Natural & Physical Sciences	36.7	33.3
Aerospace engineering	6.1	39.5
Process and resources engineering	32.9	38.7
Geomatic engineering	25.2	36.0
Other engineering	34.2	34.4
Maritime engineering	2.5	32.7
Civil engineering	14.9	24.3
Mechanical and industrial engineering	8.1	12.1
Automotive engineering	1.9	8.0
Electric and electronic engineering	7.8	6.5
Manufacturing engineering	-12.3	5.2
Total engineering	7.1	13.5

Source: Centre of Policy Studies, Monash University, 2005.

2.2 Projected annual job growth and replacement demand for skills in Australian SET industries

Monash projections of demand for SET skills in the period from 2004–05 to 2012–13 for engineering and science graduates from higher education and VTE suggest that graduates from the education and training sector, together with planned levels of migration, will largely be able to meet industry and the scientific research community's SET skill needs. It is expected that the Skilled Migration Programme will also assist in meeting demand for skills, especially specialist skills.

However, the Monash projections are based on historical data and may not reflect recent, planned, or likely growth in the resources sector, infrastructure development and renewal projects, or emerging defence materiel needs. In addition, Australia's SET skill pool may be reduced by possible moves in outward migration as a result of increased international demand for SET skills.

Employment grew in most SET professional occupations and just over half of the SET related trades between 1995–96 and 2003–04 (Table 2.4). Strong jobs growth was recorded for professionals in environmental and agricultural science, geologists and geophysicists, other building and engineering and business analysts.

For SET associate professionals, the highest annual job growth in the period to 2004–05 was in building, architecture and surveying as well as other building and engineering associate professionals. All other associate professional groups experienced negative annual job growth. Relatively strong annual job growth was also recorded for some SET trades occupations including: general fabrication engineering, aircraft maintenance engineering and refrigeration/air conditioning mechanics.

Monash anticipates stronger employment growth in most SET occupations than the overall employment national average in the period ahead, outside of SET trades.

In the sciences, Monash projects strongest annual job growth between 2003–04 and 2011–12 for mathematicians, statisticians and actuaries, and environmental and agricultural scientists. Some groups of professional engineers experienced annual job growth of up to 5.5 per cent between 1995–96 and 2003–04, but Monash projects future job growth for professional engineers at up to 14 per cent to 2011–12. Job growth for building and engineering professionals, mining and material engineers, electrical and electronic engineers, and mechanical engineers is projected to be offset by a decline in employment of civil engineers.

For associate professionals, annual job growth is expected to be negative except for building, architecture and surveying associate professionals and other building & engineering associate professionals. Total employment in SET trades is anticipated to grow only slightly to 2011–12. However, growth projections vary markedly among trades. Among the main trades (over 20,000 employees) job growth is expected to be strongest for structural steel and welding trades, followed by the electronic/office trades. However, employment of motor mechanics and electricians is expected to decline.

Overall, Monash projections suggests that ‘replacement’ demand for SET skills will be more important than ‘new’ demand from job growth for SET skills in the next decade (Table 2.4). Projected annual replacement demand ranges from 2 to 12 per cent for all categories with engineering technologists, general fabrication engineering tradespersons, forging tradespersons and electronic instrument tradespersons showing an annual replacement demand of greater than 8 per cent from 2004–05 to 2012–13. SET professional and trade occupation groups are projected to experience replacement demand greater than that of the average for all Australian occupations at 3.2 per cent per year. This reflects anticipated age based retirement of ‘baby boomers’ born between 1946 and 1959.

Table 2.4: Levels of annual replacement demand and new employment growth between 1995–96 and 2003–04 and projected levels of replacement demand and new employment growth between 2003–04 and 2011–12 for SET occupations by ASCO code*

ASCO Occupation	Persons Employed	Annual Employment Demand		Persons Employed	Annual Employment Demand	
	1995–96	1995–96 to 2003–04		2003–04	2003–04 to 2011–12	
	(000's)	Repl (%)	Growth (%)	(000's)	Repl (%)	Growth (%)
Chemists	7.7	4.5	-1.3	7.0	4.1	-0.4
Geologists & Geophysicists	5.7	4.1	4.9	8.3	5.1	1.6
Life Scientists	6.7	3.9	1.5	7.5	3.4	1.5
Environmental and Agricultural Science Professionals	12.5	1.5	7.0	21.6	2.0	3.9
Medical Scientists	12.4	1.6	3.2	16.0	4.3	2.8
Other Natural & Physical Science Professionals	5.5	4.5	-6.0	3.3	4.5	-2.3
Mathematicians, Statisticians & Actuaries	3.7	5.3	-0.5	3.6	5.9	-0.8
Business Analysts	26.9	1.2	5.2	40.3	2.0	3.2
Pharmacists	13.2	2.7	1.8	15.1	3.1	0.9
Total Science Professionals	94.3	3.3	1.8	122.7	3.8	1.2
Architects & Landscape Architects	14.0	2.3	3.7	18.7	3.0	1.1
Quantity Surveyors	1.7	5.3	-5.1	1.1	4.1	-3.4
Cartographers & Surveyors	7.7	3.4	2.1	9.1	4.0	-0.2
Total Building Professionals	23.4	3.7	0.2	28.9	3.7	-0.8
Civil Engineers	24.7	2.9	1.5	27.9	3.8	0.4
Electrical/Electronics Engineers	21.4	2.2	1.7	24.5	3.7	0.9
Mechanical Production and Plant Engineers	24.0	2.5	-3.0	18.8	4.8	-1.9
Mining & Materials Engineers	4.7	4.2	-1.4	4.2	5.7	-3.6
Engineering Technologists	0.5	7.5	-9.4	0.2	8.4	-4.9
Other Building and Engineering Professionals	9.2	4.1	5.5	14.1	3.3	2.8
Total Engineering Professionals	84.5	3.9	-0.9	89.7	5.0	-1.1
Science Technical Officers	27.3	2.2	-4.5	18.8	3.1	-2.4
Building, Architecture and Surveying Associate Professionals	38.5	2.3	3.8	52.0	2.4	1.5
Civil Engineering Associate Professionals	8.5	3.6	-1.6	7.5	3.7	-1.5
Electrical Engineering Associate Professionals	8.7	2.4	-3.8	6.4	2.5	-2.6
Electronic Engineering Associate Professionals	21.3	1.7	-4.2	15.1	2.5	-2.3

ASCO Occupation	Persons Employed	Annual Employment Demand		Persons Employed	Annual Employment Demand	
	1995–96	1995–96 to 2003–04		2003–04	2003–04 to 2011–12	
	(000's)	Repl (%)	Growth (%)	(000's)	Repl (%)	Growth (%)
Mechanical Engineering Associate Professionals	8.9	3.0	-1.0	8.2	4.4	-1.4
Other Building & Engineering Associate Professionals	7.5	2.5	3.3	9.7	2.2	2.1
Total SET Associate professionals	120.7	2.5	-1.1	117.7	3.0	-1.0
Aircraft Maintenance Engineers	8.4	2.2	5.0	12.5	3.3	2.7
Precision Metal Trades	8.1	3.6	1.6	9.2	5.2	1.8
General Fabrication Engineering Trades	0.7	8.3	7.1	1.2	8.8	4.1
Structural Steel & Welding Trades	60.7	2.2	1.7	69.4	1.8	1.7
Forging Tradespersons	1.2	6.9	0.8	1.3	9.2	-2.9
Sheetmetal Tradespersons	9.9	3.3	-0.6	9.4	5.0	0.3
Metal Casting Tradespersons	0.8	5.7	0.5	0.9	7.1	-1.8
Metal Finishing Tradesperson	1.8	5.7	3.4	2.4	5.9	1.5
Motor Mechanics	96.2	2.7	0.5	100.2	2.9	1.1
Automotive Electricians	7.0	4.8	1.0	7.6	5.9	2.8
Panel Beaters	20.8	2.9	-1.9	17.8	3.1	0.4
Vehicle Painters	10.5	3.8	1.7	12.0	4.8	3.5
Vehicle Body Makers	2.2	5.6	-1.3	2.0	5.8	0.0
Vehicle Trimmers	2.0	6.4	1.3	2.2	5.9	0.4
Electricians	93.0	2.2	1.5	104.6	2.8	-0.2
Refrigeration/Air-Conditioning Mechanics	11.9	2.4	4.0	16.2	3.4	2.2
Electrical Distribution. Trades	7.9	2.7	-0.9	7.4	4.7	-1.7
Electronic Instrument Trades	1.0	5.2	-3.4	0.8	9.6	3.4
Electronic/Office Equip Trades	29.9	2.5	2.0	35.1	3.7	1.3
Communications Tradespersons	30.3	2.4	-2.5	24.8	3.1	-3.1
Total SET Trades	514.1	4.0	0.8	537.3	4.9	0.7
All occupations	8,289.0	2.6	1.7	9,518.4	3.2	1.4

Source: Centre of Policy Studies, Monash University, 2004, based on ABS data.

* pre-2001 data contains duplication of enrolments, only the trends should be considered.

Looking ahead to the next 15 to 20 years, a foresighting exercise into the long-term influences on demand for SET skills undertaken by members of the audit's Steering Committee suggested that the most important factors for SET skills demand would be: population issues; globalisation and technological change; the need for 'enabling' capabilities among SET personnel; and skill requirements of emerging industries.

Population pressures, including ageing, geographic location and changes to the family unit will all impact significantly on future patterns of demand for SET and in turn SET skills over the next 15 to 20 years. Innovative solutions will be needed to address demand for energy and water consumption, to improve transport links, and balance increased demand for housing fuelled by more separate one person or single parent households. Longer life spans will also be facilitated by further advancements in health technologies, services and infrastructure.

Globalisation of the world economy is likely to continue to be driven by developments in transportation and communication technologies and the policy decisions of governments to reduce barriers to international commerce. An increasingly globalised world suggests that the Australian economy will progressively specialise in products and services in which it has a natural or developed comparative advantage. Higher concentration of employment in areas of natural or created comparative advantage suggests greater skill requirements in the future in areas such as resources, high-skilled services (e.g. health and medical services and business and financial services), and niche, high value-added manufacturing.

The integration of the world economy and increasing global competition has also increased the pace of technological change. Higher trans-border technology flows and the increased importance placed on innovation as a result of globalised competition has led to shorter product life-cycles and faster technological change processes. Continued technological change will also be an important contributor to the changing productive structure of the economy, and thus a driver of changing comparative advantage and skill needs.

The result of increased globalisation and rapid technological advancements is an economy in which productive processes and skill requirements are in a constant state of change. In such an environment, the skill needs of employees have been extended beyond just technical skills, to requiring underpinning generic skills like self management, initiative and enterprise, and the ability for ongoing learning. The Steering Committee suggested that the importance of these ‘employability’ skills will only increase in the future and will provide the workforce with the best ability to meet uncertain changes in skill requirements as a result of evolving technological change.

Further, Steering Committee members indicated that it was difficult to predict where the skill needs of future industries may lie but suggested that the following industries will be amongst those of increasing importance and/or significance over time: environmental technology solutions; tourism; energy generation and exports and mining technologies; electronics; pharmaceutical, health and medical technologies; healthcare and aged care industries; and agriculture and aquaculture. Steering Committee members suggested it is likely that these industries will be clustered around nano- and biotechnology, new materials and ICT. Although it may not be possible for Australia to become a leader in these technologies, Steering Committee members believed it is critical that Australia at least has the skills to support a “fast follower” strategy.

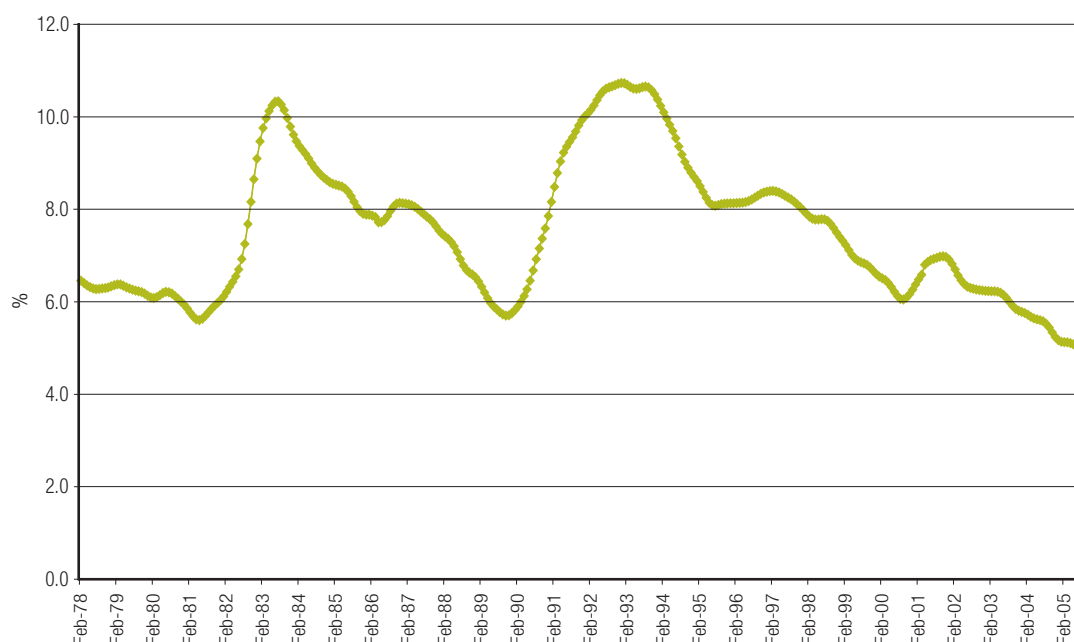
Steering Committee members also noted that the incidence of cross disciplinary research is growing, increasing the need for project management skills and improved communication skills for SET workers. In addition, Steering Committee members noted that it is important to enhance SET workers’ entrepreneurial skills to better facilitate commercial applications of Australian research and development.

On the domestic front, the issues for researchers most commonly raised in stakeholder discussions and audit submissions were a lack of career paths (particularly opportunities for mid-career researchers), the challenge of complying to an ever growing body of regulatory requirements, insufficient resources to build research capacity at an internationally competitive level through investment in infrastructure and resources (staff, supplies, etc.) and promotion and encouragement of collaborations and linkages on an international scale.

2.3 Skill needs for specific industries

The 2006 Australian labour market is relatively tight. Australia's unemployment rate is now around 5 per cent following sustained employment growth in many industries (Figure 2.1). It is therefore likely that employers in most sectors will be experiencing more difficulty in meeting their skill needs than in a slack labour market where the unemployment rate is higher. Recruiting difficulties could be exacerbated for industries with lower remuneration, less attractive reputations or in remote and regional locations.

Figure 2.1: Unemployment rate in Australia, 1978–2005 (trend series)



Source: Australian Bureau of Statistics, Austats, *Labour Force Survey*. Catalogue No. 6202.0, 2005.

As a result, the audit found there are significant *sectoral labour supply* issues in several SET skill sets. There has been strong recent growth in demand for many SET skills, reflecting growth in the resources sector and infrastructure development and renewal projects. The Business Council of Australia's (BCA) Infrastructure Action Plan highlights Australia's infrastructure needs. The BCA estimated that to meet Australia's medium term energy needs, investment of \$30 to \$35 billion is needed. The BCA report also emphasised the need for major upgrades to water supply and road infrastructure. Defence materiel needs, including those required for surface warfare ship construction are likely to add to these pressures.

Similarly, ongoing DEWR occupational demand assessments, particularly the assessments for the current Migration Occupations in Demand List indicate skill shortages for several engineering professions, over half of the SET trades, and science professionals in the fields of geology, photonics and spatial information.

Recent (2004–05) employment and salary outcomes for university bachelor engineering graduates were generally stronger than those for science graduates and most other disciplines. Salaries for experienced

engineering staff have also grown more rapidly than average weekly earnings in the recent past and industry sources suggest salary pressures are becoming more significant. Similarly, vocational and technical education (VTE) engineering and technology graduates have enjoyed higher employment rates shortly after graduation than VTE natural and physical science graduates.

2.3.1 Industry Survey

The audit's industry survey conducted in mid 2005 indicated that employers were having considerable difficulties in recruiting engineers compared to recruitment in other skill sets. The survey received responses from 4,362 organisations, representing a response rate of 71 per cent. The industry survey also indicated that recruiting periods in engineering disciplines were longer than for non SET skills among survey respondents. The industry study on consulting engineers confirmed this concern, despite increasing industry attempts to recruit in international markets. Similar concerns were raised during audit consultation processes and in many submissions to the audit.

Industry survey respondents reported 856 SET vacancies, of which two-thirds (67 per cent) were engineering-related vacancies: building and engineering professionals (43 per cent), building and engineering associate professionals (11 per cent); mechanical engineering tradespersons (10 per cent), engineering managers (2 per cent); and fabrication engineering tradespersons (2 per cent) (Table 2.5).

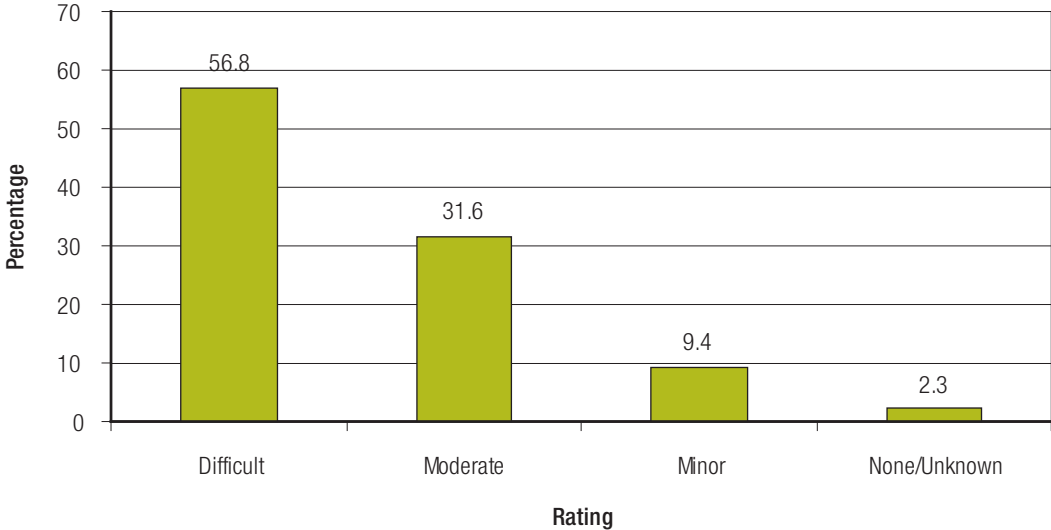
Table 2.5: Current vacancies in SET occupations by level

Occupation Level/Occupation	Number of vacancies	Per cent (%)
Managerial level		
Engineering managers	17	2.0
<i>Sub-total</i>	<i>17</i>	<i>2.0</i>
Professional level		
Building & engineering professionals	367	42.9
Natural & physical science professionals	71	8.3
Secondary school SET teachers	40	4.7
University SET lecturers & tutors	10	1.2
Pharmacists	9	1.1
Business & organisation analysts/Mathematicians, statisticians & actuaries	8	0.9
<i>Sub-total</i>	<i>505</i>	<i>59.0</i>
Associate professional level		
Science technical officers	25	2.9
Building & engineering assoc. professionals	90	10.5
<i>Sub-total</i>	<i>115</i>	<i>13.4</i>
Trade level		
Mechanical engineering tradespersons	89	10.4
Electrical & electronics tradespersons	75	8.8
Automotive tradespersons	42	4.9
Fabrication engineering tradespersons	13	1.5
<i>Sub-total</i>	<i>219</i>	<i>25.6</i>
Total	856	100.0

Source: DEST, *The SET Industry Survey*, 2005.

Just over half of the participant organisations with vacancies in engineering-related occupations rated these vacancies as 'difficult' to fill. Almost a third of these vacancies were rated as 'moderately' difficult to fill, 9.4 per cent were rated as having a 'minor' level of recruitment difficulty, and 2.3 per cent recorded 'no' recruitment difficulties or there was no response (Figure 2.2).

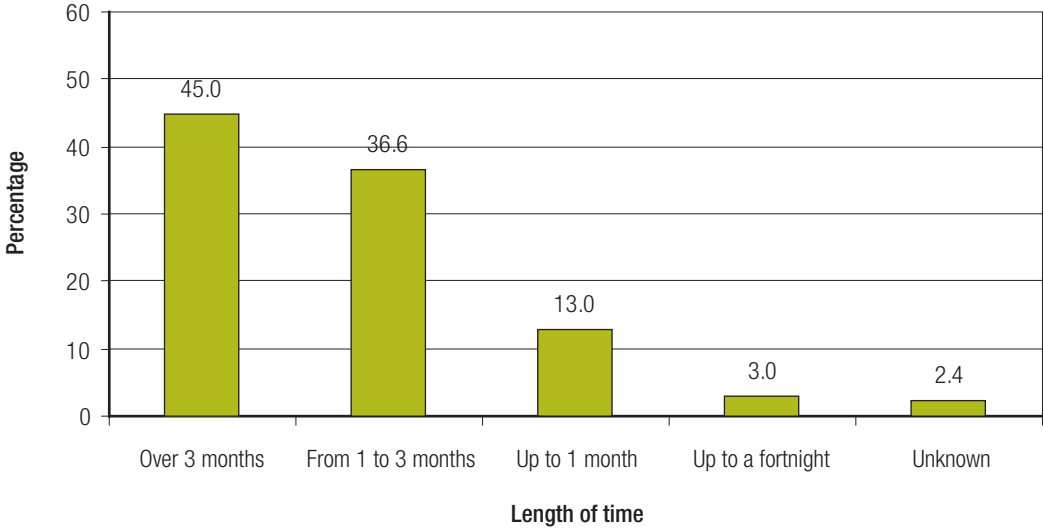
Figure 2.2: Recruitment difficulty rating for engineering-related occupations (per cent)



Source: DEST, *The SET Industry Survey*, 2005.

Just under half of the organisations took over 3 months to fill their vacancies in engineering-related occupations, one third spent 1 to 3 months, 13 per cent spent up to 1 month, and only 3 per cent spent up to a fortnight (Figure 2.3).

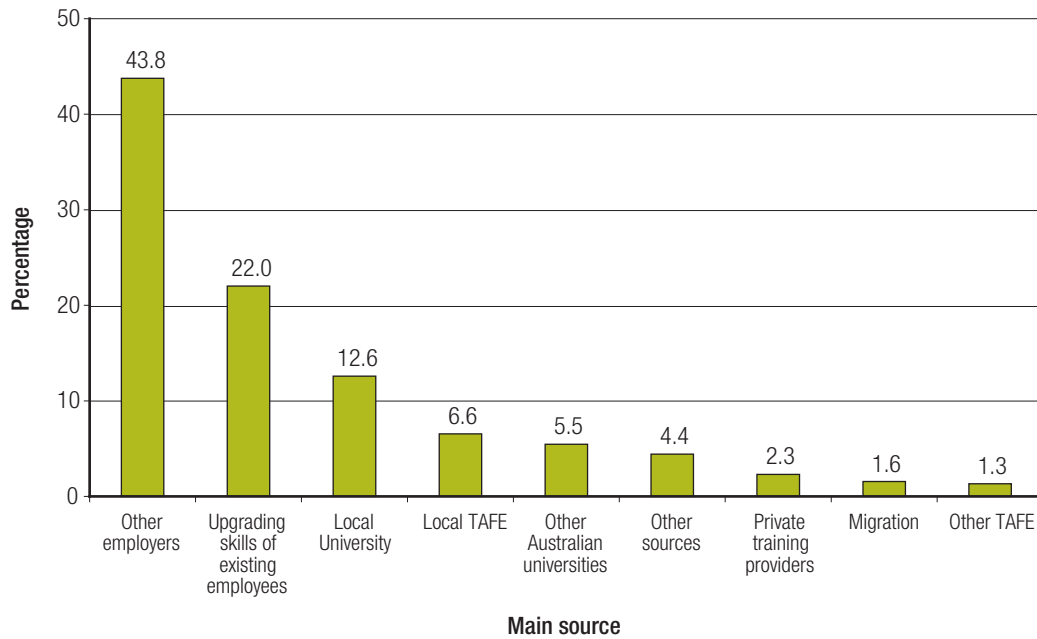
Figure 2.3: Typical length of time spent on recruiting engineering-related occupations (per cent)



Source: DEST, *The SET Industry Survey*, 2005.

Participants were asked to rank the main sources of their employees on a scale of 1 to 5, where 1 was a main source. Two in five businesses selected ‘other employers’ as their main source of employees, followed by ‘upgrading skills of existing employees’ (22 per cent), ‘local university’ (13 per cent), ‘local TAFE’ (7 per cent), and ‘other Australian universities’ (6 per cent) (Figure 2.4).

Figure 2.4: Main sources of employees in SET-related occupations (per cent)



Source: DEST, *The SET Industry Survey*, 2005.

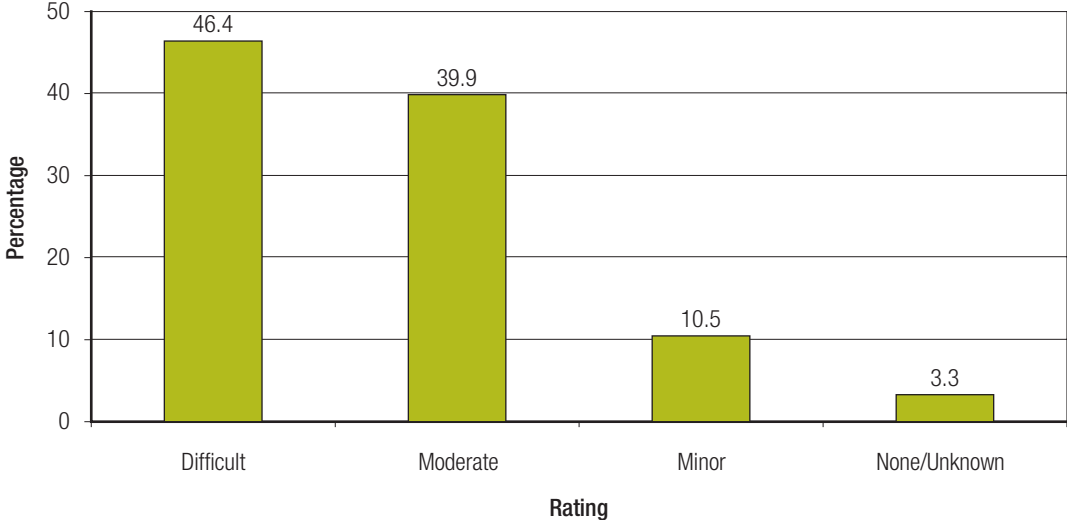
These findings suggest that 'poaching' is a common practice in SET occupations. However, organisations are starting to look into other recruitment activities, such as investing in existing employees to upgrade skills and conducting recruitment exercises via universities and technical and further education institutions.

2.3.2 Industry Survey Case Study: Consulting Engineers

The industry case study of consulting engineers reflects the broader trends. Almost half of the participants who stated that they had vacancies in engineering-related occupations rated those vacancies as 'difficult' to fill, with 40 per cent and 11 per cent of participants rating them as being of 'moderate' and 'minor' difficulty to fill respectively (Figure 2.5).

Half of the organisations spent over 3 months filling their current vacancies, 39 per cent spent 1 to 3 months, 7 per cent spent up to 1 month, and 4 per cent spent up to a fortnight or did not indicate time spent on filling these vacancies.

Figure 2.5: Consulting engineering industry study; rating of level of recruitment difficulty (per cent)



Source: DEST, *The Consulting Engineering Industry Study*, 2005.

The consulting engineering industry study also drew attention to substantial recent salary movements in engineering professions, a further indicator of recruiting difficulties in the industry. Increased salary pressures, which are more evident for engineering than science skills, reflect a tight labour market. There is also evidence of rising salaries in some science related occupations where demand for skills has increased in the past 12–18 months. This has led to more frequent salary reviews in the consulting engineering industry. Industry study participants expressed concerns that skill capacity constraints are leading to an inability to engage in emerging business opportunities.

The audit also found significant challenges in meeting future SET skills requirements, in part reflecting SET workforce ageing and likely retirement patterns. This was a major issue, for example, in spatial information sciences. Similar issues were reflected in the 2005 Department of Employment and Workplace Relations (DEWR) publication, *Workforce Tomorrow*. This report suggested that population ageing is likely to lead to significant skills shortages in many SET occupations.

Migration was not a common source of skills among SET audit industry survey participants, although organisations that recruited from overseas rated their overseas recruits’ skills as equal to, or better than Australian qualified staff. Nonetheless, as discussed later in this report, migration represents a substantial source of skilled workers in some SET sectors, such as mining.

The fact that the Monash model projected replacement demand to exceed potential growth in many occupations emphasises the need for effective strategies to encourage older staff to stay longer and younger staff to remain in the industry to reduce skill shortages. A major concern raised during consultations was the limitations in the public research sector to create an environment that would attract and retain skilled SET workers in Australia.



THE SUPPLY OF SET SKILLS FROM ALL TRAINING AND EDUCATION SECTORS

SET education and training is provided by schools, vocational and technical education (VTE) and higher education as well as through industry training. A plentiful supply of graduates to fill entry level vacancies in science and engineering begins with engaging students in SET at an early age.

Audit research indicates engagement in science, mathematics and technology courses at school is influenced primarily by three different factors. The first factor is the curricula, i.e. the implemented curricula - what is actually delivered by the teachers in the classroom. This can differ significantly from the intended curriculum, as expressed in syllabus and curriculum documents produced by curriculum writers within jurisdictions. The second factor is the lack of inspirational, high quality teachers, especially in primary schools, due to teacher training and resource issues. Some students receive little or no science teaching in primary school and this varies from school to school, teacher to teacher and year to year. More detail about this issue is contained in the Australian Science Teachers Association (ASTA) submission. The final contributing factor is the level of awareness of parents and the general community of the perceived benefits of, and career opportunities arising from SET.

Students participating in science, mathematics and technology subjects at school have the potential to go on to VTE and higher education to study SET, amongst other courses. Skilled workers may also enrol in VTE and higher education courses to upgrade their skills base. The audit examined trends in enrolments and completions of students in SET at school, VTE and higher education. An examination of enrolment numbers gives an indication of the share of students interested in pursuing a SET career while an examination of completion numbers provides information on potential supply. The audit also examined youth attitudes towards science, mathematics and technology study and career options.

3.1 Participation in SET study

Current and projected industry and scientific research community skill needs suggest that a larger pool of students with quantitative skills is needed to fill VTE and higher education places in SET courses. Unfortunately, the share of participation in SET across all Australian education and training sectors has remained static or declined, particularly in the enabling sciences (advanced and intermediate mathematics, chemistry and physics) over the decade to 2003.

3.1.1 Trends in school enrolments

Across Australia, while patterns vary between States (and analysis is hindered by State classification

differences), the proportion of school enrolments in SET subjects remained static or declined over the decade to 2003 (see Table 3.1). Year 12 mathematics enrolments have consistently made up 18 per cent of total enrolments while science enrolments have declined, from 19.1 per cent of total enrolments in 1993 to 15.4 per cent of total enrolments in 2003. Declining participation in physics, chemistry and biology has contributed to this decline. School participation in advanced mathematics, physics and chemistry was low, with each subject making up less than 5 per cent of total enrolments (Table 3.1). Stakeholder discussions and audit submissions suggested the shift away from science may be driven by greater Year 12 subject choice, as well as wider career choices.

These trends are of concern as further education providers suggest that students undertaking studies in the enabling sciences at school are best equipped to pursue further education and training leading to SET careers, particularly at a professional level.

Table 3.1: Potential supply of SET skills from schools

Schools													
Mathematics													
Year	Total number	Adv maths (%)	Intermed maths (%)	General maths (%)	Total maths (%)								
1993	910,674	2.8	25,499	6.7	61,015	9	81,961					19	168,475
1997	859,444	2.5	21,486	9.8	84,225	5.9	50,707					18	156,418
2001	900,776	2.3	20,718	10	90,078	5.8	52,245					18	163,041
2003	948,749	3.4	32,257	9	85,387	6	56,925					18	174,569
Sciences													
Year	Total number	Physics (%)	Chemistry (%)	Biology (%)	Other science (%)	Total science (%)							
1993	910,674	4.1	37,338	4.5	40,980	6.9	62,837	3.5	31,874	19	173,029		
1997	859,444	3.7	31,799	4.2	36,097	5.3	45,551	3.9	33,518	17	146,965		
2001	900,776	3.5	31,527	4	36,031	5.1	45,940	3.8	34,229	16	147,727		
2003	948,749	3.4	32,257	3.6	34,155	4.6	43,642	3.8	36,052	15	146,106		

Source: Department of Education, Science and Training Higher Education Dataset, 2004.

The audit's youth attitudes survey found that the Year 11 and 12 students hoping to attend university¹ were fairly evenly divided in study preferences between science, engineering or ICT; medicine, pharmacy or health sciences (health); law, business or economics (business); and other university courses.

The survey also showed that the pattern of subject participation differed depending on university career destinations (Table 3.2). Year 11 and 12 students hoping to pursue a business career were more likely to participate in mathematics (advanced and intermediate) and technology subjects than science. In contrast, participation in science and mathematics subjects was higher than technology subjects for students hoping to pursue a health career. There was relatively even participation in science, mathematics and technology subjects for students hoping to pursue a SET career.

¹ n = 591 out of a total 930 surveyed

Table 3.2: Percentage of Year 11 and 12 students participating in science, mathematics and technology across different university career destinations

Student Career Preference	Subject Participation		
	Science	Mathematics	Technology
Business	19.6	27.4	36.4
Health	40.8	34.0	23.2
SET	39.6	38.6	40.4
	100.0	100.0	100.0

n = 346, 365 and 228 for science, mathematics and technology respectively

Source: Department of Education, Science and Training, Youth Attitudes Survey, 2006.

3.1.2 Trends in vocational and technical education enrolments and completions

Analysis of trends in VTE participation in SET is hindered by a change in classification in 2002 from Field of Study (FOS) to Field of Education (FOE). Data has been disaggregated and re-aggregated to Field of Education for the purposes of the audit. Notwithstanding these difficulties, trends for three FOEs were examined: natural and physical sciences (NPS); agricultural, environmental and related studies (AERS); and engineering and related technology (ERT). The share of students (expressed as a percentage of total VTE enrolments excluding non-award levels) studying SET at VTE has remained around 30 per cent over time. The majority of SET enrolments were at the certificate level.

Table 3.3: Supply of SET skills from the vocational and technical education sector

Year	VTE SET Studies							
	Diploma and above				Certificates			
	Enrolments		Completions		Enrolments		Completions	
% of Total	Total Number	% of Total	Total Number	% of Total	Total Number	% of Total	Total Number	
Natural & Physical Sciences								
1996	7.8	15,251	8.7	2,086	6.2	31,133	7.3	5,988
1999	8.6	18,932	9.1	2,431	7.0	70,268	6.7	11,546
2001	8.1	18,187	7.5	2,567	7.4	84,724	5.8	13,486
2002	1.3	2,956	1.2	483	0.3	3,331	0.4	864
2004	1.5	2,940	1.2	371	0.3	3,464	0.4	813
Agriculture, Environmental & Related Studies								
1996	3.0	5,790	2.8	678	6.0	30,121	4.8	3,932
1999	2.7	8,124	3.1	839	6.1	61,550	5.3	9,206
2001	4.4	9,853	4.1	1,389	6.5	74,304	4.4	10,110
2002	3.2	7,053	2.3	951	6.9	80,593	5.1	12,552
2004	3.7	7,244	3.2	1,001	6.1	68,894	4.7	9,753
Engineering & Related Technologies								
1996	15.3	29,907	12.6	2,994	22.4	111,697	18.4	15,122
1999	15.6	34,571	12.2	3,261	18.2	182,440	16.1	27,827
2001	15.4	34,441	8.7	2,977	18.2	207,248	13.7	31,830
2002	15.7	34,562	8.7	3,540	19.3	224,180	14.7	36,002
2004	14.3	28,014	8.7	2,736	18.9	213,348	14.7	30,351

Source: National Centre for Vocational Education Research, VTE dataset, 2005.

The trends in enrolments for SET FOE examined in the audit varied (Table 3.3). The share of total commencements was low to very low for NPS and AERS for diploma and above and certificate qualifications for the same period.

The share of students (expressed as a percentage of total VTE completions excluding non-award qualifications) completing SET studies at VTE declined over time, from 29 per cent in 1996 to 22 per cent in 2004.

In general, trends in completions tended to follow enrolment trends after taking into consideration a delay of several years to allow commencing students to complete their studies. The trend in SET completions (expressed as a percentage of total completions) from 1996 to 2004 is shown in Table 3.3. In most instances, numbers of completions tended to be significantly lower than enrolments.

Data limitations did not allow comparisons in enrolment or completion share over time within FOE. The apparent difference in the share of enrolments pre- and post-2002 for NPS and AERS may not be real due to difficulties in marrying up two classification systems (see Appendix A). Nonetheless, it is still valid to compare trends within years pre- and post-2002 for the three FOE.

The share of enrolments and completions remained relatively static for all three FOE between years 2002 and 2004. Pre-2002, the share of completions for AERS was also fairly static, while the share of completions declined for NPS and ERT.

3.1.3 Participation in higher education

In higher education, growth in overseas student enrolments and completions has been higher than for domestic students across SET FOE as a whole. Variations occurred between course groups and qualifications levels. Domestic student numbers remained static or declined in several SET course groups in recent years. Anecdotal evidence from the consultation and submission processes and other audit research suggests that these course groups are fields experiencing recruitment difficulties.

3.1.4 Trends in higher education enrolments

Analysis of trends in higher education participation in SET is hindered by a change in classification in 2001 from Field of Study to Field of Education. Data has been disaggregated and re aggregated to Field of Education for the purposes of the audit. A second difficulty is a change in collection methodology for enrolments. From 2001, data reflects enrolments throughout the academic year, whereas earlier data reflected enrolments in April. As a result, post-2001 data are not fully consistent with pre-2001 data.

Notwithstanding these difficulties, available data indicate that the share of students (expressed as a proportion of total university enrolments) studying SET at university has remained around 17 per cent over time. In 1989, the number of total enrolments was 437,304 and the number of students enrolled in SET was 76,178; and in 2004, the number of total enrolments was 915,704 and the number of students enrolled in SET was 157,726. The majority of SET enrolments were at the undergraduate level.

Over the same time period, the share of overseas students undertaking SET study had almost doubled while the share of domestic students undertaking SET study had declined by around 2 per cent. In 1989, overseas SET students made up 1.6 per cent of total enrolments and in 2004, they made up 3.2 per cent. In contrast, in 1989, domestic SET students made up 15.8 per cent of total enrolments, but by 2004 this had dropped to 14.0 per cent.

Trends in enrolments for the three broad SET FOE examined in the audit varied amongst one another, between undergraduate and postgraduate study and between domestic and overseas students. The share of undergraduate enrolments (expressed as a percentage of total university enrolments) for domestic students has remained fairly static over the past decade to 2003 for NPS. The share of undergraduate enrolments for AERS and ERT has slowly declined over time.

Trends in the share of total enrolments were very different for undergraduate enrolments of overseas students over the same period. The share of total undergraduate enrolments for overseas students has risen for NPS and roughly doubled for ERT between 1993 and 2003 (albeit from a low base). The AERS share fell by two-thirds between 1993 and 2001 before regaining its 1993 level in 2003 (Table 3.4).

At the postgraduate level, the share of total enrolments (expressed as a percentage of total enrolments) for domestic enrolments declined across the three SET fields of education. The share of NPS enrolments nearly halved between 1993 and 2003; for AERS, the share of enrolments fell by a quarter; and for ERT, the share of enrolments fell by around 40 per cent (Table 3.4).

The share of total enrolments for overseas postgraduates for NPS and AERS has remained fairly constant between 1993 and 2003. In contrast, the share of total enrolments for overseas postgraduates for ERT rose over time from just over 1 per cent in 1993 to just over 2 per cent in 2003 (Table 3.4).

Table 3.4: Supply of SET skills from the higher education sector

Year	Qualification	University SET Study			Completion		
		Domestic (% total)	Overseas (% total)	Total number all FOE	Domestic (% total)	Overseas (% total)	Total graduates all FOE
Natural & Physical Sciences							
1993	Undergraduate	7.2	0.5	453,926	6.9	0.5	98,079
	Postgraduate	5.9	0.9	113,643	4.2	0.9	34,781
1997	Undergraduate	8.0	0.5	504,141	7.5	0.8	104,863
	Postgraduate	5.5	0.9	144,960	3.9	0.9	50,274
2001	Undergraduate	9.1	0.6	544,788	9.4	0.6	120,492
	Postgraduate	4.5	0.9	167,674	2.4	0.7	66,009
2003	Undergraduate	8.4	0.9	637,647	8.1	0.8	133,791
	Postgraduate	3.5	0.9	261,297	2.3	0.7	81,324
Agriculture, Environmental & Related Studies							
1993	Undergraduate	2.7	0.1	453,926	2.6	0.1	98,079
	Postgraduate	1.8	0.5	113,643	1.3	0.6	34,781
1997	Undergraduate	2.4	0.03	544,788	2.4	0.03	120,492
	Postgraduate	1.6	0.4	144,960	1.1	0.4	50,274
2001	Undergraduate	2.4	0.03	544,788	2.4	0.03	120,492
	Postgraduate	1.7	0.4	167,674	1.1	0.4	66,009
2003	Undergraduate	2.1	0.1	637,647	2.2	0.04	133,791
	Postgraduate	1.4	0.4	261,297	1.0	0.4	81,324
Engineering & Related Technologies							
1993	Undergraduate	8.0	0.7	453,926	5.2	0.5	98,079
	Postgraduate	5.4	1.2	113,643	3.7	1.2	34,781
1997	Undergraduate	7.7	1.0	504,141	5.7	0.8	104,863
	Postgraduate	4.5	1.1	144,960	3.5	1.5	50,274
2001	Undergraduate	7.0	1.2	544,788	5.3	1.4	120,492
	Postgraduate	3.4	1.4	167,674	2.3	1.8	66,009
2003	Undergraduate	6.2	1.7	637,647	4.6	1.6	133,791
	Postgraduate	3.1	2.2	261,297	2.0	2.5	81,324

Source: Department of Education, Science and Training Higher Education Dataset, 2004.

An analysis of trends in enrolments at the more disaggregated 4-digit ASCED course group level (see Appendices B and C for classifications) between 1989 and 2004 showed a declining number of undergraduate domestic students in mathematical sciences and earth sciences while all other science course groups experienced growth (Table 3.5). The growth experienced was low in biological sciences and physics and astronomy.

Within AERS, domestic student enrolments at the undergraduate level decreased between 1989 and 2004 with the exception of fisheries studies and other agriculture and environmental studies. Enrolments in these two courses have remained static over time (Table 3.5). Overseas student enrolments in undergraduate AERS courses have increased over the same time period.

For engineering, domestic student numbers at the undergraduate level have increased in process and resources engineering, aerospace engineering and maritime engineering over recent years. In contrast, domestic student enrolments in geomatic engineering, electric and electronic engineering and other engineering have declined over time. Enrolments for the rest of the courses remained static over time for domestic students. From 1989 to 2004, enrolments for overseas students have risen considerably in seven of the ten course groups in comparison to domestic student enrolments.

At the postgraduate level, enrolments grew in science and engineering courses for both domestic and overseas students from 1989 to 2004. The few exceptions were chemical sciences, agriculture and maritime engineering where enrolments declined for domestic students. In most course groups at the post-graduate level, overseas student enrolments have increased at a greater rate than domestic student enrolments (Table 3.6).

Relatively few domestic or overseas students undertook PhD studies in engineering in comparison to science (e.g. 7,237 domestic and 1,494 overseas science PhD students; and 416 domestic and 107 overseas engineering PhD students in 2004). The number of overseas students enrolled in Masters by coursework in 2004 was similar for overseas students in science (1,384) and engineering (1,380); in contrast, it was much greater for science (2,135) than engineering (585) for domestic students.

Table 3.5: Enrolments in undergraduate programmes for science and engineering 4-digit ASCED course groups across domestic and overseas students from 1989 to 2004*

		1989	1993	1997	2000	2001	2002	2003	2004
Natural & Physical Sciences									
Math. sciences	Domestic	3,161	3,329	3,108	2,692	2,215	2,347	2,316	2,393
	Overseas	285	251	217	188	135	171	191	227
Physics, astronomy	Domestic	1,104	1,439	1,623	1,298	783	879	937	988
	Overseas	29	27	48	46	13	15	20	24
Chemical sciences	Domestic	1,941	2,301	2,320	1,623	1,209	1,142	1,213	1,558
	Overseas	55	78	94	77	65	66	61	104
Earth sciences	Domestic	1,756	2,303	3,144	3,149	1,708	984	898	934
	Overseas	40	63	97	209	126	27	28	30
Biological sciences	Domestic	5,823	8,277	11,602	11,922	10,194	11,008	11,131	11,506
	Overseas	85	145	261	410	984	1,198	1,004	1,325
Other natural sciences	Domestic	3,225	4,631	6,424	7,758	18,849	20,333	23,653	23,821
	Overseas	117	291	422	641	1,435	1,969	3,269	4,200
Agriculture, Environmental & Related Studies									
Agriculture	Domestic	282	722	609	878	4,350	4,234	3,945	3,505
	Overseas	5	14	12	9	52	59	63	63
Horticulture, viticulture	Domestic	1,154	1,752	2,270	2,034	1,564	1,504	1,522	1,456
	Overseas	16	48	45	28	16	20	17	33
Forestry studies	Domestic	231	306	436	367	384	363	352	312
	Overseas	11	9	11	9	9	8	5	6
Fisheries studies	Domestic	4	412	312	506	601	579	575	595
	Overseas	0	14	9	4	8	10	11	13
Environmental studies	Domestic	2,781	4,213	5,542	5,646	6,509	6,305	6,448	6,396
	Overseas	17	35	81	108	128	195	221	226
Other agriculture, environmental	Domestic	4	412	327	601	408	444	434	409
	Overseas	0	14	9	6	4	7	8	9
Engineering & Related Technology									
Manufacturing engineering	Domestic	735	2,175	3,612	5,206	536	536	557	572
	Overseas	120	147	321	563	415	527	568	422
Process, resources engineering	Domestic	2,873	4,753	6,961	8,783	3,270	3,665	3,579	3,761
	Overseas	164	305	548	1,056	567	748	906	1,099
Automotive engineering	Domestic	4,055	5,169	4,755	4,222	19	49	64	85
	Overseas	314	316	609	851	0	8	21	30
Mechanical, industrial engineering	Domestic	14,610	18,749	18,171	17,446	4,780	4,967	4,755	4,866
	Overseas	1,397	1,269	2,245	2,969	1,262	1,572	1,741	1,905
Civil engineering	Domestic	4,570	5,606	5,339	4,674	4,463	4,615	4,565	4,636
	Overseas	387	169	547	727	819	836	935	1,085
Geomatic engineering	Domestic	931	1,054	910	850	1,540	1,488	1,518	1,458
	Overseas	62	45	61	39	47	62	65	77
Electric, electronic engineering	Domestic	12,244	17,126	18,108	19,050	10,774	11,466	11,124	10,232
	Overseas	1,250	1,651	2,470	3,428	2,685	3,483	3,993	3,974
Aerospace engineering	Domestic	1,117	1,454	1,348	1,570	1,523	1,906	1,934	2,016
	Overseas	83	107	150	226	219	283	328	394
Maritime engineering	Domestic	127	285	288	350	234	670	672	662
	Overseas	2	13	79	118	39	54	40	62
Other engineering	Domestic	319	1,235	2,579	4,734	6,097	5,933	6,059	5,914
	Overseas	19	47	233	435	1,529	1,847	2,193	2,308

Classification Change

* 1989–2000 data is not comparable to post-2000 data because changes in the field of study classification codes and the method of reporting have created a series break in the material. For these reasons, trends should be examined separately over the 1989–2000 and 2001–2004 periods.

Source: DEST Higher Education Group aggregated data sets.

Table 3.6: Enrolments in post-graduate programmes for science and engineering 4-digit ASCED course groups for domestic and overseas students from 1989 to 2004*

		1989	1993	1997	2000	2001	2002	2003	2004
Natural & Physical Sciences									
Math. sciences	Domestic	528	869	771	594	756	907	919	1,011
	Overseas	71	131	91	96	168	166	178	189
Physics, astronomy	Domestic	448	640	686	661	834	895	957	1,040
	Overseas	86	136	102	128	400	400	436	431
Chemical sciences	Domestic	468	740	808	667	1,016	869	889	910
	Overseas	134	152	128	106	174	164	172	196
Earth sciences	Domestic	761	1,344	1,297	1,606	881	810	801	748
	Overseas	269	343	251	307	163	147	144	168
Biological sciences	Domestic	2,085	3,509	4,382	4,009	3,105	3,237	3,329	3,458
	Overseas	363	532	632	726	567	601	718	841
Other natural sciences	Domestic	693	1,216	1,731	2,187	1,446	1,856	1,989	2,087
	Overseas	215	251	264	420	392	604	680	939
Agriculture, Environmental & Related Studies									
Agriculture	Domestic	72	253	359	355	905	855	863	872
	Overseas	64	93	144	106	245	235	225	249
Horticulture, viticulture	Domestic	62	119	161	151	173	159	206	195
	Overseas	12	19	31	37	40	45	40	25
Forestry studies	Domestic	27	40	83	40	35	105	111	102
	Overseas	33	48	22	13	21	32	47	41
Fisheries studies	Domestic	24	135	128	157	107	117	112	111
	Overseas	19	32	36	50	27	37	46	44
Environmental studies	Domestic	608	1,510	1,818	1,412	1,741	1,968	2,115	2,206
	Overseas	57	106	171	252	420	462	512	560
Other agriculture, environment	Domestic	36	214	294	286	274	310	307	339
	Overseas	37	59	82	83	49	54	51	72
Engineering & Related Technology									
Manufacturing engineering	Domestic	772	1,245	1,513	1,354	40	73	88	79
	Overseas	69	146	269	648	100	134	336	471
Process, resources engineering	Domestic	876	1,452	1,699	1,791	1,002	1,128	1,189	1,246
	Overseas	251	313	390	669	261	313	385	497
Automotive engineering	Domestic	268	473	473	418	7	6	6	5
	Overseas	96	160	184	125	0	0	0	0
Mechanical, industrial engineering	Domestic	2,139	3,430	3,313	2,724	1,063	1,119	1,241	1,216
	Overseas	477	748	839	1,169	459	546	586	581
Civil engineering	Domestic	726	1,110	758	566	1,177	1,208	1,283	1,365
	Overseas	174	248	189	210	705	776	940	848
Geomatic engineering	Domestic	125	65	65	86	247	250	240	256
	Overseas	24	23	30	25	46	68	71	80
Electric, electronic engineering	Domestic	1,635	2,746	2,651	2,503	1,898	2,009	2,188	2,286
	Overseas	321	551	788	1,045	1,014	1,480	2,276	2,645
Aerospace engineering	Domestic	75	225	364	553	324	328	346	355
	Overseas	13	47	51	63	67	108	134	146
Maritime engineering	Domestic	0	34	6	11	13	18	6	8
	Overseas	0	0	2	5	5	5	161	3
Other engineering	Domestic	554	976	950	1,057	1,107	1,083	1,201	1,235
	Overseas	47	117	213	429	502	429	611	877

Classification Change

* 1989–2000 data is not comparable to post-2000 data because changes in the field of study classification codes and the method of reporting have created a series break in the material. For these reasons, trends should be examined separately over the 1989–2000 and 2001–2004 periods.

Source: DEST Higher Education Group aggregated data sets.

3.1.5 Trends in higher education completions

The supply of SET skills from university completions is significant, particularly for domestic undergraduate students, because it is the best indicator of supply of entry level professionals into the workforce. Completions at the PhD level are also an important indicator of supply into research professions.

In 2003, the total number of domestic undergraduate students completing was 10,835, 2,013 and 6,199 for natural and physical sciences (NPS), agricultural, environmental and related studies (AERS) and engineering and related studies (ERT) respectively. The number of overseas students was 1,087, 59 and 2,084 for NPS, AERS and ERT respectively. Domestic undergraduates made up the majority of students completing NPS and AERS and approximately three quarters of students completing ERT.

The share of total completions for NPS domestic undergraduates increased slightly between 1994 and 2003. AERS and ERT both declined slightly for the same time period. The share of overseas undergraduates was fairly stable between 1994 and 2003 for NPS, AERS and ERT.

In terms of total numbers, in 2003 the total number of postgraduate domestic students completing was 1,911, 805 and 1,646 for NPS, AERS and ERT respectively while the number of overseas postgraduate students was 603, 342 and 2,016 for NPS, AERS and ERT respectively.

The share of total completions declined between 1994 and 2003 for domestic postgraduate students in all three fields of education. Over the same time period, the share of total completions remained static for overseas postgraduates in NPS and AERS and rose for ERT overseas postgraduates.

However, it should be noted that overseas students with qualifications relating to occupations in the Migration Occupations in Demand List (MODL) can apply to migrate to Australia while still on shore. A recent evaluation of the Skilled Migration Programme indicates that substantial numbers of overseas students now migrate to Australia after completing their studies (12,978 in 2004–05). A number of engineering occupations were added to the MODL in 2005, when the Skilled Migration Programme increased by 20,000 places in skill shortage occupations.

3.2 Quality of students studying SET

In 2004, the SET FOE attracted only an average performing cohort of students, as well as some of the lowest scoring. According to the University Admissions Index/Tertiary Entrance Rank (UAI/TER), Engineering & Related Technologies, Dental Studies, Medical Studies, Law and Veterinary Studies received the majority of higher scoring students, placing the SET fields of Education, Architecture, Natural & Physical Sciences and Agriculture, Environmental & Related Studies in the lower half of applicant student performances (Table 3.7).

Table 3.7: UAI/TER at quartile percentile rankings, students who accepted offer by selected field of education – 2004

Selected FOE	100	75	50	25	Cut-off
Agriculture	86.15	79.21	74.33	69.77	64.47
Architecture	92.74	87.55	83.85	80.6	74.43
Society/Culture/Creative Art	89.91	84.89	80.99	77.62	72.23
Management/Commerce	88.53	83.41	79.48	76.22	71.8
Education	89.11	83.13	79.16	75.73	69.13
Engineering	92.48	88.41	84.67	81.68	77.55
Dental Studies	94.53	92.32	89.03	86.35	83.76
Nursing	87.44	81.04	77.01	73.31	66.2
Medical Studies	98.69	96.31	94.71	91.85	82.12
Health Other	91.67	87.56	84.34	81.63	76.95
Law	95.48	94.19	92.57	90.77	87.71
Justice/Law Enforcement	90.74	83.5	78.69	74.95	65.87
Natural & Physical Science	91.47	86.09	82.42	79.54	75.06
ICT	87.04	81.66	77.23	73.81	70.2
Veterinary Studies	99.43	98.93	98.48	98.04	97.27

Source: AVCC report *Applications for undergraduate Higher Education courses, 2004*

During consultations and through submissions, the higher education and VTE sectors and industry groups consistently raised concerns regarding the preparedness of SET students for university study and employment. Low academic performance in SET fields may be a result of higher achieving students tending not to choose to study SET subjects (as previously discussed in section 3.1).

Nonetheless, university teachers and academics expressed concern that the quality of SET education in schools was limiting their capacity to graduate students suitably qualified to meet the high expectations of industry. Many of the issues related to SET education in schools were discussed in a 2005 report prepared for the Australian Council of Deans of Science entitled *Who's teaching Science? Meeting the demand for qualified science teachers in Australian secondary schools*.

This report sought early action from all governments and education authorities to implement rigorous workplace planning for the teaching of science in schools to ensure that sufficient numbers of suitably qualified teachers of science disciplines would be available to nurture future generations of school students. The main issues covered were related to the supply, retention and quality of science teachers.

The report argued that the supply of science teachers was being impacted by a lack of qualified applicants to fill vacancies. It noted that this would be of particular concern in coming years as the bulge of 'baby boomers' born between 1946 and 1959 approach retirement. The report suggested that science graduates were choosing jobs in industry over a teaching career because they were higher paid, better resourced and had a 'higher status' in the wider community.

The report indicated that retaining science teachers in schools was difficult due to a dissatisfaction with long hours, high workloads and teaching students who lacked motivation. The report stated that the quality of science teaching was being impacted by a lack of discipline-specific qualifications of senior school science teachers, particularly in the fields of physics, chemistry and geology. The report called for the development of meaningful accreditation mechanisms for science teachers, involving minimum qualification levels in science as well as pedagogy.

The Deans' report also emphasised the need to attract more people to the study of science, particularly physics and chemistry, at a tertiary level, as graduates with science majors were the preferred candidates for science teaching positions at a secondary school level. These students would require both training and incentives to pursue teaching careers in secondary schools.

3.3 Engagement with SET

A common theme arising from the audit consultation process was that a lack of community awareness of SET, including a poor understanding of the beneficial role that SET plays in society, and limited knowledge of SET career options, is inhibiting the uptake of SET study. Participants were concerned that the career advice provided by parents, teachers and career counsellors may act to discourage participation in SET study and careers because their knowledge of SET career opportunities is limited.

The audit youth attitudes study, in common with other recent DEST surveys, showed that socioeconomic factors, gender, parental education and school type are all important influences on subject choice. Factors that encouraged an uptake of science, mathematics and technology subjects by students included perceived usefulness, future prospects (tertiary entrance (TE) score and jobs), performance (grades) and an engaging learning environment including a curriculum involving 'real life' examples and inspiring teachers. Poor performance (poor grades and finding the subject hard) and not being engaged with the curriculum (boring) were the main factors for students choosing not to study SET.

The youth attitudes study also examined the motivators behind career choice by asking survey participants to rate what they considered was important for choosing their career: advice from parents or teachers and career counsellors; exposure to the career through work experience or from other sources (media or role model); influence by peers or salary earning capacity; and own choice. Career choice was found to be influenced most strongly by students pursuing what they had always wanted to do, followed by salary and work experience. In contrast, and counter to some other evidence, the influence of peers was not considered important (Table 3.8 and Figure 3.1).

Table 3.8: Top reasons influencing subject choice and reasons for interest/disinterest in science (S), mathematics (M) and technology (T) subjects by cohort and student interest level

A: Subject Choice – Year 11 and 12 and School Leavers

Enrolled Interested in subject			Enrolled Disinterested in subject			Not enrolled in subject		
Factor	Year 11&12	School Leaver	Factor	Year 11&12	School Leaver	Factor	Year 11&12	School Leaver
TE Score	SM	M	TE Score	SM	M	Boring	S	T
Good Grades	SMT	MT	Good Grades	T		Poor Grades	M	M
Perceived Usefulness	SMT	SMT	Perceived Usefulness	MT	MT	Hard	M	M
Parental Encouragement	M	M	Parental Encouragement	M				
Job Prospects	T		Staff Encouragement	M				
			Teachers		M			

B: Factors important for learning – Year 10

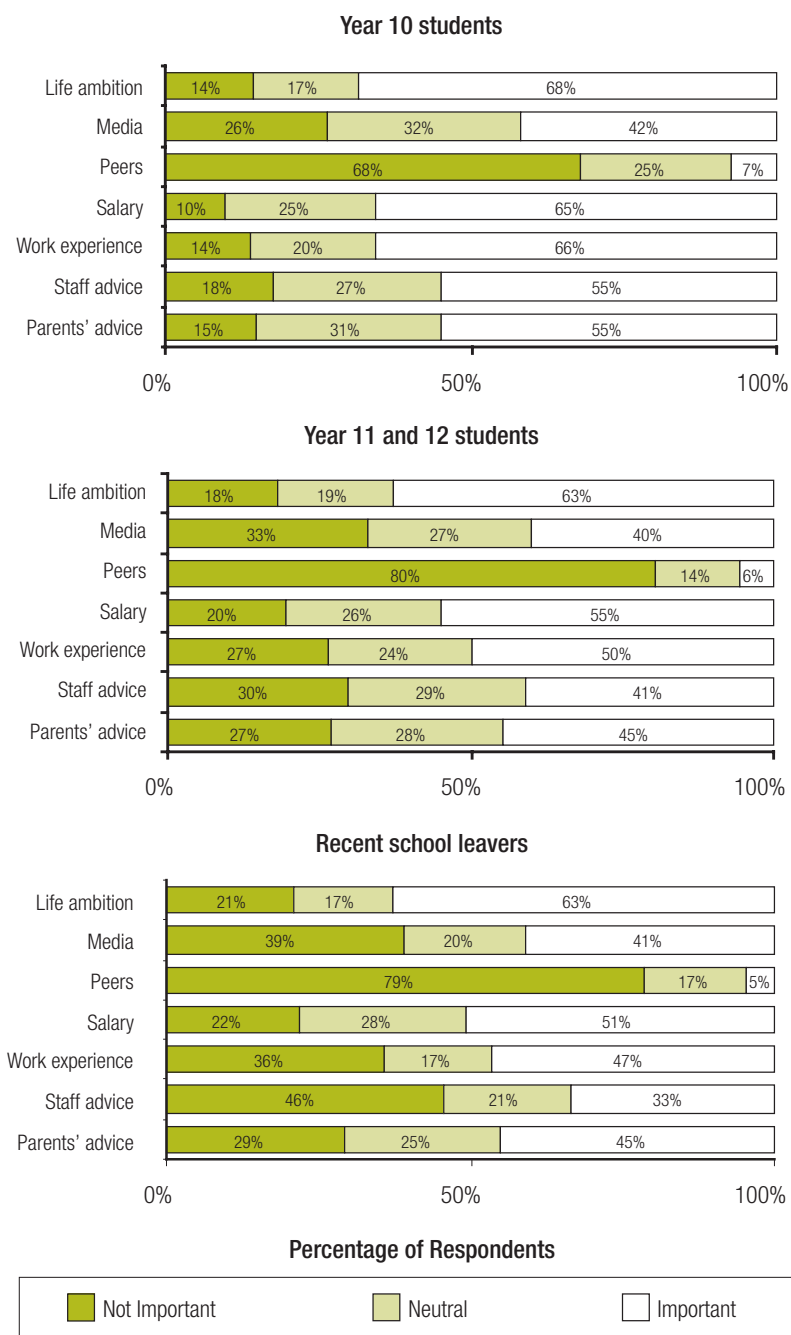
Enrolled – Interested in Subject	Enrolled – Disinterested in Subject
Perceived Usefulness (SMT)	Perceived Usefulness (SMT)
TE Score (SM)	TE Score (MT)
Equipment/Experiments (ST)	Project Work (ST)
Job Prospects (M)	Job Prospects (MT)
Exciting and Challenging (T)	Real Life Examples (S)

C: Factors influencing the development or lack of development of interest in subjects

Enrolled Interested in Subject				Enrolled Disinterested in Subject			
Factor	Year 10	Year 11&12	School Leaver	Factor	Year 10	Year 11&12	School Leaver
Teachers	SM	SM	SMT	Teachers	SMT		
Parental Encouragement	M	M	M	Real Life Examples	---	S	
Grades	SMT	---	---	Boring	---	SMT	SMT
Real Life Examples	---	ST	ST				
Enjoyment	---	SMT	SMT				
Projects	---	ST	ST				
Work Experience	---	T					

Source: Department of Education, Science and Training, *Youth Attitudes Survey*, 2006.

Figure 3.1: Factors influencing career choice for the three cohorts surveyed: Year 10 students, Year 11 and 12 students and School Leavers



Survey Items:

Life ambition: It is what I have always wanted to do

Media: Being inspired by a documentary, film, TV, show or book or person in that career

Peers: What my friends have decided to do

Salary: The kind of salary that I would like to earn

Work experience: Work experience

Staff advice: My career counsellor or teachers advice on career options

Parents' advice: My parents' advice on careers

Source: Department of Education, Science and Training, *Youth Attitudes Survey*, 2006.

4

DEMAND FOR SET SKILLS COMPARED TO SUPPLY OF SET SKILLS

The Monash projections of demand for SET skills, in the period from 2004–05 to 2012–13, for engineering and science graduates from higher education and VTE suggest that graduates from the education and training sector, together with planned levels of migration, would largely be able to meet industry and the scientific research community's SET skill needs. It is expected that the Skilled Migration Programme will also assist in meeting demand for skills, especially specialist skills.

However, it needs to be acknowledged that the Monash projections are based on historical data and may not reflect recent, planned, or likely growth in the resources sector, infrastructure development and renewal or planned defence materiel needs. Possible moves in outward migration as a result of increased international demand for SET skills would also have the potential to reduce SET skills supply to Australian SET employers.

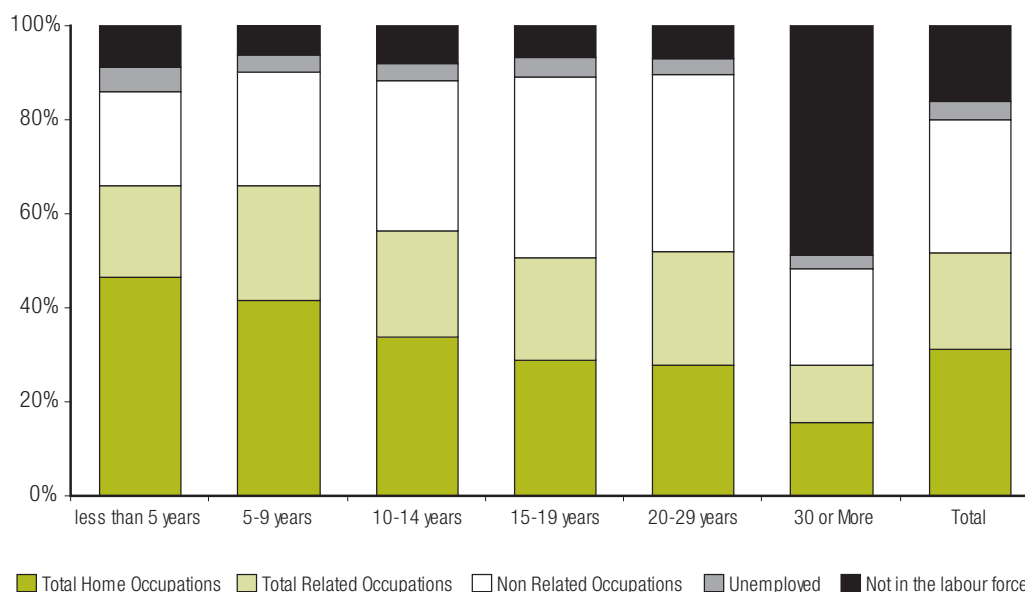
Recent labour market data, as reflected in the audit industry survey and the audit industry studies indicate that the current level of demand for engineers is high, employers are having difficulty recruiting engineers, recruiting periods are being extended, and engineers' salaries are increasing more rapidly than in other sectors of the Australian labour market. This suggests that supply of engineers may not be adequate to meet current or emerging needs.

The contradiction between Monash labour demand projections and labour market demand trends for engineers, as evident in employer views, may not be reflected in labour market projections, which are based on longer term historical trends. This suggests a need to further monitor developments in these skill sets to ensure that supply is adequate to meet industry demand.

In part, one of the reasons why it is difficult to predict supply of skills accurately is that a significant proportion of qualified people tend to work in occupations which may not be immediately relevant to their training. While a proportion of persons go on to related employment, e.g. management roles related to their qualifications, others go on to work in unrelated fields. For example, as shown in the diagram below, a significant proportion of persons with civil engineering qualifications work in unrelated fields.

Shortly after graduating, most graduates worked as Civil Engineers. In the first 5 years after qualifying, 47 per cent were working as Civil Engineers, falling to 34 per cent after 10 to 14 years, 28 per cent after 20 to 29 years; and 16 per cent after 30 years or more.

Figure 4.1: Labour force status of persons aged 15 and over with Bachelor Degrees or Higher Qualifications in Civil Engineering by period since qualifying



Source: Australian Bureau of Statistics, 2001 Census of Population and Housing

The supply/demand projections compared potential change in demand for SET skills to projections of supply for science professionals, engineering professionals and engineering tradespersons from the educational and training sectors in the next ten years.

The demand projections arise from Monash's equilibrium model forecasts of demand from employment by occupations. A simple estimate of future supply from education and training providers was provided using a regression analysis based on historical completion trends in SET courses.

The supply projections are based on historical places available. DEST notes that the Government recently announced that it would provide a further 39,000 new places to the higher education sector by 2009. Many of these are targeted to areas of skills shortage. In SET, 216 new engineering and 967 new science-related discipline places were allocated to Australian higher education providers, commencing in 2005. These places will grow to 591 and 2,644 places by 2008 for engineering and science respectively. On the other hand, expanding supply depends on attracting suitable numbers of high quality students to study SET courses. If places are available but not filled, supply will not increase.

For *science* professionals, the model predicts a total increase in demand (defined as the change in total demand from year to year plus replacement demand) from 2004–05 to 2012–13 of around 55,000 (Table 4.1). When compared to projections of total supply from higher education, demand is not expected to exceed total supply of science graduates.

However, supply is predicted to be reduced significantly by many graduates choosing not to work full-time. For example, the Graduate Careers Council data indicates graduates may elect to study further, in related or

unrelated fields, or may have family responsibilities. In addition, Australian Bureau of Statistics (ABS) data shows that even at graduation, many graduates elect to work in areas unrelated to their studies and this proportion tends to increase over time. These predictions indicate that available supply may total only 35,981, leaving a possible shortfall of about 35 per cent (Table 4.2).

The bottom 'available' supply line incorporates all losses based on historical employment outcomes for recent graduates and postgraduates and thus may not accurately reflect future outcomes under differing demand conditions. As well, patterns of demand and supply will vary markedly for particular occupations, especially with respect to higher level science qualifications where labour markets are smaller and employers' skill needs are more specialised.

Table 4.1: Total demand increase and supply from education for science professionals

	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	Total
Total Demand increase	10,139	5,959	4,181	8,061	8,236	6,032	6,025	6,565	55,198
Education supply	20,882	21,651	22,420	23,188	23,957	24,726	25,494	26,263	188,582
Available for FT work	11,569	11,995	12,421	12,846	13,272	13,698	14,124	14,550	104,474
Supply after loss to unrelated occupations*	3,984	4,131	4,278	4,424	4,571	4,718	4,864	5,011	35,981

*Figures in this row also include loss of those unavailable for full time work.

Sources:

- Graduate Careers Council of Australia.
- DEST Higher Education Group aggregated data sets.
- Centre of Policy Studies, Monash University, 2004, based on ABS data.

For *engineering* professionals, the model predicts a total increase in demand from 2004–05 to 2012–13 of around 46,640 (Table 4.2). When compared to projections of total supply figures from higher education, demand is not expected to exceed projected total supply of engineer graduates from higher education. However, when 'reduced' or available supply rates are considered, demand may already exceed supply by approximately 2,000 persons. If all reductions in the supply estimates are considered, then demand for engineering professionals may exceed supply for much of the period, with total demand for the period potentially exceeding overall supply (Table 4.2). Again, it should be noted that the labour demand projections are based on historical data, and may not fully reflect recent, planned or potential developments and therefore may understate demand for engineering professionals in the period to 2012–13.

The Monash employment projections are based on employment in professional engineering occupations. This does not include persons working in management roles with engineering qualifications.

ABS data distinguishes four occupations where such qualifications are primarily relevant, Engineering Managers, Manufacturing Managers (15.9 per cent holding engineering degrees in 2004–05), Building and Construction Managers (15.3 per cent holding engineering degrees) and General Managers (9.4 per cent in holding engineering degrees). Considering these occupations together as a group, Monash estimates employment growth of 5500 persons in these occupations between 2004–05 and 2012–13 for persons with engineering qualifications. This would increase demand for persons with engineering qualifications, and add to demand/supply imbalances.

Table 4.2: Total demand increase and supply from education for engineering professionals

	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	Total
Total Demand increase	7,298	4,163	2,904	7,605	6,943	6,151	5,627	5,949	46,640
Education supply	9,333	9,520	9,708	9,896	10,084	10,271	10,459	10,647	79,918
Available for FT work	7,219	7,364	7,509	7,655	7,800	7,945	8,090	8,235	61,817
Supply after loss to unrelated occupations*	5,274	5,380	5,486	5,592	5,698	5,804	5,910	6,017	45,162

* Figures in this row also include loss of those unavailable for full time work.

Sources:

- Graduate Careers Council of Australia.
- DEST Higher Education Group aggregated data sets.
- Centre of Policy Studies, Monash University, 2004, based on ABS data.

The loss of supply of workers to unrelated occupations for science and engineering professionals (Table 4.1 and Table 4.2) illustrates the need for employers to implement effective policies to attract and retain staff, possibly through better conditions and pay rates.

Anecdotal evidence from the consultations and submissions to the audit also suggest that students who complete a double degree with engineering often do not choose a career in engineering, but instead use their engineering background for the analytical and conceptual skills it provides. In a relatively tight labour market it may be that such graduates will choose to work in unrelated fields in increasing numbers (e.g. in the finance industry where pay rates may be higher).

For engineering tradespersons, the model predicts that current supply is already inadequate to meet labour market demand (Table 4.3). This scenario is consistent with other evidence considered throughout the audit. The increase in demand for 2005–06 is estimated to be approximately 15,000 and the supply from VTE around 9,000. The model predicts that the significant gap between supply and demand for engineering trades is likely to persist.

Non-completion and early attrition in the trades remains a concern and is the subject of recent studies by the National Centre for Vocational Education Research. Measures to reduce this attrition or to encourage more adults into trade training are to be encouraged.

Table 4.3: Total demand increase and supply from education for engineering trades.

	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	Total
Total Demand increase*	14,978	15,749	17,032	17,407	15,625	14,479	16,611	14,346	126,227
Education supply	8,944	9,097	9,272	9,467	9,678	9,904	10,143	10,395	76,900

Sources:

- Centre of Policy Studies, Monash University, 2004, based on ABS data.
- Unpublished National Centre for Vocational Education Data, 2005.

The projections discussed above assume that education and training providers are the sole source of SET workers through training and retraining. Other sources include the return of skilled employees to the workforce, employees poached from other workplaces (both within and between sectors) and migration. To ensure our future capacity in SET through the provision of an adequate supply of skilled workers, a delicate balancing act is required. Workplace planning will need to consider SET requirements in terms of the mix of training and retraining being provided by the educational and training sector, as well as the kinds of policies and strategies needed to attract and retain workers on a global scale.



5

THE SUCCESS OF THE EDUCATION SECTOR IN MEETING EXISTING SKILL NEEDS AND RESPONDING TO EMERGING NEEDS

The Australian Government has anticipated the needs of skills in Australia and has provided a range of flexible options through its \$53 billion support for science and innovation programmes from 2001–02 to 2010–11. In part, a focus of the government has been on boosting SET skills in schools, VTE and higher education through programmes that promote and support training in science, mathematics and technology; reforming higher education based on the principles of sustainability, quality, equity and diversity; building collaboration and linkages between educational providers, research organisations, industry and the community; enhancing the quality and number of teachers in SET; and raising awareness through national prizes and out-reach programmes.

5.1 Education and training

The audit provided valuable information on the degree to which education and training in Australia is preparing students to work in SET industries and the scientific research community for the future. Key issues revolved around the preparedness of school students to undertake further SET study and static and declining levels of participation in SET at all levels of training. The Australian Government has a number of initiatives in place to address these problems.

A key thrust of the Government's policy on schooling in recent years has been to improve student outcomes. As part of the requirements for Australian Government funding over 2005–08, schools and students are participating in a programme of common national testing and two international programmes of student assessment.

Australian students are performing well in the international context. The results from the 2000 OECD Programme for International Student Assessment (PISA) showed that Australian students performed better than the OECD average for reading literacy, mathematical literacy and scientific literacy.

An examination of performance by Australian students in the Trends in International Mathematics and Science Study (TIMSS) 2002–03 showed that Year 4 student performance in mathematics in 2002–03 was at the international average, while science was above average. Year 8 students were placed significantly above the TIMSS 2002–03 averages for mathematics and science in 2002–03. The study also showed that computer use by Years 4 and 8 students in Australia was high. However, the PISA and TIMSS studies indicated there was a considerable disparity between the performance of Australia's best performing and lower performing students.

A range of Australian Government funded projects have contributed to the successful results of Australia's students including: Australian Schools Innovation in Science, Technology and Mathematics (ASISTM) Projects; National Primary School Science and Literacy Projects (Primary Connections) by the National Academy of Science; Science Education Assessment Resources (SEAR); and The Learning Federation Schools Online Curriculum Content Initiative (SOCCI).

Since 1999, over \$14 million has been committed by the Australian Government to investigate and address current and future industry skills needs in VTE. The National Skill Shortages Strategy, a co-operative approach to tackling industry skills needs, particularly in the traditional trades, has delivered many outcomes including careers education materials and recognition of existing workers' skills and enhancement of their career paths.

Further initiatives in 2005–06, worth \$2.5 billion, are helping transform the national training system through the establishment of 25 Australian Technical Colleges, the Australian Institute for Trade Skills Excellence and an Australian Network of Industry Careers Advisors; provision of a toolkit to New Apprentices in skills needs occupations; Trade Learning Scholarships to New Apprentices in skills needs occupations completing first and second year; and funding 15,000 additional places over three years in the New Apprenticeships Access Programme to assist disadvantaged job seekers enter skills needs industries.

The Australian Government has introduced a range of programmes to address existing and emerging skill needs in the higher education sector through the *Backing Australia's Ability* initiatives and the reform package, *Our Universities: Backing Australia's Future*.

In *Backing Australia's Ability*, the Government funded 2,000 new commencing higher education places a year from 2002, with a priority on programmes in the areas of ICT, mathematics and science. These places have grown to almost 5,500.

In 2004, the Government announced that it would provide a further 39,000 new places to the higher education sector by 2009. Many of these are targeted to areas of skills shortage. In SET, 216 new engineering and 967 new science-related discipline places were allocated to Australian higher education providers, commencing in 2005. These places will grow to 591 and 2,644 places by 2008 for engineering and science respectively.

Universities have sought to respond to the needs of emerging industries. They have introduced dual degrees in response to the need for interdisciplinary skills whilst retaining the discipline specific training of skills necessary for cross-disciplinary projects. Many dual degrees combine disciplines from social sciences and SET in recognition that R&D in SET encapsulates innovation and discovery, safety, regulation, environmental sustainability and ethics, amongst other factors. Nonetheless, industry groups have observed that dual degree holders are attractive to a variety of industries, and may choose to seek alternatives to SET careers.

The reform package, *Our Universities: Backing Australia's Future*, and other initiatives, are helping build Australia's skills base and attract the highest calibre people to the university sector through the development of a first class higher education system that provides high quality teaching, research and career opportunities and is competitive on an international scale.

5.2 Investment in research and development (R&D)

The audit noted evidence relating to the benefit of private and in some instances public R&D investment in facilitating Australia's future economic growth. The Government believes that investment in science and innovation will contribute to building a strong, secure future for Australia. *Backing Australia's Ability* is already producing significant achievements towards a world-class science and innovation system. *Backing Australia's Ability – Building Our Future through Science and Innovation* will continue that work.

Backing Australia's Ability significantly increased incentives for business to undertake R&D through the reformed R&D Tax Concession and grants programmes such as R&D Start and Commercialising Emerging Technologies (COMET) programme. The early indications are encouraging. As at 30 June 2004, the total number of companies registered was 4,981 with a total R&D expenditure of \$6.0 billion, 1,822 companies were registered for the Tax Offset with an R&D expenditure of \$493.6 million, and 598 companies were registered for the 175% Premium R&D Tax Concession with an R&D expenditure of \$2.4 billion.

COMET has made a notable contribution to building an entrepreneurial economy, with 850 reported commercialisation outcomes, including 250 capital raisings and numerous business alliances, licences or agreements. The 2004–05 Innovation Report notes that since 1999, capital raisings have totalled \$280 million, with 848 strategic alliances, licences or agreements formed, and 163 instances of manufacturing commencements or product and service launches.

The Government has also refocused the Cooperative Research Centres (CRC) Programme towards generating industrial, commercial and economic outcomes. The recent report by The Allen Consulting Group, *The economic impact of CRCs in Australia: Delivering benefits for Australia* showed that the Australian economy's overall performance had been considerably enhanced by the CRC Programme. For every \$1 spent by the Australian Government on the CRC Programme, GDP is cumulatively \$0.60 higher than it would have been had that \$1 instead been allocated to general Government expenditure.

5.3 Building research capacity to support research excellence

The audit reinforced the notion that research and innovation springs from world-class facilities, well resourced to support a critical mass of high quality researchers. The Government has invested heavily in research infrastructure, salaries and funding to attract and retain internationally renowned researchers.

The National Research Priorities, developed as part of *Backing Australia's Ability*, focuses our research effort on the number of challenges and opportunities facing Australia. As part of this, the Government has substantially

strengthened its commitment to the development of CSIRO National Flagships to address major national goals, with additional funding of \$305 million. It has committed \$89 million over the period 2003–07 to establish Australian Research Centre (ARC) Centres of Excellence in the ARC's designated areas of research priorities. Additionally, it supports three world class centres of excellence in plant functional genomics, information and communications technology and biotechnology.

Backing Australia's Ability has been instrumental in helping Australia to put in place a world-class ICT capability for research and innovation as well as substantially improve general research infrastructure in Australia.

Backing Australia's Ability has provided funding for the period 2001–02 through to 2005–06, including \$337 million from the Research Infrastructure Block Grant Scheme, \$246 million from the Systemic Infrastructure Initiative and \$155 million from the Major National Research Facilities Programme. The National Collaborative Research Infrastructure Strategy is providing funding of \$542 million over seven years (2004–05 to 2010–11) to provide researchers with access to major research facilities by supporting infrastructure investments.

The latest independent international science performance data (from Thomson ISI Web of Science) shows that the citation impact of Australian research, the number of times a scientific paper is referred to in other papers, is rising, and is now at about the world average, at 4.2 citations per paper. The data also show that quality, as measured by citations, is particularly strong in certain key fields of research such as geosciences, computer science and clinical medicine.

5.4 Building collaboration and linkages

Consultations held with stakeholders during the audit process highlighted the need for building collaboration and linkages. The Government recognises the importance of collaboration to increase 'interconnectedness' of the system and provide more varied pathways for research to be used and commercialised. A fundamental objective of *Backing Australia's Ability* has been to boost collaboration between the key players in the innovation system: business, universities and publicly funded research agencies.

The near-doubling in the size of ARC university-industry collaborative grants from \$131,000 in 2001 to \$219,000 in 2004 is increasingly attracting industry to joint university research projects. Total ongoing industry investment in research co-sponsored by the ARC since the introduction of *Backing Australia's Ability* now exceeds \$346 million in around 1,300 projects.

In July 2004, the Australian Government established the Business, Industry and Higher Education Collaboration Council (BIHECC) to foster greater collaboration between higher education providers, industry, business, other education providers and communities. The Council is addressing issues such as skills mapping, re-skilling and educational responsiveness, and graduate skills formation for employers.

5.5 Raising community awareness of and engagement in SET

The decline in the uptake of SET training and a general perception that science literacy across the community has not kept pace with scientific advances was a constant theme in consultation carried out for the audit. The Government has introduced a range of programmes to raise community awareness of and engagement in SET, many of which are still in an early stage of implementation so their successes are yet to be determined.

In 2001, the National Innovation Awareness Strategy (NIAS) was established with \$31.3 million in funding over a 5-year period. The Strategy included Australian Government support for National Science Week; the Prime Minister's Prizes for Science; the ABC Science Broadcasting Project; "Smart Moves" (a Questacon initiative); the Science and Mathematics Olympiads; the University of Newcastle's Science and Engineering Challenge; and "Science Meets Parliament", an initiative of the Federation of Australian Scientific and Technological Societies.

A review conducted in 2003 found that NIAS had effectively reached a number of target audiences – youth, the general community, businesses, politicians and scientists themselves. In 2004, NIAS was replaced by the Science Connections Programme, which continues the science awareness elements of NIAS.

The Australian Government is enhancing the services of Careers Advisers through the Australian Network of Industry Careers Advisers (ANICA). ANICA will provide a comprehensive national career and transition support network for all young Australians from 13 to 19 years of age. Delivered through Local Community Partnerships (LCPs), funding of \$143.2 million from 2005–06 to 2008–09 will build on existing programmes to further improve the career choices of young people and increase levels of student engagement.

5.6 Enhancing SET teacher quality and numbers

The audit noted strong concerns from stakeholders, backed by research by the Australian Council of Deans of Science, that Australia lacked sufficient qualified and inspirational science teachers, especially in country areas. The recent Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) report on teacher supply and demand also indicated difficulties in this regard². The importance of an adequate supply of high quality, appropriately qualified teachers in engaging students was emphasised by the student attitudes survey undertaken for the audit.

The Australian Government has implemented a range of initiatives calculated to increase the number of teachers in areas of shortage, and especially in the fields of mathematics, science and technology. These include: providing an additional \$109.2 million in practicum funding for 2005–08; placing a cap on the maximum student contribution in education units of study to 2004 HECS levels to attract students to teaching; allocating over 4,000 extra places in teacher education courses to higher education providers between 2005

² MCEETYA, *Demand and Supply of Primary and Secondary School Teachers in Australia, 2004*, at http://www.mceetya.edu.au/verve/_resources/-DAS_teachers-PartsA-d.pdf.

and 2008; allocating nearly 770 new, fully-funded places to teacher education programmes focusing on maths, science and information technology for the years 2001 to 2006; and contributing to an independent Review of Teaching and Teacher Education.

The programme, *Boosting Innovation, Science, Mathematics and Technology Teaching* (BISMTT), worth \$38.8 million over 7 years from 2004–05, will strengthen science, mathematics and technology education, increase the number of talented people attracted to teach in the fields of science, technology and mathematics and build a culture of continuous innovation in Australia.

5.7 Other areas for action

Despite the considerable efforts being made by the Australian Government and other key stakeholders to meet existing skills needs and address emerging skills needs, there is a clear recognition that the timelines necessary to achieve tangible benefits will often be long. As a result, consideration needs to continue to be given to immediate priority areas for action.

6

THE LONG AND SHORT-TERM TRENDS IN THE EMIGRATION AND IMMIGRATION OF SET GRADUATES AND THE IMPACT ON AUSTRALIA'S SET SKILL BASE

The mobility of skilled human resources contributes to the diffusion of knowledge, the transfer of technology and skills and to innovation more generally. As the SET workforce is internationally mobile, skill shortages in other countries can impact on Australia through international demand for Australian SET skills. Population ageing in major OECD countries, an apparent lessening of interest in SET careers in many OECD and developing countries, actual and intended growth in Gross Domestic Expenditure on Research and Development (GERD) and an increasing preference for SET skills across a broad range of industries have all contributed to increasing the global demand for Australian SET skills.

In the past, developing countries such as India and China have made up the shortfall in skilled labour in Australia (among other countries). However, their own domestic needs may curtail this source of supply in the future. This could increase international demand for SET graduates from other countries, including Australia. Australian SET skills are also likely to be in greater demand overseas in the foreseeable future as a result of current US immigration policies, the Australia-United States Free Trade Agreement, the United States' recent boost to funding for non-defence research, and an increasing demand for English-speaking researchers worldwide.

Australians, including those with SET skills, are increasingly taking the opportunity to live and work overseas. In turn, this movement has been offset by skilled migration to Australia. The audit examined Australia's SET capacity compared to other countries and the international factors influencing the availability of Australia's SET skills, drawing heavily on information from the OECD and a study undertaken for the audit by The Allen Consulting Group, amongst other material.

6.1 Australia's SET capacity compared to other countries

Australia's contribution to global scientific knowledge is impressive relative to its population. Making up only 0.3 per cent of the world's population, Australia produced nearly 3 per cent of the world's scientific publications in 2002. In the same year, it ranked 9th out of 21 countries in total number of research publications; and 8th out of 21 in the number of research publications per capita, ahead of the United States, Canada, Germany and France.³

³ Australian Government, 2004, *Australian Science, building our future*, p. 18.

OECD data on researcher numbers suggested that Australia's share of researchers working in R&D is comparable to the OECD overall and Australia's population has a relatively good overall proportion of tertiary qualifications. However, Australia has a relatively low proportion of persons with SET tertiary qualifications in comparison to other OECD countries, and has fewer females participating in SET higher education courses than in many OECD countries. Australia also has comparatively fewer graduates in engineering than in other OECD countries (Table 6.1).

Table 6.1: Proportion of higher education graduates by field of study, Australia compared to the OECD, 2003

	Australia %		OECD % (country mean)	
	A	B	A	B
Education	11.8	1.5	13.6	18.5
Humanities and the arts	11.0	9.2	11.5	8.9
Social sciences, business and law	37.7	45.3	32.2	28.4
Services	2.7	6.4	2.8	10.8
Engineering, manufacturing and construction	7.3	10.8	13.1	17.2
Agriculture	1.0	2.5	2.0	2.1
Health and welfare	13.8	13.7	13.2	19.2
Life sciences	3.0	1.0	2.9	1.1
Physical sciences	2.1	0.3	2.5	0.8
Mathematics and statistics	0.4	n	1.0	1.1
Computing	9.2	9.3	3.9	8.0
Not known or unspecified	n	0.1	3.4	3.5

Source: Organisation for Economic Cooperation and Development (2005) *Education at a Glance*, Table A 3.5.

* Type A programmes are for a minimum of 3 years tertiary full-time equivalent, and are designed for entry to advanced research programmes and professions with high skill requirements, while type B programmes are for a minimum of two years tertiary full-time equivalent, and focus on practical, technical or occupational skills for direct entry into the labour market.

In terms of investment, Australia's GERD doubled between 1986–87 and 2002–03, accounting for 1.6 per cent of Australia's GDP compared to the OECD average of 2.3 per cent. Australian expenditure on R&D as a share of GDP was about two-thirds the OECD average, representing around 1 per cent of total OECD R&D expenditure.

The Australian Treasury has noted that it is often argued that Australia's research and development (R&D) effort is low when compared with other OECD countries. While business expenditure on R&D in Australia appears relatively low, this is to a significant extent a result of Australia's industry structure. Also, it does not appear that policy towards business R&D is the main driver of R&D intensity. Countries with policies that promote R&D are typically not high R&D-spending countries. Finally, the relationship between R&D and more direct measures of innovation does not appear to be strong or stable across countries. R&D is one input into the process of innovation — the development of new products, services and business processes — that is a key driver of economic growth. Having lower levels of R&D expenditure does not necessarily mean a country is less innovative.

Table 6.2: Sources of finance for research and development and performance of research and development by sector, Australia compared to the OECD and China, 2003

	% financed by		% performed by		
	Industry	Government	Industry	Higher Education	Government
Australia	46.4	44.4	48.8	28	20.3
United Kingdom	43.9	31.3	65.7	21.4	9.6
United States	63.1	31.2	68.9	16.8	9
EU-25	54.5	34.8	63.5	22	13.4
Total OECD	61.6	30.5	67.3	18.7	10.9
China	60.1	29.9	62.4	10.5	27.1

Source: Organisation for Economic Cooperation and Development (2005) *Main Science and Technology Indicators*, p. 1.

6.2 International factors influencing the availability of Australia's SET skills

Substantial and growing numbers of Australians now live and work abroad. Migration to Australia has offset these losses in most skill sets. Australians with SET skills are highly mobile, reflecting international tendencies in this area.

The flow of workers, including SET professionals, associate professionals and tradespersons, into and out of Australia over five years was investigated by Birrell *et al.* in their 2004 paper *Skilled Movements in the New Century: Outcomes for Australia* (Table 6.3). The total net flow of skilled persons from 1998–99 to 2002–03 was 151,735, representing the equivalent of 4 per cent of the stock of persons employed in these occupations in 2001.

Overall, gains and losses were greater for professional occupations than associate professionals and tradespersons. The mobility of SET professionals was high; there was a total net loss of 11 per cent for other natural and physical science professionals (the only net loss recorded in skilled occupations for the five year period) and total net gain of 15 per cent for life scientists, 22 per cent for other building and engineering professionals and 37 per cent for economists (Table 6.3).

Table 6.3: Net flow of persons from migration, for selected occupations, permanent and long term movements, 1998–99 to 2002–03, as a percentage of 2001 stock *

Occupation	Stock (employed persons August 2001)	Total net flow over 5 years	
		No.	% of stock
Chemists	5,367	689	13
Geologists and Geophysicists	5,090	733	14
Life Scientists	5,227	793	15
Environmental & Agricultural Science Prof.	16,613	773	5
Medical Scientists	11,112	755	7
Other Natural and Physical Science Prof.	7,883	-878	-11
Total Natural & Physical Science Prof.	51,292	2,865	6
Building and Surveying Professionals	22,392	1,678	7
Engineers	43,210	8,212	19
Other Building & Engineering Professionals	24,597	5,326	22
Total Building & Engineering Professionals	90,199	15,216	17
Accountants	107,507	8,231	8
Auditors	6,645	749	11
Corporate Treasurers	1,193	66	6
Computing Professionals	126,546	17,495	14
Mathematicians, Statisticians and Actuaries	3,422	223	7
Medical Practitioners	48,225	4,375	9
Nursing Professionals	171,680	4,614	3
School Teachers	256,035	1,851	1
University Lecturers and Tutors	31,931	2,632	8
Economists	2,382	892	37
Other Professionals	616,946	18,427	3
Total Finance, Medical and Education Prof.	1,372,512	59,555	4
Total Professionals	1,514,003	77,636	5
Building & Eng Assoc. & Technical	79,311	2,605	3
Financial Dealers & Brokers, Assoc Prof.	39,144	523	1
Financial Investment Advisors, Assoc Prof.	20,942	538	3
Chefs	38,944	692	2
Other Associate Professionals	797,867	8,221	1
Total Associate Professionals	976,208	12,579	1
Mechanical Eng Tradespersons	106,683	2,784	3
Fabric Eng Tradespersons	61,693	955	2
Automotive Tradespersons	115,583	2,483	2
Electronic and Electrical Tradespersons	141,664	3,064	2
Construction Tradespersons	233,029	4,024	2
Other Tradespersons	360,250	6,841	2
Total Tradespersons	1,018,902	20,151	2
Total Managers & Administrators	764,863	41,369	5
Total Skilled Occupations	4,273,981	151,735	4
Other Occupations	3,858,417	23,921	1
Total	8,132,398	175,656	2

Source: Birrell, B., Dobson, I.R., Rapson, V. & Smith, T.F., (2004), *Skilled Movements in the New Century: Outcomes for Australia*, Centre for Population and Urban Research, Monash University, p. 15: from Australian Bureau of Statistics, Census 2001, customised matrix.

*This table compares the stock of employed persons in Australia as of August 2001 with the net flow of persons (Australian residents, long-term temporary residents and settler arrivals) for each occupation listed over the years 1998–99 to 2002–03.

International demand for Australian SET skills appears to be increasing as OECD countries, amongst others, place greater emphasis on R&D. Losses from an ageing SET workforce in many OECD countries as ‘baby boomers’ retire seem likely to add to this demand.

Globalisation has also led to increased mobility of SET skills in the business sector. Multinational companies move SET personnel between countries to meet their own internal needs. Outsourcing of R&D efforts and offshore production of high technology intermediate goods can also result in an increase in the mobility of SET personnel in this sector.

Reflecting growth in demand for SET skills, anticipated losses of SET skills to age based retirement and inadequate SET skill formation in their own countries, many countries have adopted a range of policies to attract and retain SET skills. Most fall under the following five categories: improvement to, and increased investments in, national research systems; information and facilitation services for SET study and career opportunities; targeted funds, mostly to support foreign-born PhD students but in some cases to support returning SET personnel; a reduction in regulatory barriers, such as immigration and work permits; and fiscal measures such as tax-based incentives.

The European Commission has set ambitious targets with the goal of making Europe the world’s most competitive and dynamic knowledge-based region by 2010 by pressing for a growth in the R&D budget and relaxing visa restrictions. Additionally, individual nations in the European Union have expanded their research capacities.

Similarly, the United States has increased investment in research and adopted more open immigration policy regimes in recent years to enable them to meet their skill needs. In particular, more facilitative visa arrangements under the Australia United States Free Trade Agreement will add to opportunities for Australians to emigrate to the United States.

Brazil, Russia, India and China are expanding their own SET capacities at a rapid rate which will both draw in SET qualified staff from outside and restrict the numbers of their own nationals seeking employment in countries like Australia and the United States. Given the major imbalance between national supply and demand for SET personnel in the United States, Australian-trained SET personnel are likely to continue to be in demand.

These changes in policy stance will increase opportunities for Australians with SET skills to live and work abroad, particularly given differences in research funding, researchers’ salaries and comparative certainty of career paths between Australia and major OECD countries.

Pressing skills shortages identified by industry and the research sector has prompted the Government to increase its Skilled Migration Programme to provide skills growth in short time-frames, facilitating Australia’s continued economic growth and complementing other avenues to address skills needs. In particular, the Skills Stream of the 2005–06 Migration Programme has been increased by up to 20,000 extra places and

the Migration Occupations in Demand List (MODL) has been extended to include 38 professional, 1 associate professional and 26 trade occupations, including mining, petroleum and chemical engineers.

The Australian Government has also introduced measures to encourage expatriate Australians to return to Australia. These include expanding the potential job market for appropriately skilled researchers by establishing world class centres of excellence; offering generous research awards such as Federation Fellowships; and providing opportunities for Australians to return to upgrade their skills base through enhanced career opportunities.



CONCLUSIONS AND NEXT STEPS

7.1 Summary of audit findings

Australia has an extensive SET sector which provides many valuable services to industry and will play a key role in our future economic development. To this end, Australia has invested significantly in building capacity in the SET sector. Australia's SET skills base will be a key resource in years to come. Ensuring the supply of necessary SET skills has been a high priority for the Australian Government.

In early 2006 Australia's labour market was very tight, with the unemployment rate approaching 5 per cent, reflecting strong employment growth in many industries. As a result, employers are likely to face recruiting difficulties. Recruiting difficulties are likely to be intense for lower paid jobs, where employers have adverse reputations, or for jobs located in remote or rural areas.

The audit has found that:

Reflecting tight labour market conditions, there are *sectoral SET labour supply* issues. There has been strong recent growth in demand for some SET skills, reflecting growth in the resources sector, infrastructure development and renewal, and defence materiel needs. This has led to recruitment difficulties with respect to several SET skills, including many engineering disciplines, and in sciences such earth sciences, chemistry, spatial information sciences and entomology. High level mathematical skills are also in strong demand.

Recent, planned and potential developments may not be reflected in labour demand projections, as these projections are based on historical employment data. Industry views indicate that there are specific, immediate and long-term supply issues that must be addressed.

Participation in SET will be impacted by demographics, including the ageing of the SET workforce, a decline in the number of school leavers from 2010 onwards as a result of demographic change, the low community profile of SET and the lack of community awareness of the benefits of investment in the sector.

There is declining participation in SET study which relates to an inadequate supply of suitably qualified teachers. The ability to attract high quality candidates into SET will also impact on Australia's ability to build its future SET capacity.

The longer term supply of SET skills is likely to be challenging for the following reasons:

On the supply side, the pool of SET workers will shrink dramatically due to substantial losses at the experienced end of the spectrum and an insufficient pool of potential recruitments being available at the other end of the spectrum.

- This will be brought about by the ageing of the SET workforce leading to increased age based retirement and a decline in the number of school leavers from 2010 onwards.
- Recent trends towards static or declining participation in SET, if continued, will also impact adversely on supply.

Australia's SET skills supply will face challenges from international demand for SET skills. OECD countries are placing increased emphasis on R&D. These countries also face significant age-based retirement issues. The international labour market for SET skills is being driven by policy initiatives in the European Union (EU), the USA and the BRIC countries (Brazil, Russia, India and China).

- In the EU, the European Commission is pressing for a growth in the R&D budget, a relaxing of visa restrictions and an expansion of research capacity in individual nations.
- Post 9/11, the USA has relaxed visa restrictions for Australians; and President Bush recently announced a major budget increase for science agencies.
- The BRIC countries are expanding their own SET capacities at a rapid rate which will both draw in SET qualified staff from outside and restrict the numbers of their own nationals seeking employment in countries like Australia.

Key influences on domestic demand for SET skills are the recent, planned and likely growth of Australia's resources sector, the need for infrastructure development and renewal, and defence materiel requirements.

Skill shortages remain in several SET skill sets, particularly in engineering at professional and trade levels and in occupation areas such as earth scientists, chemists and spatial information sciences.

The findings from the audit will provide an analytical basis for further consideration of issues relating to building Australia's research and innovation capacity to ensure Australia can perform successfully in a highly competitive global market.

7.2 Challenges

The audit therefore poses a number of challenges in terms of building Australia's science, research and innovation capacity for the future. Challenges include:

- Improving information and awareness of SET and SET career opportunities among students, parents, industry and the community to encourage growth in the number of school students studying SET and aspiring to SET careers.

- Facilitating more rapid SET skills acquisition by existing workers, apprentices and new entrants to the labour market to meet demand in a responsive way.
- Improving the capacity of the education and training system to deliver high quality SET courses. An adequate supply of well qualified science and mathematics teachers is a key to success.
- Continuing to ensure that Australia has an adequate stock of scientists, engineers and technologists in Australia including through emigration and immigration of SET graduates to meet the skill needs of industry and the scientific research community.
- Enhancing the understanding of SET career opportunities among early to mid-career researchers and working with the public and private research sectors to provide rewarding career paths for young researchers.
- Continuing Government and industry reforms to ensure that flexible employment practices are in place to facilitate the long-term supply of skilled SET workers.
- More effective staff retention strategies, (especially for older workers) to reduce attrition of qualified SET workers either to retirement or to other occupations.
- Ensuring quality infrastructure to support SET training and research.

7.3 Next steps

In meeting these challenges, we will need to ensure practical solutions are developed to best meet Australia's SET skill needs now and into the future.

7.4 Related Material

The summary report is supported by a number of background papers. These papers include:

- Public submissions
- Summary of issues from submissions to the audit of science, engineering and technology skills
- Summary of forum consultations outcomes to inform the audit
- Working papers, including:
 - Supply of SET skills from the Australian education and training system
 - Demand for Science, Engineering and Technology Skills in Australia
 - Trends in international demand for Australian SET skills
 - Scenarios of supply of SET skills from higher education and vocational and technical education compared to demand projections
- Industry survey report

- Industry case study reports, including:
 - Biotechnology
 - Consulting Engineering
 - Research Organisations
 - Spatial Information
 - Cast Metals
 - Finance
- Youth attitudes survey report
- Literature review
- MONASH model framework

Background papers can be accessed on the audit website at:

www.dest.gov.au/setsa



APPENDIX A: STEERING COMMITTEE MEMBERS

Steering Committee Members - Science, engineering and technology skills audit

Australian Academy of Technological Sciences and Engineering

Australian Academy of Science

Australian Chamber of Commerce and Industry

Australian Council of Deans of Science

Australian Council of Engineering Deans

Australian Industry Group

Australian Institute of Agricultural Science and Technology

Australian Research Council

Australian Science Teacher's Association

Australian Vice-Chancellors' Committee

Business Council of Australia

TAFE Directors Australia

Cooperative Research Centre (CRC) Appraisal Panel

Commonwealth Scientific and Industrial Research Organisation

Engineers Australia

Evogenix Pty Ltd

Federation of Australian Scientific & Technological Societies

National Health and Medical Research Council

Rural Industries Research and Development Corporation



APPENDIX B: ASCED 2-, 4- AND 6-DIGIT CLASSIFICATION SYSTEM

Australian Standard Classification of Education Description's (ASCED) Field of Education (FOE) classification

01	Natural & Physical Sciences	0101	Math. sciences	10100	Mathematical Sciences
				10101	Mathematics
				10103	Statistics
				10199	Mathematical Sciences n.e.c.
		0103	Physics, astronomy	10300	Physics and Astronomy
				10301	Physics
				10303	Astronomy
		0105	Chemical sciences	10500	Chemical Sciences
				10501	Organic Chemistry
				10503	Inorganic Chemistry
				10599	Chemical Sciences n.e.c.
		0107	Earth sciences	10700	Earth Sciences
				10701	Atmospheric Sciences
				10703	Geology
				10705	Geophysics
				10707	Geochemistry
				10709	Soil Science
				10711	Hydrology
				10713	Oceanography
				10799	Earth Sciences n.e.c.
0109	Biological sciences			10900	Biological Sciences
		10901	Biochemistry and Cell Biology		
		10903	Botany		
		10905	Ecology and Evolution		
		10907	Marine Science		
		10909	Genetics		
		10911	Microbiology		
		10913	Human Biology		
		10915	Zoology		
		10999	Biological Sciences n.e.c.		
0199	Other natural sciences	19900	Other Natural and Physical Sciences		
		19901	Medical Science		
		19903	Forensic Science		
		19905	Food Science and Biotechnology		
		19907	Pharmacology		
		19909	Laboratory Technology		
		19999	Natural and Physical Sciences n.e.c.		

03	Engineering & Related Technologies	0301	Manufacturing engineering	30100	Manufacturing Engineering and Technology
				30101	Manufacturing Engineering
				30105	Textile Making
				30199	Manufacturing Engineering and Technology n.e.c.
		0303	Process, resources eng	30300	Process and Resources Engineering
				30301	Chemical Engineering
				30303	Mining Engineering
				30305	Materials Engineering
				30307	Food Processing Technology
				30399	Process and Resources Engineering n.e.c.
		0305	Automotive engineering		
		0307	Mechanical, industrial eng	30700	Mechanical and Industrial Engineering and Technology
				30701	Mechanical Engineering
				30703	Industrial Engineering
				30799	Mechanical and Industrial Engineering and Technology n.e.c.
		0309	Civil engineering	30900	Civil Engineering
				30901	Construction Engineering
				30903	Structural Engineering
				30905	Building Services Engineering
				30907	Water and Sanitary Engineering
				30909	Transport Engineering
				30911	Geotechnical Engineering
				30913	Ocean Engineering
				30999	Civil Engineering n.e.c.
		0311	Geomatic engineering	31100	Geomatic Engineering
				31101	Surveying
				31103	Mapping Science
31199	Geomatic Engineering n.e.c.				
0313	Electric, electronic eng	31300	Electrical and Electronic Engineering and Technology		
		31301	Electrical Engineering		
		31303	Electronic Engineering		
		31305	Computer Engineering		
		31307	Communications Technologies		
		31309	Communications Equipment Installation and Maintenance		
		31399	Electrical and Electronic Engineering and Technology n.e.c.		
0315	Aerospace engineering	31500	Aerospace Engineering and Technology		
		31501	Aerospace Engineering		
		31503	Aircraft Maintenance Engineering		
		31505	Aircraft Operation		
		31599	Aerospace Engineering and Technology n.e.c.		
0317	Maritime engineering	31701	Maritime Engineering		
		31703	Marine Construction		
		31705	Marine Craft Operation		
		31799	Maritime Engineering and Technology n.e.c.		
0399	Other engineering	39900	Other Engineering and Related Technologies		
		39901	Environmental Engineering		
		39903	Biomedical Engineering		
		39905	Fire Technology		
		39999	Engineering and Related Technologies n.e.c.		

05	Agriculture, Environmental & Related Studies	0501	Agriculture	50100	Agriculture
				50101	Agricultural Science
				50103	Wool Science
				50105	Animal Husbandry
				50199	Agriculture n.e.c.
		0503	Horticulture, viticulture	50300	Horticulture and Viticulture
				50301	Horticulture
				50303	Viticulture
		0505	Forestry studies	50500	Forestry Studies
				50501	Forestry Studies
		0507	Fisheries studies	50700	Fisheries Studies
				50701	Aquaculture
				50799	Fisheries Studies n.e.c.
		0509	Environmental studies	50900	Environmental Studies
				50901	Land, Parks and Wildlife Management
				50999	Environmental Studies n.e.c.
		0599	Other agric, environment	59900	Other Agriculture, Environmental and Related Studies
			59901	Pest and Weed Control	
			59999	Agriculture, Environmental and Related Studies n.e.c.	



APPENDIX C: ABS CORRESPONDENCE OF PRE-2001 6-DIGIT FIELD OF STUDY CODES TO POST-2000 ASCED 4-DIGIT FIELD OF EDUCATION GROUPS

Mapping 6-digit FOS (pre-2001 classification) to 4-digit ASCED FOE

Post-2000 2 and 4 digit codes		Pre-2001 6 digit Codes				
01	Natural & Physical Sciences	0101	Math. sciences	090401	Mathematics - General	
					090402	Applied Mathematics
					090403	Pure Mathematics
					090404	Statistics, Operations Research
					090499	Mathematics - Other
		0103	Physics, astronomy	090505	Physics	
				090599	Physical Sciences - Other	
		0105	Chemical sciences	090502	Chemistry	
		0107	Earth sciences	010204	Soil Sciences	
				030208	Geography	
				090399	Life, General Sciences - Other	
				090503	Geology, Earth Sciences	
				090599	Physical Sciences - Other	
		0109	Biological sciences	030208	Geography	
				090302	Anatomy	
				090303	Biochemistry	
				090304	Biology	
				090305	Botany	
				090306	Environmental Science	
	090311			Microbiology, Bacteriology, Virology		
	090313			Physiology		
	090314			Zoology		
	090399			Life, General Sciences - Other		
	0199			Other natural sciences	010206	Viticulture and Oenology
					070405	Medical Technology
					070501	Medical Science
		090307	Food Science			
		090310	Laboratory Techniques			
		090312	Pharmacology			
	090399	Life, General Sciences - Other				
			090599	Physical Sciences - Other		

Post-2000 2 and 4 digit codes			Pre-2001 6 digit Codes		
03	Engineering & Related technologies	0301	Manufacturing engineering	060207	Industrial Engineering/technologies
				060299	Engineering - Other
		0303	Process, resources eng	060203	Chemical/Plastics Engineering/technologies
				060210	Metallurgical Engineering/technologies
				060211	Mining/Minerals Engineering/technologies
				060299	Engineering - Other
				090307	Food Science and Technology
		0305	Automotive engineering	060209	Mechanical Engineering/technologies, Fabrication
		0307	Mechanical, industrial eng	060204	Civil, Structural Engineering/technologies
				060205	Electrical Engineering/technologies
				060207	Industrial Engineering/technologies
				060209	Mechanical Engineering/technologies, Fabrication
				060299	Engineering - Other
		0309	Civil engineering	060204	Civil, Structural Engineering/technologies
0311	Geomatic engineering	060302	Cartography		
		060303	Surveying, Survey Drafting		
		060399	Surveying - Other		
0313	Electric, electronic eng	060205	Electrical Engineering/technologies		
		060206	Electronic, Computer, Communications Engineering/technologies		
		060209	Mechanical Engineering/technologies, Fabrication		
		060299	Engineering - Other		
0315	Aerospace engineering	060202	Aeronautical Engineering/technologies		
		090501	Physical Sciences - General		
0317	Maritime engineering	060208	Marine Engineering/technologies		
		090504	Nautical Science		
0399	Other engineering	060299	Engineering and Related Technologies - Other		
05	Agriculture, Environmental & Related Studies	0501	Agriculture	010203	Plant Sciences
				010299	Agriculture, Forestry - General
				010301	Animal Husbandry - General
		0503	Horticulture, viticulture	010205	Horticulture - Ornamental and Utilitarian
				010206	Viticulture and Oenology
		0505	Forestry studies	010202	Forestry and Timber
		0507	Fisheries studies	010299	Agriculture, Forestry - General
		0509	Environmental studies	010403	Parks and Wildlife Management
				090306	Environmental Science
		0599	Other agric, environment	010203	Plant Sciences
		010299	Agriculture, Forestry - General		



REFERENCES

- Australian Bureau of Statistics (2001) *Australian Standard Classification of Education*, Cat. No. 1272.0. ABS, Canberra.
- Australian Bureau of Statistics (2005) *Labour Force Survey*, Cat. No. 6202.0. ABS, Canberra.
- Australian Council for Educational Research (2005) *Science Education Assessment Resources Project*. DEST, Canberra, <http://cms.curriculum.edu.au/sear/>.
- Australian Education Systems Officials Committee (2001) *The Le@rning Federation Schools Online Curriculum Content Initiative*. The Learning Federation, Melbourne, <http://www.thelearningfederation.edu.au/tlf2/>.
- Australian Government (2004) *Backing Australia's Ability – Building Our Future through Science and Innovation Package*, May 2004.
- Australian Vice-Chancellor's Committee (2004) *Applications for Undergraduate Higher Education Courses 2004*. AVCC, Canberra.
- Birrell, B, Rapson, V, Dobson, I.R. & Smith, T.F. (2004) *Skilled Movements in the New Century: Outcomes for Australia*. Monash University, Melbourne.
- Birrell, B, Richardson, S, & Hawthorne, L. "Evaluation of the General Skilled Migration Categories", 2006.
- Centre for Population and Urban Research (2003) *Skill Utilisation of Persons Trained in Australia*. Monash University, Melbourne.
- Centre of Policy Studies (2004) *CoPS Briefing Handbook December 2004*, Monash University, Melbourne.
- Committee for the Review of Teaching and Teacher Education (2003) *Australia's Teachers: Australia's Future – Advancing Innovation, Science, Technology and Mathematics*. DCITA, Canberra.
- Department of Education, Science and Training (2005) *The Australian Government's Innovation Report 2004–05*. DEST, Canberra.
- Department of Education, Science and Training (1999) *Australian Science – Building our Future*. DEST, Canberra.
- Department of Education, Science and Training (2005) *Australian Technical Colleges: A Discussion Paper*. DEST, Canberra.

Department of Education, Science and Training (2001) *Backing Australia's Ability: an innovation action plan for the future*. DEST, Canberra.

Department of Education, Science and Training (1990) *Cooperative Research Centres (CRC) Programme*. DEST, Canberra, <https://www.crc.gov.au/Information/default.aspx>.

Department of Education, Science and Training (2005) *Facilities Maintenance Backlog*. DEST, Canberra.

Department of Education, Science and Training (2003) *Higher Education Statistics Collection – Course Completions*. DEST, Canberra.

Department of Education, Science and Training (2003) *Higher Education Statistics Collection – Student Enrolments*. DEST, Canberra

Department of Education, Science and Training (2006) *The Consulting Engineering Industry Survey*. DEST, Canberra.

Department of Education, Science and Training (2006) *The SET Industry Survey*. DEST, Canberra.

Department of Education, Science and Training (2004) *Major National Research Facilities Programme*. DEST, Canberra, http://www.dest.gov.au/sectors/research_sector/programmes_funding/general_funding/research_infrastructure/mnrf/default.htm.

Department of Education, Science and Training (2004) *National Skills Shortages Strategy*. DEST, Canberra, <http://www.skillsinitiative.gov.au/>.

Department of Education, Science and Training (2000) *New Apprenticeships Access Programme*. DEST, Canberra, <http://www.newapprenticeships.gov.au/default.asp>.

Department of Education, Science and Training (2003) *New Apprenticeships Incentive Programme*. DEST, Canberra, <http://www.newapprenticeships.gov.au/employer/incentives.asp>.

Department of Education, Science and Training & Australian Academy of Science (2005) *Primary Connections Programme*. DEST, Canberra, <http://www.science.org.au/primaryconnections/background.htm>.

Department of Education, Science and Training (2003) *Research Infrastructure Block Grants Scheme*. DEST, Canberra, http://www.dest.gov.au/sectors/research_sector/programmes_funding/general_funding/rbgrants/default.htm.

Department of Education, Science and Training (2002) *Students 2001: Selected Higher Education Statistics*, Appendix 7.1. DEST, Canberra.

Department of Education, Science and Training (2006) *Youth Attitudes Survey*. DEST, Canberra.

Department of Employment and Workplace Relations (2005) *Workforce Tomorrow*. DEWR: Canberra.

Department of Immigration and Multicultural Affairs (2005) *Skilled Migration Programme*, DIMA, Canberra, <http://www.immi.gov.au/migration/skilled/>.

Department of Workplace Relations (2005) *Migration Occupations in Demand List (MODL)*. DEWR, Canberra.

Economic and Social Data Service (1998) *Eurostat New Cronos* ESDS International, University of Manchester.

Harris, KL, Jenz, F, & Baldwin, G. (2005) *Who's teaching Science? Meeting the demand for qualified science teachers in Australian secondary schools*. Centre for the Study of Higher Education, University of Melbourne.

Lahey, K (21 September 2005) *Locking in or Losing Prosperity: Australia's Choice*. Address presented at the Midmarket CEO symposium, Hobart, Australia.

Minister for Education, Science and Training (2003) *Our Universities: Backing Australia's Future*. Policy Paper, May 2003.

National Centre for Vocational Education Research (2005) *Australian vocational education and training statistics: Apprentices and trainees – June quarter 2005, Summary*, Item No. 1650. NCVET, Adelaide.

Organisation for Economic Co-operation and Development (2005) *Main Science and Technology Indicators*. OECD, Paris.

Organisation for Economic Co-operation and Development (2004) *Messages from PISA 2000*. OECD, Paris.

The Allen Consulting Group (2005) *The economic impact of cooperative research centres in Australia: Delivering benefits for Australia; A report for the Cooperative Research Centres Association Inc*. The Allen Consulting Group, Melbourne.

Thomson, S. & Fleming, N. (2004) *Summing it up: Mathematics Achievement in Australian Schools in TIMSS 2002* (TIMSS Australia Monograph no. 6) Australian Council for Educational Research (ACER), Camberwell.

Thomson Scientific (2005) *International Science Performance Data*. Thomson Scientific, Sydney.

The Treasury (2005) *Economic Roundup Spring 2005*. The Treasury, Canberra.