

**WOMEN IN SCIENCE IN AUSTRALIA:**  
MAXIMISING PRODUCTIVITY, DIVERSITY AND INNOVATION

Report prepared for FASTS  
October 2009

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with assistance from Kate O'Halloran,  
Jesslyn Saw & Yu Zhao

**Women in Science:**  
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Technological Societies**

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## Abbreviations

AAS	Australian Academy of Science
ABS	Australian Bureau of Statistics
ACER	Australian Council for Education Research
ACG	Australian Centre for Geomechanics
ANZSCO	The Australian and New Zealand Standard Classification of Occupations
AOU	Academic Organisational Unit
APESMA	The Association of Professional Engineers, Scientists & Managers
ARC	Australian Research Council
ASCED	Australian Standard Classification of Education
ASCO	Australian Standard Classification of Occupations
ASSET	The Athena Survey of Science, Engineering and Technology
ASX	Australian Securities Exchange
ATNWEXDEV	Australian Technology Universities' Women's Executive Development
ATSE	Australian Academy of Technological Sciences and Engineering
AVCC	Australian Vice-Chancellor's Committee
CHASS	Council of the Humanities and Social Sciences
COSEPUP	Committee on Science, Engineering, and Public Policy
CRC	Cooperative Research Centres
CREW	Careers Review of Engineering Women
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSWP	Committee on the Status of Women in Physics
DEET	Department of Education, Employment and Training
DEEWR	Department of Education, Employment and Workplace Relations
DEST	Department of Education, Science and Training
DETYA	Department of Education Training & Youth Affairs
DIISR	Department of Innovation, Industry, Science and Research
DPF	Division of Particles & Fields
ECU	Equality Challenge Unit
EOWA	Equal Opportunity for Women in the Workplace Agency
FASTS	Federation of Australian Scientific and Technological Societies
FTE	Full-time equivalent
ICT	Information Communication and Technology
NAS	National Academy of Sciences (US)
NBEET	National Board of Employment, Education and Training
NCVER	National Centre for Vocational Education Research
NGO	Non-government organisations

NHMRC	National Health and Medical Research Council
NTEU	National Tertiary Education Union
NSF	National Science Foundation
OECD	Organisation for Economic Co-Operation and Development
PAID	Partnerships for Adaptation, Implementation, and Dissemination
PM&C	Department of the Prime Minister and Cabinet
PMSEIC	The Prime Minister's Science, Engineering and Innovation Council
POWRE	Professional Opportunities for Women in Research and Education
SET	Science Engineering and Technology
STEM	Science, Technology, Engineering and Mathematics
SWAN	Scientific Women's Academic Network
UAEW	Universities Australia Executive Women
UKRC	UK Resource Centre for Women in Science, Engineering and Technology
VET	Vocational Education and Training
WEHI	Walter and Eliza Hall Institute
WiE	Women in Engineering
WISENET	Women in Science Enquiry Network
WiSET	Women in Science, Engineering and Technology Advisory Group
WiT	Women in Technology



## Executive Summary

It is timely that as this report goes to press, molecular biologist Professor Elizabeth Blackburn has been confirmed as the first Australian woman Nobel laureate (6 October 2009). That such individual achievement is possible when the progress of the majority of Australian women hoping to make careers in science, engineering or technology related fields has stalled is cause for cautious optimism. This report, looking at the place and progress of women in science in Australia, presents a sobering account.

The report takes as its benchmark the 1995 Women in Science, Engineering and Technology Advisory Group's report to the Australian Government, titled 'Women in Science, Engineering and Technology'. The similarities between the two reports are telling. Most obviously almost a decade and a half has passed since the first report, yet the issues are yet to be addressed. A comparison between the two reports reveals that any changes have been minimal. The 1995 report, like this report, noted that women were seriously under-represented in some specific disciplines of science, engineering and technology (SET), and were not well-represented at the most senior levels in all disciplines. They affirmed the importance of this in terms of diversity and innovation as well as in terms of maximising productivity, noting that continued under-representation and under-participation of women in SET-based education, training and employment is a cause for social concern on equity grounds. Further, it is also likely to inhibit Australia's capacity to develop internationally competitive research and industries.

The Commonwealth government recognises that support for science and innovation is essential to ensuring Australia's international economic competitiveness. There are emerging skills and labour shortages in some key technical and scientific areas. Consequently it is timely to ask two questions. How far have we come? Are we maximising our scientific and technical potential?

This review focuses on the participation, retention and success of women in the science and technology fields in Australia, concentrating on the persistent horizontal and vertical segregation of women academics and researchers as key contributing factors that impact on Australia's research and innovation agendas. The aim is to assist stakeholders (government, policy advisers, tertiary education providers, and leaders in industry and scientific research institutes) to negotiate shared understanding and shared meaning about the importance of the participation, retention and success of women in science. Particular emphasis is placed on identification of the barriers women face in their career paths as researchers and tertiary education professionals, and the barriers to attaining the highest levels of achievement and recognition. Emphasis is also placed on the cost of attrition of women from SET in terms of international competitiveness and return on educational investment.

The negligible changes since the production of the 1995 discussion paper are graphically captured in comparative data. Over the 16-year period from 1992 to 2008 the data indicate a small overall increase in women's participation in the workforce with the most significant growth registered in the feminisation of traditional areas of female employment. In traditionally male dominated fields there are small to moderate increases in women's participation. In terms of leadership, the category of female administrators and managers has grown by only 4 percentage points yet female participation in professional fields has increased by 11 percentage points.

SET specific occupational data indicates that women constituted 18.1% of full-time professionals in the field of Design, Engineering, Science and Transport in 1996. This grew by only 4.2 percentage points to 22.3% in 2009. ICT professionals did not fare as well; while females constituted 19% of all full-time ICT professionals in 1996, this number fell 3.8

percentage points to 15.2% in 2008. Similarly, the percentage of women in full-time Engineering, ICT and Science Technician roles similarly dropped from 18.9% in 1996 to 17.1% in 2008. Moreover, earnings for women in these fields, and indeed in highly feminised fields, have remained consistently lower than their male counterparts.

A 'Women in Professions Survey Report' produced by the Association of Professional Engineers, Scientists and Managers (APESMA) in 2007 found that women were less likely to be employed as full-time science professionals than men. Women were also more likely to be working part-time as a science professional and at lower levels of classification. This is consistent with data from the CSIRO, where of 1,727 research scientists only 21% are women and fewer than 10% at the top salary level are women. Of the CSIRO's 194 research managers, only 8% are women and only 3 of 12 on the Executive Team are women, although a woman has recently been appointed as CEO.

Data on participation in higher education graphically illustrates established patterns of low levels of participation in engineering and IT and low rates of retention and success in and beyond the post-doctoral phase for all other broad fields of science. This results in low levels of female representation amongst academic staff, which consistently declines with seniority and measures of esteem. In the learned Academy of Science women constitute only 7% of Fellows. In the learned Academy of Technological Sciences and Engineering 6% of Fellows are female. Women make up only 8.5% of ARC Federation Fellows, the fellowships designed to attract world-class researchers and world-class research leaders to key positions.

In this context the answer to the question 'How Far Have We Come?' must be 'not nearly far enough'. As numerous comparable international studies attest, this tardiness arguably impacts on our scientific productivity and capacity to innovate. In 1995 Australia was leading this policy field. Today Australia has now been overtaken in the international arena. In 1998 the European Commission's Research Directorate-General set up an expert group on women in science and charged the members with the task of preparing a report on women in science policy in the European Union. Growing concern had been expressed at the lack of women both among career scientists and among those who shape scientific policy.

In 2001, the US National Science Foundation initiated the ADVANCE program. ADVANCE was designed to improve the institutional climate, and the recruitment and retention of women faculty in science and engineering. More recently the US National Academies of Science took up the issue with their investigation into the persistent barriers to women's participation in SET published in the report *Beyond Bias and Barriers* (2007). This report clearly documents the barriers to success women face in every field of science and engineering; obstacles that, it is argued, deprive the country of an important source of talent.

In the UK in 2002 the Secretary of State for Trade and Industry commissioned a high level report, *Set Fair*, on the difficulties faced by women in science. Subsequently the UK's Resource Centre for Women in Science, Engineering and Technology (UKRC) was established in 2003. The UKRC aims by 2030 to 'have an environment in UK SET employment in which women contribute to, participate in and share the benefits equally with their male counterparts'. This environment is seen as essential if the UK economy is to thrive as a knowledge economy on the global economic stage.

Why then has the issue of women in science and technology fallen off the equity and productivity agendas in Australia just when other OECD countries have launched major initiatives? Why are women almost invisible in the *Australia 2020 Summit Report* (Australian Government 2008), the Bradley Review of Higher Education (2008), and the Cutler & Company Review of innovation (*Venturous Australia*, 2008)?

Perhaps because in recent years there have been significant advances in terms of female participation in science and technology at the secondary school level and the undergraduate

level of higher education. This is mirrored in shifts in equity policy priorities, most notably the prominence given to the differential achievements of boys in education. Recently, research policy on gender and education has focused on the perception that girls are now 'doing better' than boys in a number of key areas, most notably retention to Year 12, end-of-school results and competence in literacy. As noted in the Bradley Review of Higher Education, women now outnumber men in university enrolments. These achievements mask the continuing low levels of participation of women in Engineering and ICT, the high levels of attrition in the postdoctoral phase of women's scientific careers and the small number of women in senior and leadership roles in the science and technology sector.

The current focus is on compounded inequality (membership of multiple equity groups), and on popular perceptions of male versus female educational achievements, both viewed in the context of the relative gains made by women since the late 1980s vis à vis other equity groups. This has led to the renewed invisibility of women in the current equity, higher education, productivity and innovation policy debates.

In this report it is argued that while there are strong imperatives to focus on the most disadvantaged in terms of equity and social inclusion there are also strong imperatives to keep in sight persistent patterns of gender inequality. Persistent gender inequality impacts negatively on men as well as women by narrowing choice and reinforcing historic workforce patterns. It also limits the range of responses available to meet other equity group participation targets as these groups are constituted by women and men in roughly equal proportions. It is argued that the (now often overlooked) persistent vertical segregation in science and technology disciplines, in addition to continuing horizontal segregation, impact on women's capacity to participate, contribute and succeed in 'non-traditional disciplines'. It is these disciplines, after all, that are the research and research training engines of our universities and critical to the nation's productivity and economic well-being.

It is acknowledged that examples of extraordinary individual achievement and leadership are cause for cautious optimism. Such achievement, plus the systemic change that has occurred at the secondary school level and in some disciplines at the undergraduate and postgraduate levels, provide evidence that such change can be achieved if a clear agenda is set and pursued.

This report suggests that this is an agenda that is currently only half prosecuted. It demands renewed attention if we are to maximise the outcomes in terms of productivity and innovation as well as equity.

It is time for a renewed focus on women in science and technology. This is a dynamic period in which a new federal government is pursuing a vigorous reform agenda. The Commonwealth government's response to the Bradley Review prioritises the social inclusion agenda (2008) and is generating new challenges and new opportunities in tertiary education. The Ministerial response (2009) to the Cutler Review (2008) promises to reinvigorate the innovation agenda, emphasising the need for creative and purposeful leadership. The Prime Minister's recent announcement of a review of the Public Service (2009) foreshadows the possibility of a more dynamic interface between the public and higher education sectors.

Such a dynamic policy environment is the ideal time to pursue systemic change that will enrich Australian science and society by capitalising on the expertise, skills and promise that women can more fully bring to the fields of science, engineering and technology.

## **Recommendations**

Following the approach of the US National Science Foundation (NSF), FASTS supports a multifaceted strategy to broaden participation in the science and technology workforce – in particular to realise the potential of women's participation. FASTS encourages institutions of higher education and the broader science community (including government, professional societies, the learned academies, science and technology related industries and not-for-profit organisations) to address various aspects of science and technology organisational culture and institutional structure that may negatively affect women. The following recommendations have been drafted with the input of a range of key stakeholders.

### **Advancing the Agenda**

1. The Minister for Innovation, Industry, Science and Research takes a leadership role in ensuring the urgent prosecution of the agenda outlined in the following recommendations, including identifying and co-ordinating the appropriate responsible agencies.
2. Identify incentives for change including a stronger business case linking diversity with innovation.

### **Scientific Career Paths**

3. Clearly map scientific career paths with opportunities for leadership and mentorship identified in tandem with the systematic identification and elimination of barriers to women.
4. Address the mechanisms that will enable women to 'thrive and excel', not just 'survive', in science and technology careers, including supporting flexible, non-traditional career paths.

### **Institutional Cultures and Decision-making**

5. Following the US ADVANCE program, support leadership and employers to implement policies and practices that generate positive organisational cultures which create contemporary family friendly and equitable workplaces that value diversity.
6. Following the EU example ensure that women constitute one third of policy-making, funding and decision-making boards.

### **Evidence and Evaluation**

7. Improve the evidence base – institute consistent, systematic reporting of gender data in the sector on the part of the major research and research funding agencies (including CSIRO and the NH&MRC), the centres of excellence (the Learned Academies, the CRCs, the ARC Centres and Networks) and industry. Ensure that the ABS and Office for Women generate data sets that link participation to innovation in keeping with international practice.
8. Create a clearinghouse for best practice in the sector comparable with the UK's Resource Centre for Women in Science, Engineering and Technology. The responsibilities of the clearinghouse will include the monitoring and evaluation of SET initiatives.
9. Continue the monitoring and research in schools on gendered participation with a renewed emphasis on the four questions: Which girls? Which boys? Which disciplines? Why?

### **Leadership**

10. Empower leaders to address these issues through resources, interventions, and a robust policy and evaluation framework; and on an organised and ongoing basis identify high profile male and female individual and organisational champions.

## Section 1: Background

*As Commissioner for Research, the lack of women scientists within European research is one of my particular concerns. It is important that this issue is given high priority in the debate on future science policy, and that steps are taken to try to re-address the imbalance between male and female researchers. The stronger presence of women in research would improve the utilisation of human resources while enriching the scientific enterprise by bringing in new themes and perspectives.*

*Philippe Busquin,  
Commissioner for Research, EU, 2000*

This report was initiated by FASTS in response to two long term issues around women's participation in science and technology: first, increasing concern in the Commonwealth government regarding levels of participation in science subjects in the senior years of high school and the flow on effects of this; and second growing awareness of the looming personnel shortages facing the academic and research sectors. The Commonwealth government recognises that we must learn from successful knowledge-based economies around the world: 'Making innovation work requires a workforce with sophisticated skills of all kinds — including leadership and management skills. It also requires cooperative workplaces in which creativity is encouraged (DIISR 2009, 17).' There are already skills and labour shortages in some key technical and scientific areas and these are forecast to worsen. It is recognised that it is 'important that we reverse the historic decline in the study of science and maths'. (DIISR 2009, 40)

Australia's science knowledge and skills base is very fragile. Many research fields are increasingly dependent on international talent and securing international talent is becoming extremely competitive. This report argues that identification of strategies to correct these trends through the participation and retention of women is crucial. The 1995 report to the Australian Government by the Women in Science, Engineering and Technology Advisory Group noted that:

**Women remain seriously under-represented in some specific disciplines of science, engineering and technology (SET), and furthermore, are not well-represented at the most senior levels in all disciplines...** There needs to be a greater recognition of the value of the different perspectives, priorities and operating styles that women can bring to SET. Women in SET-based education, training and employment contribute additional creativity, imagination and intelligence to the strong SET base of which Australia is justly proud.  
(Emphasis added, 5-6)

### Terms of Reference

The FASTS Board agreed on the following terms of reference for this report:

1. Identify the key issues based on existing studies and consultation with key stakeholders – 'what we know and what we don't know'.
2. Prioritise the issues that are critical to the emerging productivity and innovation agendas (economic and human resource argument).
3. Generate new ways of thinking about issues that have current and future importance and can gain gravitas.
4. Propose a dissemination strategy – including reports targeted to identified government and private sectors.

## Scope of the Review

Science is formally constituted by a number of broad fields of education, research and practice. Some policies focus on the grouping of Science, Engineering and Technology (SET). Still others refer to Science within the grouping of Science, Technology, Engineering and Mathematics (STEM). The disciplines of science identified in the FASTS' constitution are: Biological sciences, Geological and geographical sciences, Agricultural and food sciences, Mathematical sciences, Chemical sciences, Aquatic sciences, Medical and cognitive sciences, Physical sciences, Plant and ecological sciences, and Technological sciences.

This review focuses on the participation, retention and success of women in Australia in these science and technology disciplines. The review concentrates on the horizontal and vertical segregation of women academics and researchers as key contributing factors that impact on the research and innovation agendas. Within the scope of this project it is not possible to examine in any detail the evidence relevant to gendered socialisation, the impact of early childhood experience or the extensive literature on participation in science, mathematics and technology in pre-tertiary education (see [Ainley et al. 2008](#)).

## Methodology

In this report the aim is to address the systemic challenge ([Head & Alford 2008](#)) of women's participation, retention and success in science by drawing on the evidence base of relevant national data and to inform analysis with reference to the literature in the field. The 1995 report 'Women in Science, Engineering and Technology' prepared by the Women in Science, Engineering and Technology Advisory Group is taken as a benchmark study. This has enabled examination of the important question 'How Far Have We Come?' over the last decade and a half. International interventions have also been highlighted as possible models to generate a learning framework around which to structure interventions appropriate to the Australian context. The overarching aim is to generate shared understanding and shared meaning about the issue and the possible solutions.

The methodology adopted was: to define the problem; to identify the complexity of differential patterns or participation of women in different science and technology disciplines; to review the literature to identify knowledge gaps and relevant strategies; and to generate informed recommendations. Key themes and draft recommendations have been refined by stakeholder and reviewer input.

The scope of this study has been confined to available secondary sources, although potentially fertile areas for further primary research are identified. There is significantly more readily available data on women in academia than women in science-related careers in government or in private enterprise. The one SET profession that has carefully monitored gendered participation in recent years is engineering and reference has been made to this evidence base, while remaining mindful of not simply reiterating findings relevant to the engineering profession. Understanding of the government sector and industry, limited in part by the modest scope of this report, is drawn from a range of ABS census and labour force data, examples of statutory reporting and professional association surveys. In order to offset the disadvantages of not having the capacity to engage in significant data-mining of large datasets the report takes as its benchmark the 1995 Women in Science, Engineering and Technology Advisory Group's report to the Australian Government and seeks to generate comparative data in lieu of detailed longitudinal data.

The aim is to 'help stakeholders negotiate shared understanding and shared meaning about the problem and its possible solutions.' (Conklin 2007, 5) One important aspect of this process was to hold a workshop for key stakeholders to provide the opportunity for review and input to a draft version of the report. The workshop was held on 17th of September 2009 at the House of Representatives Alcove, Parliament House Canberra. It was attended by more than 50

participants representing a diverse cross-section of people from government, industry and academia.

## **Organisation of the Review**

The organisation of the review is as follows:

In Section 1 the background to the review is presented and key themes outlined.

In Section 2 data regarding the participation, retention and success of women in science and technology is presented. The dominant paradigms that elucidate barriers to the careers of women in science and technology and the benefits of having women in the science workforce are discussed. The factors that have been identified as contributors to the horizontal and vertical segregation of women in science and technology are outlined.

In Section 3 the initiatives undertaken by major international agencies in the US, UK and Europe in an effort to reduce both horizontal and vertical segregation for women in Science are discussed. Examples of established Australian initiatives are also identified.

Section 4 identifies strategically important gaps in our knowledge and data.

In Section 5 the conclusions and recommendations are summarised.

Finally, an attached appendix presents the statistical data that has informed the discussion.

### **1.1 Cause for concern?**

In 1993 the then Minister Assisting the Prime Minister for Science and the Minister for Science and Small Business established the Women in Science, Engineering and Technology Advisory Group (WASET). The Advisory Group was tasked to advise on strategies to improve women's participation in SET careers and education. In a discussion paper from the Advisory Group in 1995 it was argued that:

Women remain seriously under-represented in some specific disciplines of science, engineering and technology (SET), and furthermore, are not well-represented at the most senior levels in all disciplines. This problem is poorly understood since statistics actually show a significant improvement in women's participation overall in SET-based education, training and employment over the last decade...Women are 51% of the nation's population. Using their talents to the full at all levels of scientific and technological education, training and employment is an economic necessity, and an investment in Australia's future national development. The Advisory Group believes that continued under-representation and under-participation of women in SET-based education, training and employment is not only a cause for social concern on equity grounds, it is also likely to inhibit Australia's capacity to develop internationally competitive research and industries. (1995, 5-6)

The Advisory Group questioned 'what it is about the environments of science, engineering and technology, and society's perception of them, that they do not attract and keep girls and women' (ibid, 14). The Advisory Group proposed three strategies. First, a short-term strategy to put in place the conceptual and structural foundations. Second, a medium-term strategy aimed at providing leverage to existing programs 'with the specific aim of preventing the loss of existing investments in SET education and training'. And third, a long-term strategy to address those areas requiring further research and analysis (ibid, 6). The fourteen recommendations generated from this report included: family friendly policies and workplaces; higher education participation in non-traditional disciplines; re-entry schemes; attraction, selection, retention and success initiatives; identification of barriers to the achievement of excellence; and public

awareness campaigns. This raises the important question posed by Carrington and Pratt (2003) in relation to women's participation in higher education: How Far Have We Come?

## How Far Have We Come?

The minimal rates of change since the production of the 1995 discussion paper are graphically captured in comparative tables A1.1-A2.1, which directly compare the statistical information presented in the 1995 report with the most current data available. Over the 16-year period from 1992 to 2008 the data indicate a small (2.8 percentage points) overall increase in women's participation in the workforce (from 42.3% in 1992 to 45.1% in 2008). The most significant changes registered were in the feminisation of traditional areas of female employment: a 14.2 percentage point growth in women's participation in community services (growing from 65.8% to 80%) and an 18.8 percentage point growth in government administration and defence (37.1% in 1992 to 55.9% in 2008). In traditionally male-dominated fields there were small to moderate increases in women's participation: 1.8 percentage points in agriculture, forestry and fishing (from 29.6% in 1992 to 31.4% in 2009), 3.9 percentage points in transport and storage (19.5% to 23.4%), 5.7 percentage points in mining (9.5% to 15.2%) and 12.6 percentage points in electricity, gas and water supply (13.6% to 26.2%).

In terms of leadership the category of female administrators and managers (A1.1, A1.2) has grown less than 4 percentage points from 25.1% in 1992 to 29.0% in 2008. Yet female participation in professional fields has increased over 11 percentage points from 42.4% to 53.4%.

More specific occupational data (A1.3-A1.6) indicates that women constituted only 18.1% of full-time professionals in the field of Design, Engineering Science and Transport in 1996 and this only grew by 4.2 percentage points to 22.3% in 2009. ICT professionals did not fare as well; while females constituted 19% of all full-time ICT professionals in 1996, this number fell 3.8 percentage points to 15.2% in 2008. The percentage of women in full-time Engineering, ICT and Science Technician roles similarly dropped from 18.9% in 1996 to 17.1% in 2008. Moreover, earnings for women in these fields, and indeed in highly feminised fields, have remained consistently lower than their male counterparts (A1.7-A1.10).

In this context the answer to the question 'How Far Have We Come?' must be 'not nearly far enough'. As a number of comparable international studies attest, this arguably impacts on our scientific productivity and capacity to innovate. In 1995 Australia was leading this policy field. Today it has been overtaken in the international arena. In 1998 the European Commission's Research Directorate-General set up an expert group on women in science and charged the members with the task of preparing a report on women in science policy in the European Union. Growing concern had been expressed at the lack of women among career scientists and among those who shape scientific policy (EC 2000).

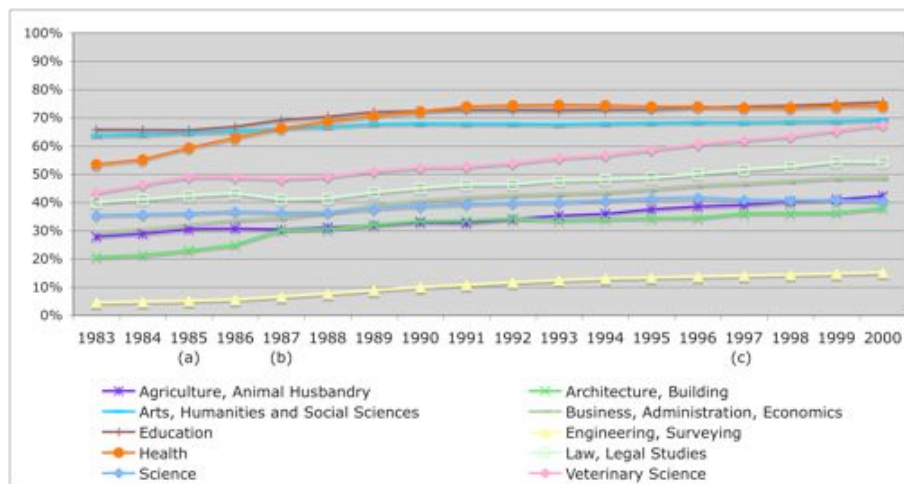
In 2001, the US National Science Foundation initiated the ADVANCE program. ADVANCE was designed to improve the institutional climate, and the recruitment and retention of women faculty in science and engineering. The US National Academies of Science have more recently taken up the issue with their investigation into the persistent barriers to women's participation in SET published in the report *Beyond Bias and Barriers* (2007).

In the UK in 2002 the Secretary of State for Trade and Industry commissioned a high level report, *Set Fair*, on the difficulties faced by women in science. Subsequently the UK's Resource Centre for Women in Science, Engineering and Technology (UKRC) was established in 2003. The UKRC aims by 2030 to 'have an environment in UK SET employment in which women contribute to, participate in and share the benefits equally with their male counterparts'. This environment is seen as essential if the UK economy is to thrive as a knowledge economy on the global economic stage (UK Resource Centre for Women in Science, Engineering and Technology 2008, 7)



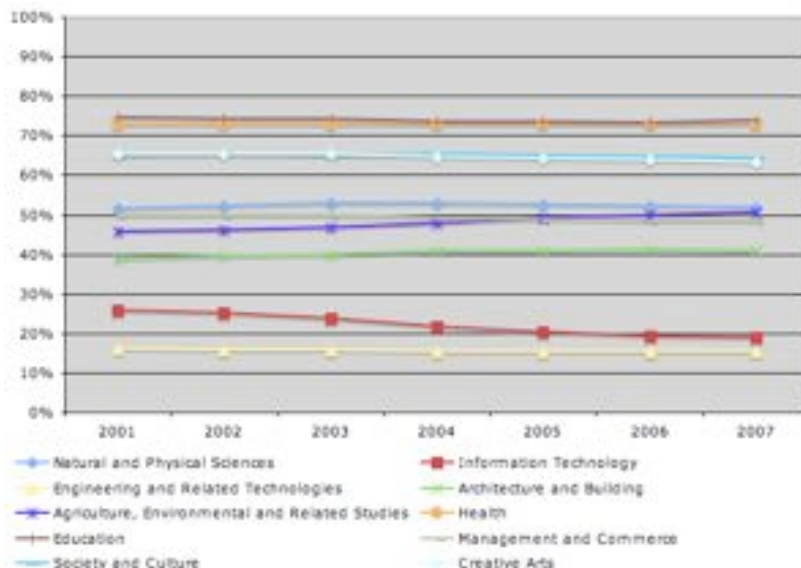
## The Productivity and Innovation Agendas

The latest student data from the Department of Education, Employment and Workplace Relations (DEEWR) shows that women make up 55% of all undergraduate students and 51.8% of postgraduate students (DEEWR 2007). However, the number of female students is not evenly distributed between the different fields of education. The Health and Education fields have the highest numbers of female students at 72.9% and 74.0% respectively. This is in marked contrast to the fields of Engineering and Information Technology where the numbers of female students make up only 15.5% and 18.9% respectively. Other fields such as Natural and Physical Sciences (52%), Management and Commerce (48.5%) and Creative Arts (63.2%) hover around 50-60%. **This uneven representation of women in the different areas of education (and the workforce) is known as horizontal segregation** (Carrington & Pratt 2003, 7).



**Figure 1.1 Female Higher Education Enrolments by Broad Field of Study 1983 – 2000**

Source: DEEWR Selected Higher Education Student Statistics, All students by gender and broad field of study, 1983-2000



**Figure 1.2 Female Higher Education Enrolments by Broad Field of Education 2000 - 2007**

Source: DEEWR Selected Higher Education Student Statistics, All students, by gender and broad field of education, 1991-2007

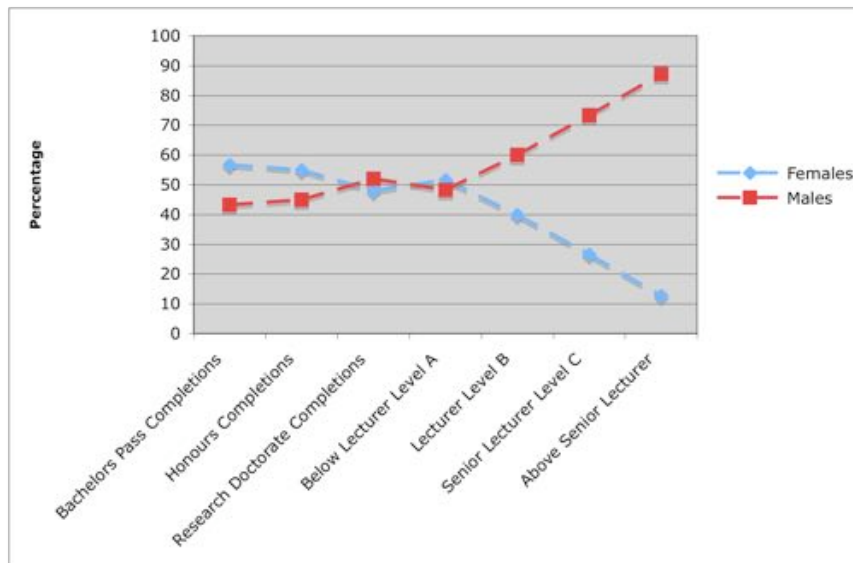
The disparity between men and women in the sciences and technology disciplines is particularly worrying given the importance of these fields in Australia's economic growth and capacity for innovation. In recent decades there have been many initiatives to encourage more

women in Science, Engineering and Information Technology. These measures have succeeded in increasing the numbers of female students in some fields. However, more in-depth study of the data shows that women's participation is relatively low in particular disciplines (Narrow Fields of Education) such as Mathematical Sciences, Physics and Astronomy and Earth and Chemical Sciences, as well as all fields of Information Technology and Engineering. In fields such as Biological Sciences as well as in Agriculture and Environmental Studies there is significant participation of women (see Figures A3.1-A3.11). It should be noted however that where increases in participation at undergraduate level have been achieved this is in part due to the introduction of a new Field of Education classification in 2001 which introduced the field of Information Technology, thereby artificially increasing the percentage of women in the field of Natural and Physical Sciences.

This uneven representation of women in the different fields of science is also a manifestation of horizontal segregation, well-documented in the literature (Langford 2006; Queensland Government Office for Women 2006; Cervantes 2006). Moreover, snapshot data clearly indicates that even when relatively high levels of participation at undergraduate and even post-graduate levels have been achieved there are persistently low levels of representation of women at senior levels of the academy – **evidence of vertical segregation** (Carrington & Pratt 2003, 7). (Figures 1.5-1.8). The research of Castleman et al (1995) on the payroll data of a sample of universities suggests that women are distributed unevenly amongst high and low demand disciplines and that where they form a sizeable minority of academics in high demand disciplines they remain concentrated in the lower levels of the classification structure (1995, 46-48).

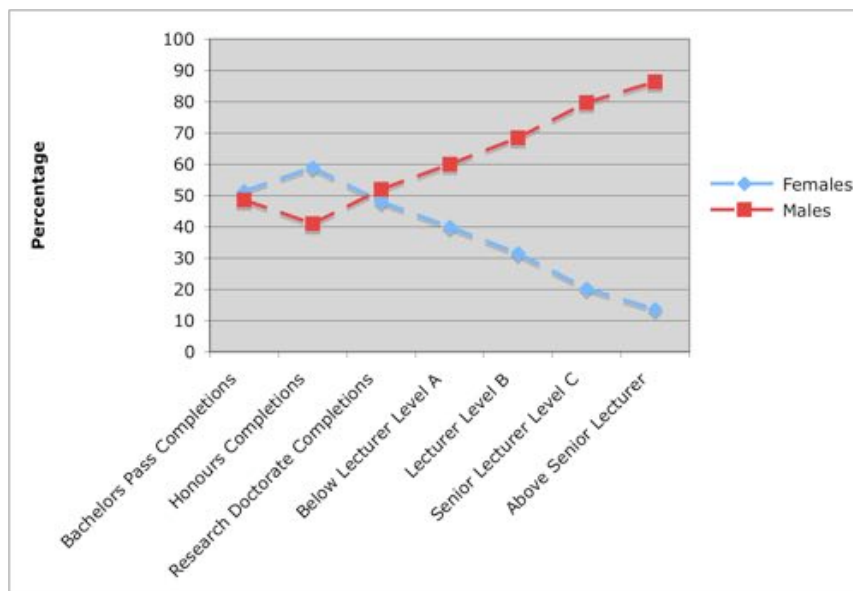
Figures 1.3 to 1.6 are constructed from the percentages of male and female completions at each level of higher education, and from academic staff profile data in 2007. In Australia, academic positions are structured into five levels, from Level A through to Level E. Level A is the equivalent of an Associate Lecturer and Level E is a Full Professor. Seniority may be regarded as a proxy measure of success.

This data is **not** longitudinal data. Indeed the data indicates a pressing need for more nuanced analysis of correlations between age, age of entry, length of service, retention, seniority and gender.



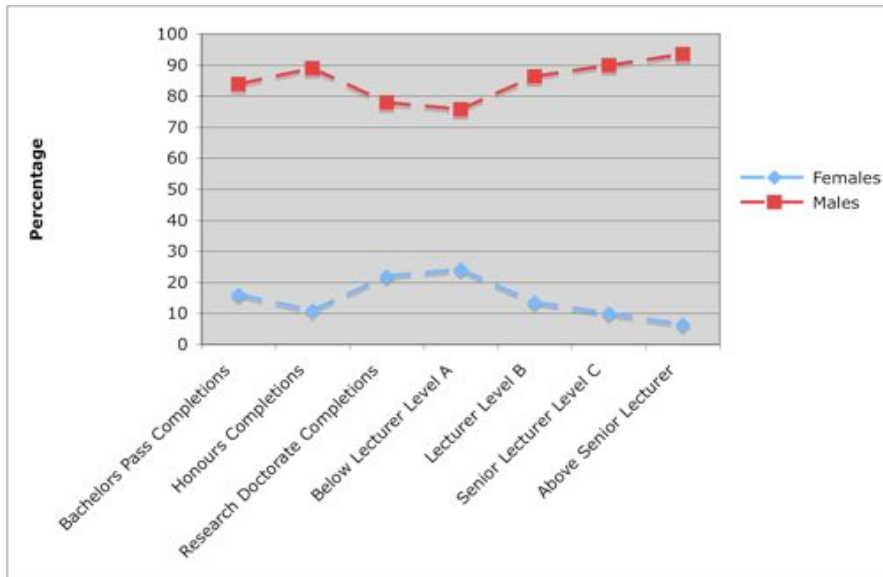
**Figure 1.3 Academic Profiles by Gender; Natural and Physical Sciences 2007**

Source: DEEWR Selected Higher Education Student Statistics 2007; DEST Special Report FTE Staff in AOU Groups 2007



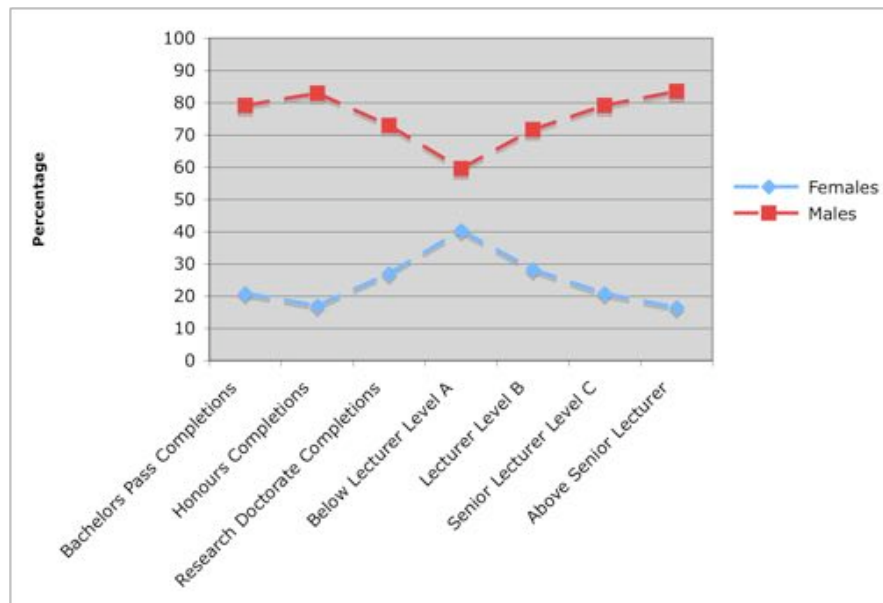
**Figure 1.4 Academic Profiles by Gender; Agriculture and Environmental Studies 2007**

Source: DEEWR Selected Higher Education Student Statistics 2007; DEST Special Report FTE Staff in AOU Groups 2007



**Figure 1.5 Academic Profiles by Gender: Engineering and Related Technologies 2007**

Source: DEEWR Selected Higher Education Student Statistics 2007; DEST Special Report FTE Staff in AOU Groups 2007



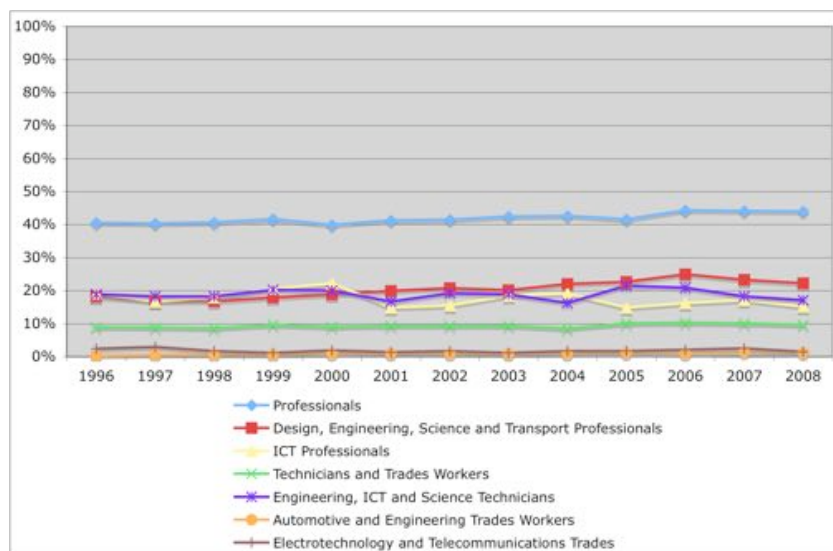
**Figure 1.6 Academic Profiles by Gender: Information Technology 2007**

Source: DEEWR Selected Higher Education Student Statistics 2007; DEST Special Report FTE Staff in AOU Groups 2007

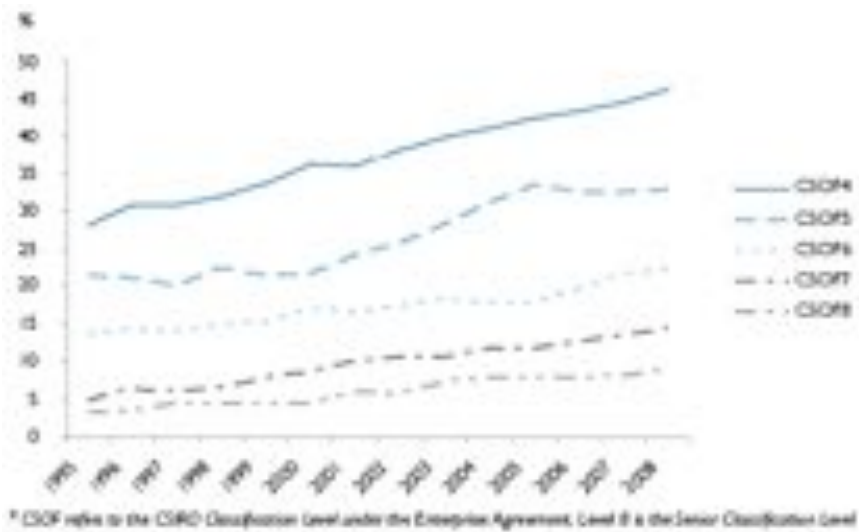
That women are under-represented in senior academic positions does indicate barriers to 'success' but does not necessarily equate to attrition. Women may be moving from the academy into productive work in industry, government or not-for-profit sectors commensurate with their knowledge and skills base. However, the absence of reliable data that tracks mobility of the scientific workforce between universities, industry and government means it is much harder to evaluate whether there is net attrition or simply a wide range of graduate and postgraduate outcomes. A sample of available data from government agencies and industry does however suggest attrition, as the pattern of feminised lower ranks and male dominated senior ranks is replicated.

Data that is readily available does suggest relatively unchanging patterns of gendered occupational participation (Figure 1.7) and comparable gendered patterns of seniority to the academy in our largest government scientific agency, CSIRO (Figures 1.8 -1.9). Data from the CSIRO 07/08 annual report shows that of 1,727 research scientists only 21% are women and fewer than 10% at the second-highest salary level, CSOF 8, are women. Of the 194 research managers, only 8% are women and only 3 of 12 on the Executive Team are women, although a woman has recently been appointed as CEO. Figure 1.9, taken from more recent (2009) figures, graphically illustrates the horizontal segregation of women into positions of lesser responsibility comparative to men.

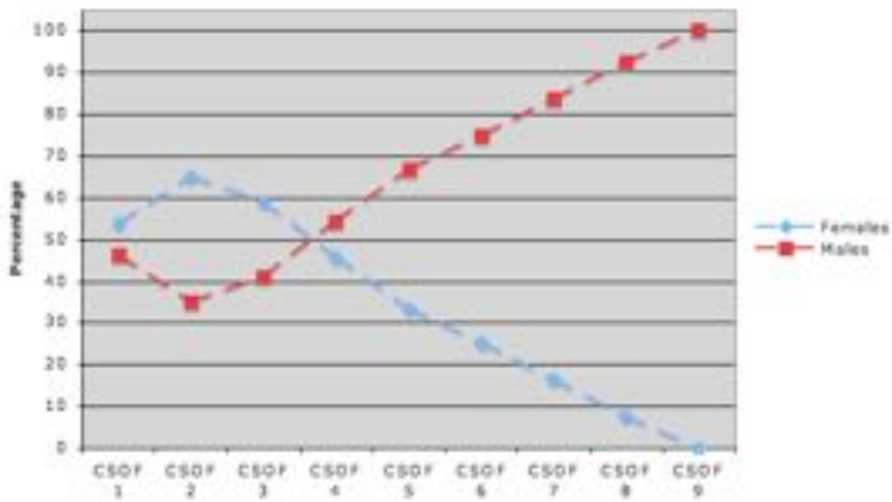
It should be noted that Commonwealth government agencies vary in role and size and there is discretion as to the extent of the information included in annual reports (Department of the Prime Minister and Cabinet, 2009). This discretion means is not possible to extract consistent information about the scientific workforce to show gender at each classification level or employment status across the large number of government statutory authorities.



**Figure 1.7 Occupational Categories and Sub-Categories by Percentage of Females 1996-2008**  
 Source: ABS Labour Force, Australia, Detailed, Quarterly May 2009



**Figure 1.8 Percentage of Females by CSOF level 1995 - 2008**  
 Source: CSIRO Annual Report 07/08



**Figure 1.9 Percentage of females by CSOF level 2009**  
 Source: CSIRO

Recent major reports from the USA and Europe indicate that this is not a phenomenon specific to Australia. These reports are critical to our understanding of this phenomenon: the National Academy of Science's *Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering* (NAS 2007); the Organisation for Economic Co-operation and Development report *Women in Scientific Careers: Unleashing the Potential* (Organisation for Economic Co-Operation and Development 2006). Tables 1.1 and 1.2 summarise the main findings of the NAS and OECD reports.

**Table 1.1 The main findings of the report from the NAS: *Beyond Bias Barriers: Fulfilling the Potential of Women in Academic Science and Engineering***

<b>Committee on Science, Engineering, and Public Policy (NAS). <i>Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering</i></b>
<ul style="list-style-type: none"> <li>• Despite the many studies of brain function and structure, of hormonal modulation of performance, of human cognitive development, and even of human evolution, there are no significant biological differences between men's and women's performance in science and mathematics. Thus, innate ability in science and mathematics does not account for the lower representation of women in academic faculty positions in the fields of science and engineering.</li> <li>• <b>The representation of women drops substantially at each transition from high school through to full professorships.</b> These women have expressed interest in science and yet have decided to opt out of pursuing a science or engineering career.</li> <li>• Women have made up of more than 30% of doctorates in social and behavioural sciences and more than 20% in life sciences for more than 30 years, but only 15.4% and 14.8% of women in social and behavioural sciences and life sciences respectively are full professors in top research institutions. In addition, these are the only fields in science and engineering where the proportion of women reaches into the double digits. Thus, the problem is not simply the pipeline.</li> <li>• Due to the tradition of male-dominated fields of science and engineering, women faculty have to contend with barriers that limit their appointment, retention and advancement in these fields, such as continued questioning of their own abilities and commitment to an academic career. As a result, women have not received as many opportunities and encouragement to develop their interest and abilities to the fullest compared to men. This accumulation of disadvantage becomes more acute in more senior positions. Thus, women are very likely to face discrimination in every field of science and engineering.</li> <li>• Research on cognitive psychology show that both men and women hold implicit biases that play a large role in the evaluations of people and their work. On average, people are less likely to hire a woman than a man with identical qualifications, are less likely to ascribe credit to a woman than a man for identical accomplishments, and when information is scarce, are less likely to give the benefit of doubt to a woman than a man. These tendencies are also true for scientists and engineers even though most believe that they are fair and objective.</li> <li>• <b>Women faculty are paid less, are promoted more slowly, receive fewer honours and hold fewer leadership positions than men. These discrepancies arise because of a "meritocratic" system that has arbitrary and subjective evaluation criteria.</b> Progress in academic careers depends on accomplishments that are evaluated by senior scientists who seem to value characteristics such as assertiveness and single-mindedness over flexibility, diplomacy, curiosity, motivation and dedication. In short, characteristics that are more vital to success in science and engineering are eschewed. At the same time assertiveness and single-mindedness are stereotyped as socially unacceptable traits for women. Thus, women are disadvantaged by evaluation criteria that are biased and contain arbitrary and subjective components.</li> <li>• Structural constraints and expectations built into academic institutions assume that faculty members have substantial spousal support and anyone lacking this support is at a serious disadvantage. In more recent times, the majority of faculty no longer have this support. Almost half the spouses of male faculty in science and engineering are employed full time. Approximately 90% of the spouses of women faculty work full time.</li> <li>• <b>Women make up an increasing proportion of students and the labour force. In order to capture and capitalise on this talent, policies will need to be revised to manage a new and diverse workforce. The consequences of <i>not</i> acting will be detrimental to the nation's competitiveness.</b></li> </ul>
<b>[Emphasis added]</b>

**Table 1.2 The main findings of the report from the OECD: *Women in Scientific Careers: Unleashing the Potential***

<b>Organisation for Economic Co-Operation and Development (OECD). <i>Women in Scientific Careers: Unleashing the Potential</i></b>
<ul style="list-style-type: none"> <li>• Gender stereotyping may affect the career choices made by women. Science and engineering have always been perceived as being male-oriented and some women may not find this aspect of the field attractive. Society and family have a great influence on girls' career choices, particularly where gender stereotyping is concerned.</li> <li>• Mathematics ability between boys and girls has been considered one of the factors for the participation of girls in scientific education and careers. However, studies have shown that the gender gap in average mathematics achievement is small and declining. Thus, gender differences in mathematics ability do not explain the gender differences in the likelihood of majoring in science and engineering fields.</li> <li>• Role models and networking has great impact on women's career choice. Research has shown that youths make occupational choices based on adult workers' experiences. Therefore, more women role models in science and engineering will be beneficial to increase women's participation in these fields.</li> <li>• <b>Workplace environment and culture as well as recruitment and promotion practices are some of the variables that affect the career path of women in science and engineering fields.</b> Attitudes towards family/work balance issues, such as parental leave or working part-time, may be considered a disadvantage by some organisations during the promotions process. Therefore, the organisational culture of the workplace is very important in the retention and advancement of women in science and engineering.</li> <li>• Some research suggests that there are dysfunctions or gender bias in the evaluation for scientific excellence system that may have an impact on women's career advancement.</li> <li>• Lower research productivity may explain the differences in promotion between men and women, but productivity is also affected by access to team leader positions, where women are under-represented. Thus, the incentives and opportunities for the promotion of women may be reduced without access to team leaders roles early in their careers.</li> <li>• Women may enter research careers at a later stage and are more likely to work part-time or on temporary contracts.</li> </ul> <p style="text-align: right;"><b>[Emphasis added]</b></p>

Such international studies raise the question of why the issue of women in science and technology has fallen off the equity agenda in Australia just when other OECD countries have launched major initiatives? Why are women invisible in the *Australia 2020 Summit Final Report* (Australian Government 2008), the Bradley Review of Higher Education (2008), and the Cutler & Company Review of innovation (*Venturous Australia*, 2008)?

## **The Equity Agenda**

As has been noted by Collins and colleagues, in 1972 it was possible for sociologist Jean Martin to observe that 'Despite manifest inequalities, the subject of sex differences in educational qualifications has aroused little serious interest' (Martin 1972, 96). At this time other sociological interests such as socio-economic status overshadowed gender inequality. From the mid 1970s, for over three decades, a significant body of research and analysis has been undertaken on gender and education. Much of that research and analysis has focused on subject choice in schools, the educational performance of boys and participation of women in 'non-traditional disciplines' particularly in higher education (Collins et al. 2000, 26).

Government policy has also reflected this interest in gender equity. In 1990, *A Fair Chance For All* (DEET & NBEET) established the Commonwealth's equity framework for participation in higher education. Six equity groups were identified:



- people from low socio-economic backgrounds;
- people from rural or isolated areas;
- people with a disability;
- people from a non-English speaking background;
- women, especially in non-traditional areas of study; and
- Indigenous people.

Thanks to this framework Australia has a well-developed database on equity in higher education. Information is systematically collected and analysed on access, participation and completion rates by the above equity groups. The equity framework treats an equitable outcome as 'one in which there is parity between percentage group representation in education and in the general population. Distance from parity is measured by reference to Equity Indicators, or target values, which are based on percentage equity group membership in the 15-64 year old Australian population' (James et al 2008, 14). The equity target group 'women in non-traditional disciplines' is an exception to this, with the targets set at 40% participation for science and 15 % participation in engineering and IT.

The *A Fair Chance for All* targets for women were:

- To increase the proportion of women in non-traditional courses other than engineering from the current level to at least 40% by 1995
- To increase the proportion of women in engineering courses from 7% to 15% by 1995
- To increase the numbers of women in postgraduate study, particularly in research, relative to the proportion of female undergraduates in each field by 1995.

These targets were to be met through:

- Promoting non-traditional courses and careers for women and girls
- Bridging courses, especially in mathematics and science
- Supplementary support concurrent with award course enrolment
- Curriculum review and development, and teaching processes that focus on non-traditional courses
- Provision of adequate childcare
- Special initiatives to encourage women to undertake postgraduate courses, particularly research
- Flexible course arrangements.

Despite shifts in equity policy priorities (Yates 1997), most notably the prominence given to the differential achievements of boys in education and to the construction of 'gender identity', the above targets have endured (James et al, 2004).

Feminist educators in the 1970s and 1980s identified the problem of the under- representation of women in the scientific workplace as a world-wide phenomenon. There is evidence that this 'push' to encourage girls to study science has had significant impact in some science disciplines. By the late 1990s, research showed that just prior to entering university, 'girls believed that there was no gender discrimination, that girls could do anything, that equality had been achieved, and that taking science represented more options in their future.' (Hatchell & Aveling, 2008, 3)

The current equity orthodox argues that whilst 'not losing sight of gender, there may also be a need to return to some of the questions which, according to Martin, once dominated educational enquiry' (Collins et al. 2000, 27). In other words, while 'it remains necessary to document gender differences, it is equally necessary to complicate our understanding of "gender" itself in order to attend to the influence of other factors such as socio-economic status,

location, ethnicity, Aboriginality, (dis)ability and sexuality' (ibid 27). Recently, research policy in gender and education has focused on the perception that girls are now 'doing better' than boys in a number of key areas, most notably retention to Year 12, end-of-school results and competence in literacy (ibid 1). As has been widely noted, women now outnumber men in university enrolments 'by a considerable margin, a margin which has grown continuously since 1989' (ibid 103).

The current focus is on compounded inequality (membership of multiple equity groups), and on popular perceptions of male versus female educational achievements, both viewed in the context of the relative gains made by women since the late 1980s vis à vis other equity groups. This focus has led to the renewed invisibility of women in the current equity, higher education, productivity and innovation policy debates.

In this context it is not surprising that Universities Australia has recently concluded that: 'As has been widely noted, women now outnumber men in university enrolments, to the extent that some commentators have started to talk about men as a disadvantaged group.' And women's [declining] participation and success in some 'non-traditional disciplines' becomes an afterthought: 'At the same time, women remain significantly under-represented in certain fields of study, particularly in the sciences and engineering.' (Universities Australia 2008, 26)

A recent ACER report on 'Participation in Science, Mathematics and Technology in Australian Education' foregrounds the high levels of participation of women in teacher education courses (70%). Yet it makes no mention of women's participation in 'non-traditional disciplines' (Ainley et al, 2008, 60).

Similarly, persistent issues around the participation and success of women in 'non-traditional disciplines' do not figure in the 2008 Bradley or the Cutler & Company reviews or in the final report (Australian Government 2008) of the *Australia 2020 Summit*. In the latter report issues are acknowledged around women's participation in the workforce, women in senior management, leadership and parliament, and the need to ensure that women's voices are retained in the social inclusion agenda. While the need to address the 'retention of women at senior levels, which remains poor' was identified as part of the research and innovation agenda (2008:161) the import of this to the productivity agenda was not.

As echoed in the Bradley Review (2008, 27):

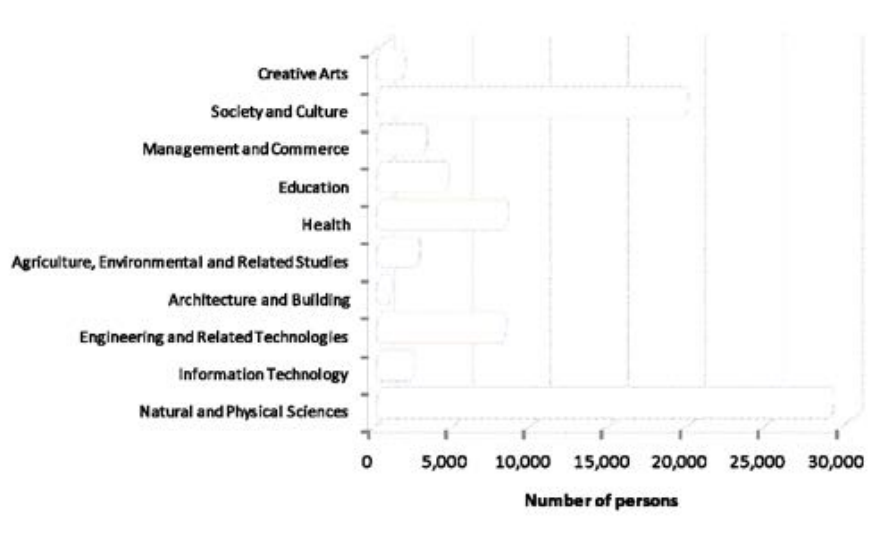
...women now participate in higher numbers than men although they still remain under-represented in higher degree research programs and in some non-traditional areas such as engineering and information technology. Now, the most seriously under-represented groups are those from remote parts of Australia, Indigenous students, those from low socio-economic backgrounds and those from regional locations.

It should seem unnecessary to state the obvious: that these are not mutually exclusive categories. But there are signs that, as equity and social inclusion are central to the current Commonwealth government's agendas, this is becoming a crowded and competitive space that is at risk of producing, albeit unwittingly, 'competing victims' (following Collins et al. 2004).

In this report it is argued that while there are strong imperatives to focus on the most disadvantaged in terms of equity and social inclusion, there are also strong imperatives to keep sight of persistent patterns of gender inequality. Persistent gender inequality impacts negatively on men as well as women by narrowing choice and reinforcing historic workforce patterns. It also limits the range of responses available to meet other equity group targets as these groups are constituted by women and men in roughly equal proportions. It is argued that the (now often overlooked) persistent vertical segregation in science and technology disciplines, in

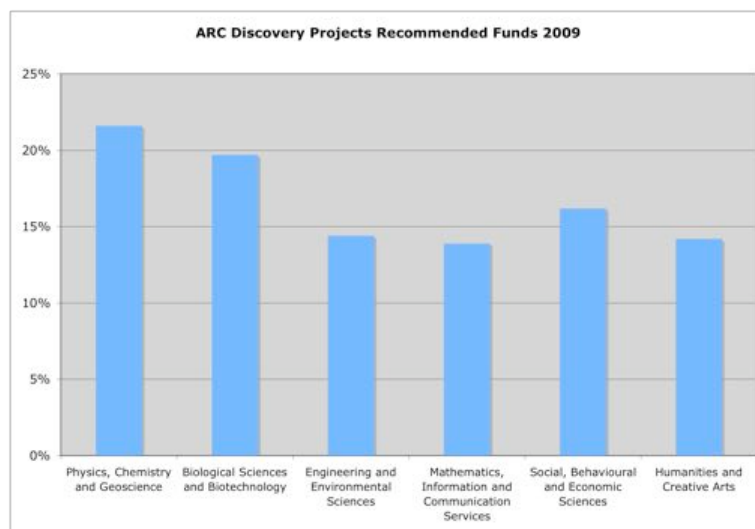
addition to continuing horizontal segregation, impact on women's capacity to participate, contribute and succeed in 'non-traditional disciplines'. It is these disciplines, after all, that are the research and research training engines of our universities and critical to the nation's productivity and economic well-being.

Figures 1.10 and 1.11 below provide a snapshot of two measures, for illustrative purposes, of the relative importance of these disciplines to our research future. Figure 1.10 illustrates the dominance of the Natural and Physical Sciences in research higher degree training of our future scientists. Figure 1.11 illustrates the relative importance of these disciplines as measured by ARC Discovery Grant funding, the prestigious scheme through which the Australian Research Council supports excellent fundamental research, research designed to expand Australia's knowledge base and research capability and foster the international competitiveness of Australian research ([www.arc.gov.au/ncgp](http://www.arc.gov.au/ncgp)).



**Figure 1.10 Doctorate population by field in which doctorate was completed, Australia 2006**

Source: Edwards, D. et al (2009): ABS Census of Population and Housing, 2006, customised data set



**Figure 1.11 ARC Discovery Projects Recommended Funds commencing in calendar year 2009**

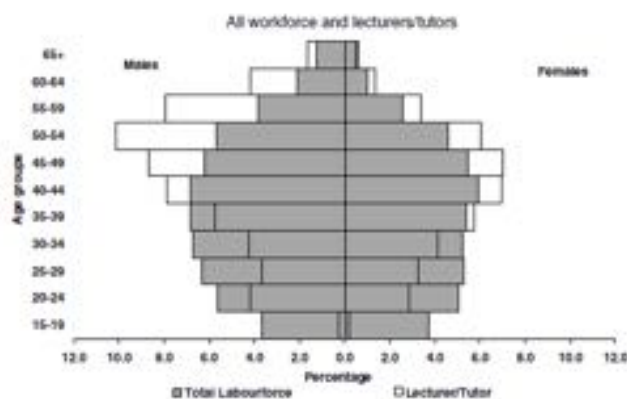
Source: ARC Discovery Projects Selection Report for funding commencing in 2009, Table 5  
[http://www.arc.gov.au/ncgp/dp/DP09\\_Selection\\_rep.htm](http://www.arc.gov.au/ncgp/dp/DP09_Selection_rep.htm)

## 1.2 Key Themes

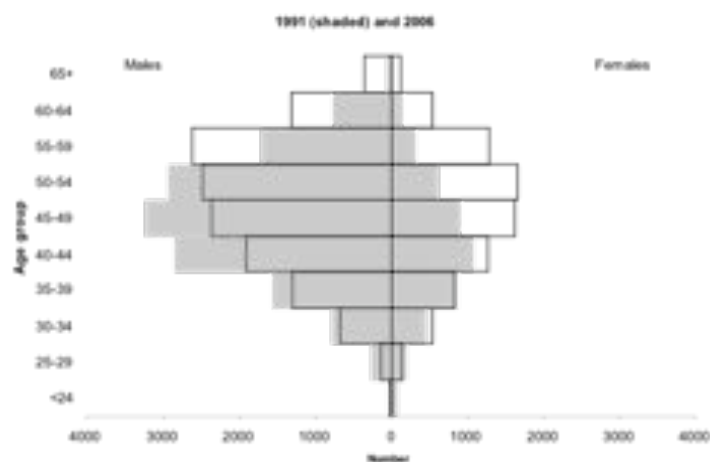
Beyond the desire to achieve gender equity, there are demonstrable benefits of having more women in the science and technology workforce. These can be grouped into three broad categories: demography; productivity and human capital; and diversity and innovation. Due to the highly credentialed nature of this workforce it is assumed that the higher education sector is critical to our understanding of the profile of the science and technology workforce.

### Demography

The Australian academic workforce is aging. Hugo (2005) reports that university academics are amongst the oldest groups of professionals in Australia. The influx of young academics in the 1960s and 1970s, many recruited internationally, coupled with subsequent slow growth in the non-casual academic workforce has resulted in the phenomenon of 'age heaping' (Figures 1.12, 1.13), which is the concentration of people into narrow age groups. In the case of the Australian university academic workforce, current demographics show that there is a larger concentration of the older age groups (Hugo 2005, 207; Hugo, 2008 11). Within the next two decades Hugo argues that there will be a shortage of academics in Australia as baby boomer academics retire. As this demographic composition of the academic workforce is common to the USA and Europe there will also be increasing global competition in the recruitment of qualified academic staff.

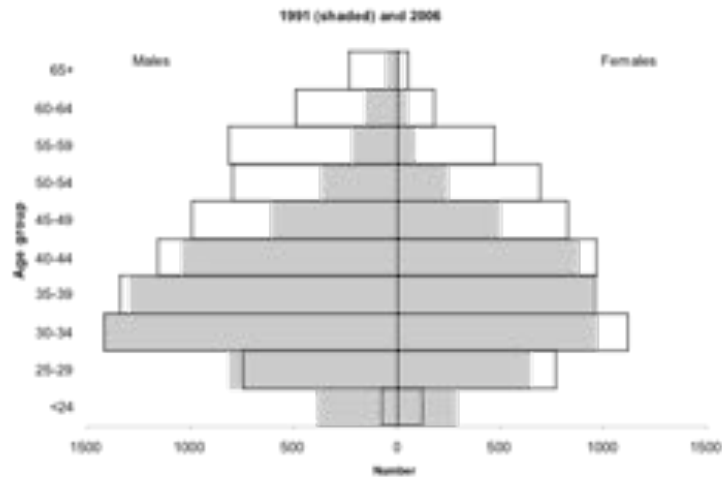


**Figure 1.12 Age-sex structures of academic staff and the Australian workforce 2001**  
Source: Hugo 2005, 214; ABS 2001 Census



**Figure 1.13 Australia: Academic Tenured Staff, Age-Sex Structure, 1991 and 2006**  
Source: Hugo 2008, 11; DEST, unpublished data

The important rider on this is that the age and gender demographics of the higher education contract workforce paints a very different picture. This picture suggests that the 'looming shortage' has been in part created by funding and related short-term employment imperatives, effectively marginalising the generation that should be replacing aging senior colleagues (Figure 1.14).



**Figure 1.14 Australia: Academic Contract Staff, Age-Sex Structure, 1991 and 2006**  
Source: Hugo 2008, 11: DEST, unpublished data

It is important to draw attention to the fact that Hugo (2008) identifies four defining elements of the contemporary Australian academic workforce: slow growth (slower than other professions); age heaping (generating problems of succession and continuity); a mature age structure (facing a period of substantial loss); and an imbalanced gender ratio (the Australian academic workforce is still one of the least balanced between males and females). Age heaping and the mature age structure have gained a great deal of attention and have generated the notion of a 'crisis'. The implications of gender imbalance, and casualisation of the academic workforce are only just beginning to be identified (Coates et al 2009).

In addition to the aging academic population, there is also some evidence regarding the 'brain drain' from Australia's SET workforce. It has been asserted by the Productivity Commission (2007, 726) that concerns that Australia has been experiencing a 'brain drain' of scientists and engineers are unfounded 'as any loss of skilled residents has been more than offset by gains from immigration'. However, a 2001 survey of academic Australian expatriates living overseas showed that 55.7% emigrated because of better employment opportunities (Hugo et al. 2003). Indeed, a recent survey on the career paths of SET research postgraduates by Giles and colleagues (2009, 69) found that 30% of participants had travelled overseas to secure employment. Another dimension to this loss is that 'gender discrimination in these traditionally male-dominated fields was experienced to a far greater degree by women than by men' (ibid, 69) adding to the loss of human capital. In order to address this, and the loss to the sector of the valuable graduate base, it is critical to understand the relationship between productivity and human capital.

## Productivity and Human Capital

Human capital can be defined as the skills, knowledge, and attitudes of the workforce. High quality human capital is critical to productivity and innovation (Cutler & Company 2008, x-xii). A person can increase their human capital 'stock' by investing in education and training or on the job experience (Bentley and Adamson, 2003). With reference to the science and technology sector it is frequently argued, or inferred that, despite notable exceptions, the investment in women's human capital (through education and training) is a poor investment as it is 'human capital' that is not maximised or even lost through the patterns of attrition outlined above.

Probert et al (1998) cogently remind us that human capital theory argues that the labour market position of women derives from demand side characteristics of the female workforce: women have invested less in their human capital, and they therefore receive fewer returns (wages and benefits). According to their influential study *Gender Pay Equity in Australian Higher Education* human capital theory, reinforces notions that: women's primary responsibility for children and dependents is a matter of individual choice; the growth of female participation in the labour market and in higher education calls into question the need for equal opportunity and affirmative action policies; and the increasing participation of women in undergraduate, postgraduate programs and in the lower levels of academic employment will mean that women's position in the sector will inevitably improve over time, as women build up their human capital (Probert et al 1998 6-7).

Probert and colleagues' research confirms the importance of the number of full-time years working in higher education to level of responsibility. It also confirms that women are likely to have fewer full-time years of experience than men because of the strategies used to balance work and carer demands, including part-time work and career breaks. But unlike human capital theorists they argue that [most] women have to make choices between career and family which [most] men can avoid (1998, 51-52). Importantly, their research showed that: **'there was no evidence that women are less committed to their careers than men'**; that women were just as likely to have a career plan as men; and women were just as eager to attain seniority as men' (emphasis added, ibid 52).

It is also argued that women in higher education have less human capital compared to men because women begin their careers at a disadvantage. Although very recent research indicates that gendered patterns of doctoral completions are changing quite rapidly (Edwards et al 2009, 34) studies have shown that compared to men, women are less likely to hold a PhD when they begin their academic careers and therefore commence at Level A (Allen & Castleman 2001; Probert et al. 1998). Men are more likely to hold doctoral qualifications and begin their academic careers at Level B. Women are also less likely to have published during their doctorate (Dever et al. 2008). The evidence is that these early career differentials are cumulative.

By not retaining more women in the fields of science and technology, and not having career pathways that accommodate competing demands, their knowledge and skills are not fully utilised. The under-representation of women in the science and technology academic workforce (Figures 1.3 -1.6) may well represent a significant waste of human capital.

## Diversity and Innovation

The Cutler Review notes that a challenging range of strategic, operational and integrative competencies are required to lead innovative businesses. Referring to the Karpin report (1995), Cutler endorses the need to capitalise on the talents of diversity (2008, 56).

Science has long been viewed as a male-dominated field. Women have the potential to bring new ideas and perspectives to the fields of science and technology. In a recent report Gratton and colleagues (2007) investigate the role that gender plays in innovative teams. Their study shows that the proportion of women and men in groups is a key factor, revealing that neither

gender functions well as the minority in a team. Their study into the impact of the proportion of men and women on the critical factors that drive innovation (the psychological safety of team members, and the whole team, the extent to which team members are prepared to take risks and experiment, and the general efficiency of the team), showed that the optimal gender mix was 50:50 (Gratton et al. 2007). In addition, the study also found that teams consisting of 60% women created optimal conditions related to the self-confidence of the team.

Of course, diversity in the workplace can be accompanied by other challenges. King notes that research has shown that diverse teams are harder to manage than homogenous groups: the 'different needs, behaviours, and characteristics of team members must be supported' and 'communication and social integration take[s] more effort'. King argues, however, that the ability of team leaders to manage such 'differences of opinion' and character are '**the very source of the diversity advantage**' (emphasis added). To cultivate a diverse group is to reap the associated benefits; 'diverse teams outperform on innovation, problem-solving, flexibility, and decision-making' (King 2005, 601).

## Section 2: What we know

*[Prospects for women in the life sciences were much improved since her time] 'but only up until the end of the PhD, graduate training and post-doctoral research period...the number of women in science careers drops off, indicating that the career options for women are not as well matched for women as they are for men'...[one practical remedy would be to] 'provide child care and part-time career options for those years in which a woman's family involvements are particularly demanding, so women did not have to feel that the choice is between having a career in science, or a family.'*

*Professor Elizabeth Blackburn, The Australian, 6 October 2009*

This section presents the evidence gathered from the literature regarding the participation, retention and success of women in science and technology. The dominant paradigms employed to describe barriers to the careers of women in science and technology and the benefits of having women in the science workforce are discussed. The factors that have been identified as barriers to women's career progression are highlighted and key themes identified.

### 2.1 Scientific career paths

At the *Australia 2020 Summit* it is reported that there was extensive discussion on improving the career structure in research, with the need for research to be better recognised as a 'profession':

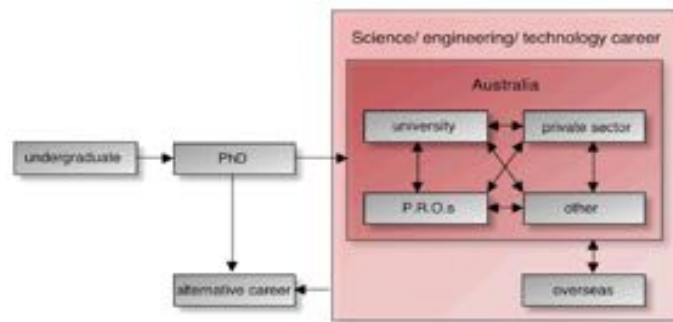
The importance of having the "best and brightest" being more disposed to return to Australia and work here was seen as critical. Development of a more secure career structure for researchers was seen as a way of achieving this. The current lack of a clear career path was seen as an issue for retention of young researchers, with issues including ensuring job security and meeting changing demands for work-life balance to take account of family needs. ... There is a clear need for a shift in how we see research as a career path and not just as being tacked onto the end of a science degree. Well-established mentorship is seen as important.

Better recognition for research will encourage recruitment and retention, including **retention of women at senior levels, which remains poor.**

(Emphasis added, Australian Government 2008, 161)

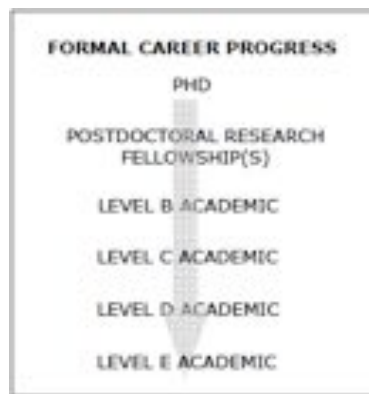
The representation of women in the science workforce is dependent on the proportion of female students who undertake science degrees in universities (A3.1-A3.11) and qualifications in the VET sector (A2.1-A2.2). There are many potential employment opportunities for students who undertake a career in science and technology. Figure 2.1 illustrates the career options that are available. A career in the university (that is academic and research) sector is one career option that is framed as a traditional progression from PhD through Postdoctoral Fellowships to academic appointments and finally to tenure (Stevens-Kalceff et al. 2007).





**Figure 2.1 The career options of students who undertake undergraduate degrees in Science, Engineering and Technology**  
Source: ACG 2006

The report by Stevens-Kalceff and colleagues (2007) on the academic profile of the School of Physics at the University of New South Wales shows that a typical Physics male follows the traditional career path as seen in Figure 2.2.



**Figure 2.2 Traditional academic career progressions in Australia**  
Source: Stevens-Kalceff et al. 2007

Conversely, a typical Physics woman follows a non-traditional career path (Fig 2.3) due to several factors such as career breaks, not having undertaken a postdoctoral appointment, and family responsibilities (Stevens-Kalceff et al. 2007). These factors ultimately lead to low levels of female participation and to limited representation of women at the more senior levels of the academic and research sectors. These factors and several others will be discussed in greater detail in the following sections.



**Figure 2.3 The non-traditional academic career progression**  
Source: Stevens-Kalceff et al. 2007

That women are still under-represented in the academic and research sectors of science and technology leads to the conclusion that there are barriers or obstacles that prevent a woman from progressing through an appropriate career path. Several metaphors have been introduced in an attempt to describe such barriers or obstacles. The 'glass ceiling' and the 'leaking pipeline' are two such metaphors.

The term 'glass ceiling', first coined in 1986 by *Wall Street Journal's* Carol Hymowitz and Timothy Schellhardt, describes an invisible barrier which women encounter as they progress through the ranks of their career. In more recent times, the efficacy of the glass ceiling metaphor has been questioned as it implies a single barrier in a linear career which women are unable to overcome.

Berryman (1983) first conceptualised the 'leaking pipeline' metaphor, which has become the commonly accepted paradigm describing the attrition of women along their career path in science. In more recent times, the leaking pipeline metaphor has been argued to be an oversimplified representation of the attrition of women from science (Soe and Yakura, 2008). Again, this metaphor fails to convey the complexities women encounter in their academic and research careers.

To quote Eagly and Carli (2007, 64), 'times have changed, and the glass ceiling metaphor is now more wrong than right [because] it describes an absolute barrier at a specific high level in organisations. The fact that there have been female chief executives, university presidents, state governors, and presidents of nations gives the lie to that charge. At the same time, the metaphor implies that women and men have equal access to entry and mid-level positions when in fact they do not. The image of a transparent obstruction also suggests that women are being misled about their opportunities, because the impediment is not easy for them to see from a distance. But some impediments are not subtle. Worst of all, by depicting a single, unvarying obstacle, the glass ceiling fails to incorporate the complexity and variety of challenges that women can face in their leadership journeys. In truth, women are not turned

away only as they reach the penultimate stage of a distinguished career. They disappear in various numbers at many points leading up to that stage’.

In a paradigm shift, Eagly and Carli (2007) propose a new metaphor, that of a labyrinth, which conveys the idea of women’s complex journey towards a worthy goal through a passage that is neither simple nor direct but which ‘requires persistence, awareness of one’s progress, and a careful analysis of the puzzles that lie ahead’. In their view, ‘routes exist for women who aspire to top leadership, but [those routes] are full of twists and turns, both unexpected and expected. Because all labyrinths have a viable route to the centre, it is understood that goals are attainable. The metaphor acknowledges obstacles but is not ultimately discouraging’ (2007,64).

## **2.2 Barriers to women’s participation in Science**

In keeping with Eagly and Carli’s paradigm, the obstacles that women face in their careers (the factors that affect career progress and research output [Fig. 2.3] such as career breaks, lack of time for research, teaching loads that are prohibitive of research) resemble the twists and turns of a labyrinth. Decisions made at turning points in careers ultimately affect progression along chosen career paths. Where a wrong turn in the labyrinth may lead to a dead end and the need to retrace steps, similarly a decision to take a career break to have children, may adversely affect a woman’s further progress in her career. As one female scientist reflects:

*It seems to me that, as a female, as you work your way further along the career path in science, it seems to get harder, rather than easier: there are less female role models at every stage; the “game” becomes more competitive and complex and involves not just what you know, but who you know (or who you are buddies with); the job requires you to work long hours (while these are not fruitless, they are strenuous and often not possible if you have out-of-work commitments); you are required to publish consistently excellent results in order to stay competitive with the field; and this is all on top of the complexities of finding the time to start and raise a family, and time for general life-work balance.*

*(from Hatchell & Aveling 2008, 11)*

The reasons for the low representation of women in science and technology can be separated into two broad categories:

First, horizontal segregation of women in the various science disciplines based on perceptions regarding women’s innate ability in science and mathematics, societal attitudes towards gender stereotypes and gender equality, and job security and employability of science graduates.

Second, vertical segregation, generated by the organisational culture of the workplace through practices that disadvantage women such as work load, promotions policies and practice, sex discrimination, lack of female role models, mentors and networks, family responsibilities and so on.

Several key themes from the literature related to these categories are now discussed in greater detail.

### **2.2.1 Horizontal segregation**

Horizontal segregation in science and technology is best illustrated through the data on fields of education in higher education (Figure A3.1). This data indicates that, since 2001 (when Information Technology was introduced as a Broad Field of Education), more than 50% of undergraduates are women in the broad fields of Natural & Physical Sciences and since 2006 in Agriculture & Environment. However, women’s undergraduate participation in Engineering and Related Technologies is barely above the target of 15% set in 1990 in *A Fair Chance for*

All. Participation in the broad category of Information Technology has fallen from 25% in 2001 to 18% in 2007. Indeed women are represented at more than 40% in only 7 of the 29 Narrow Fields of Education (Figure A3.5): Agriculture, Forestry Studies, Environmental Studies, Chemical Sciences, Earth Sciences, Biological Sciences and Other Natural and Physical Sciences. In many of these fields participation has declined since 2001 and in others it is static. Only in sub-sets of Agriculture, Environmental and Related Studies do we see consistent patterns of growth in the period 2001-2007. Interestingly bachelors honours completions (Figure A3.7) are higher in the former two broad fields than participation at undergraduate levels (59% [cf 51%] for Agriculture and Environment and 55% [cf 53%] for Natural and Physical Sciences in 2007) whereas doctoral research completions (Figure A3.3) are higher than participation at undergraduate and honours levels in the broad fields of Engineering and Related Technologies 22% [cf 15%] and Information Technology 27% [cf 18%]).

The literature provides evidence of the factors that may be shaping these patterns.

### **Innate ability**

There is a persistent popular perception that men's and women's participation in science and technology is dependent on their innate ability to perform in these fields. A recent wide ranging international study (Nosek et al. 2009) was prompted in part by significant outperformance of girls over boys in science in three nations. The study confirms the ubiquitous nature of this perception as about '70% of more than half a million Implicit Association Tests completed by citizens of 34 countries revealed expected implicit stereotypes associating science with males more than with females' (2009, 10593).

Since men have historically dominated the fields of science, engineering and technology, it is assumed that women are just not good at mathematics and science. Certainly, President of Harvard University Lawrence H. Summers' remark regarding 'issues of intrinsic aptitude, and particularly of the variability of aptitude' sparked an uproar in the scientific community when he suggested that innate ability may be a factor in the lower representation of women in science and technology (Summers 2005). Much research has been done to discover if any biological differences between men and women could indeed account for the under-representation of women in science.

In *Beyond Bias and Barriers* (NAS 2007) a comprehensive review has been compiled of studies on mathematical and spatial performance, verbal and written performance, brain structure and function, hormonal influences on cognition performance and psychological development in infancy. This report concludes that there are no 'significant biological differences between men and women in performing science and mathematics that could account for the lower representation of women in academic faculty and scientific leadership positions in these fields' (2007,2).

The question raised by this conclusion is not one about the innate ability of males and females in science and mathematics. The question is about the *self-perception* of innate ability in these subjects by males and females. On average, women have reported that they are less confident of their abilities in male-dominated occupations (Langford 2006). Watt (2007) reports that one of the reasons for the gender differences in mathematics participation is that girls have less confidence in their mathematical abilities than boys. Australian boys typically overestimate their mathematical abilities while Australian girls typically underestimate their mathematical abilities. She also notes that previous research to identify the reason for women being less likely to participate in male-dominated occupations points to 'gender differences in the motivations, self-concepts, interests, values and life-goals of individuals, the important influences of family, parents and biology, and finally, the importance of socio-cultural affordances and constraints on women's career development' (Watt 2007, 39).

## Societal attitudes

The 'enabling' secondary school subjects of mathematics and science are very important subjects especially when one is contemplating a career in science and technology. Thus, high school education in these subjects is critical as it allows students to prepare for university and ultimately a career in science. In Australia, studies have shown that many female students have not elected to study the more advanced mathematics and science subjects in high school (Henderson and Broadbridge 2009; Collins et al. 2000; Jones and Young 1995). In addition to the lower participation of girls taking higher levels mathematics courses compared to boys, girls represent less than one third of the students in physics classes, and less than half of students in chemistry classes (Jones & Young 1995). However, girls represent almost two thirds of students taking biology classes. This leads to the problem of limiting girls career choices because the subjects studied in high school to a large degree determine what field students specialise in during university studies, and ultimately, their career choices (Ainley et al. 2008; Collins et al. 2000; Jones & Young 1995).

Family and society play an important role in women's confidence in their ability to excel in science and mathematics. The gender stereotyping of science as a male profession causes females to reconsider when contemplating a career in science (DeBacker and Nelson 2000; Jones & Young 1995). Parents, and by extension teachers and counsellors, treat boys and girls differently, often discouraging girls from going into science (NAS 2007; Tindall and Hamil, 2004). For example, a longitudinal study in the UK found that girls' confidence in their abilities was gradually eroded throughout their early school years and that teachers tended to protect the girls by not entering them in the more challenging examinations (Walkerdine 1989). Gender stereotypes and peer pressure can influence girls to avoid studying mathematics and science, particularly in co-educational schools. It has been hypothesised that girls are disadvantaged in a co-educational environment where boys dominate science and teachers responded more favourably to boys in the classroom (Jones & Young 1995). In contrast, studies show that girls perform better in science in single sex schools, especially when science and mathematics are compulsory subjects in high school. (Jones & Young 1995; Carlson 2000). Collins et al. (2000) importantly draw attention to the fact that '...many analyses have obscured the ways in which education differentially distributes life chances and choices according to differences within, as well as between, the genders' (2000, 60). These analyses make clear that we must adopt a 'which girls, which boys?' approach to gender-related under-performance and disadvantage.

## Job security

Of course, gender stereotyping is not the only factor influencing students in their career choices. In a report by Preston (2006), female students identify good career opportunities, employability and future earning potential as the most important factors when selecting a course of study.

Indeed, a survey by Giles et al (2009) found that job opportunities for science graduates are low and approximately 30% of Australian survey respondents have gone overseas in order to secure employment. In another survey by Harman (2002), it was found that only 54.6% of respondents expected to follow scientific research careers after the completion of their PhD. Furthermore, only 58% were optimistic about their career prospects, leading to the conclusion that many students have negative views regarding academic work in Australian universities (ibid 2002).

The Commonwealth Government's funding of higher education research accounts for more than 40% of spending on science and innovation. Universities receive block funding directly from the Commonwealth government. This funding is allocated on a formula basis. Universities too, are the primary recipients of competitive funding programs administered by the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC), whose funds also come from the Commonwealth Government (Productivity Commission 2007).

These dual streams of funding are meant to 'encourage researchers to compete on quality and impact, while providing institutions with a base research funding level (block grants) intended to allow them to make their own strategic choices' (ibid xxix). However, the share of block grants has been increasingly eroded due to changes in the funding for higher education. Funding is now more often mediated through external, peer reviewed organisations like the ARC and NHMRC. Such competition for funding of project-based research provides little job security for those interested in a career in science and technology, and makes it extremely difficult to accommodate career breaks.

Therefore, with the current trend of fixed-term and casual employment in higher education alongside competitive postdoctoral fellowships, job security is not ensured for Australian SET researchers (Giles et al. 2009).

## 2.2.2 Vertical segregation

### Gender and the Workplace

It is well documented that there are structural factors (such as paid work and family work) and cultural factors (including gendered perceptions and gendered organisational cultures) that impact on the participation of males and females in the labour market. In 1995 the Women in Science, Engineering and Technology Advisory Group employed the term 'gender harassment' to describe 'a range of exclusion, marginalising, and resistance behaviours (usually exhibited by men) which result in women being discouraged or inhibited from access to and progression in SET education, training and employment'. (1995, 15) They recognised that the nature of this behaviour varies, and is often subtle and diffuse. More recent research suggests that (generally unintentional) gender bias in institutions operates below levels of consciousness generating 'micro-inequities' that generate significant cumulative disadvantage (Valian, 1998; MIT, 1999; Morley, 1999). Two recent Australian SET industry surveys are particularly relevant to our understanding of gender and the scientific workplace, and reinforce the fact that 'gender harassment' persists.

The Association of Professional Engineers, Scientists and Managers, Australia (APESMA) conducts a bi-annual survey entitled 'Women in the Professions' which seeks to 'address continuing issues in women's work lives, including ongoing disparity in professional women's salaries', the poor retention rates of women in non-traditional areas of employment such as engineering and science, and the ability for professional women to successfully negotiate both their professional and personal lives (APESMA 2007, 1). The most recent and fourth version of this survey, the 2007 report conducted in collaboration with FASTS, compiles the responses of 1,953 female professionals from fields such as science, engineering, ICT, pharmacy and business. The survey's purpose was to 'elicit views from female professionals on a range of issues, so that their needs can be recognised in the development of policy by government, industry and professional associations'. Some 43.2% of respondents to the survey held science degrees and 23.3% held engineering qualifications (APESMA 2007, 1).

#### Engineering

Despite '18% of all engineering graduates' in 1996 being women, 'only 11% of all engineers with between 7 and 10 years experience' a decade later were female. From these figures, we know that 'women are leaving the engineering profession at a rate of 38.8% faster than their male counterparts' (APESMA 2007, 2).

Given their equivalent preparation for a professional career, female engineers remain 'clustered at the lower levels of responsibility, with more than three quarters (77.8%) of female engineers holding positions at responsibility levels 1-3' (APESMA 2007, 4). In comparison male engineers' progression through the levels of responsibility follows an 'approximately normal distribution', with fewer men at the lower and higher levels of responsibility, and the bulk in mid-

level responsibility positions (APESMA 2007, 4). The implications of these statistics are profound. Despite entering the same profession on relatively equal footing on a number of grounds, women's progression through a professional engineering career stalls at the lower levels of responsibility, arguably forcing a significant number to turn to an alternative career.

### Science

Like engineers, female scientists remain 'clustered at the lower responsibility levels, [with] ...more than a third of female scientists (34%) holding positions at Level 1 or 2, compared to 13.3% of male scientists'. Similarly, 'more than a quarter (27%) of male scientists hold positions at Level 5 or above, compared to just 7.8% of female scientists'.

Female scientists also endure a pay discrepancy with their male peers which is not attributable to their average lower levels of responsibility: '**at nearly every level of responsibility female professional scientists are earning on average significantly less than their male counterparts**'. (emphasis added, APESMA 2007, 5).

### ICT

While female ICT professionals also find themselves under-represented at more senior levels and over-represented at more junior levels, 'the degree of disparity is much less than professional engineers or scientists' (APESMA 2007, 5). Nonetheless, we again find that 'at nearly every level of responsibility, female computer professionals are earning on average significantly less than their male counterparts' despite initially earning similar amounts (APESMA 2007, 5).

### Pharmacists

Female pharmacists generally fare much better than their female professional engineering, science and ICT counterparts. However, while 'there is little difference in the career progression of male and female pharmacists... a larger proportion of male pharmacists hold the more senior classifications of Pharmacist-in-Charge and Pharmacy Manager compared to their female counterparts'. This is the case even though 'around two-third of all pharmacists are women' (APESMA 2007, 6).

What kind of factors might influence women's choice to leave these professions, and why might women be concentrated in lower-level positions of responsibility in their professional careers? Although 'high levels of full-time employment' are available in fields such as 'engineering (84%), science (81%) and ICT (80%)', 'female engineers are eight times more likely than men to be working part-time, ICT professionals six times more likely and scientists four times more likely than males' (APESMA 2007, 2).

It may be that some of those women who are working part-time are those with dependent children, given that 'nearly 60% of respondents with children received no paid maternity leave' (APESMA 2007, 3). This means that women may be forced to return to work earlier than is ideal, taking on less responsibility than they are capable of with inadequate financial support to settle their personal lives before they return to work in an optimal capacity. It should also be noted that 26.8% of professional women respondents (including engineers, who comprise around a quarter of all participant respondents) perceived a pay disparity between themselves and their male peers, and that 'higher levels of perceived inequity were also found where respondents had more senior roles' (APESMA 2007, 6).

Given the disparity between the genders in pay, it is sobering to note that 50.3% of women respondents 'reported they were "not very confident" or "not confident" at all in negotiating good remuneration and working conditions with their employer' (APESMA 2007, 7). Indeed, APESMA suggests that 'policies that rely upon individuals advocating their own needs to address salaries, conditions or work and family needs may not necessarily succeed' (APESMA

2007, 7). Given that 39.9% of women state that an 'increase in salary' was the main factor influencing their next career move, it is not surprising that attrition is high (APESMA 2007, 7). In addition, 24.1% of women respondents listed 'workplace culture' as the 'second most significant factor affecting career achievement.

This seems convincing evidence that there are several aspects of the engineering, science and ICT professional environments that need consideration when considering how women might better be retained and appropriately rewarded in these professions (APESMA 2007, 7).

Similar findings are reflected in *CREW Revisited in 2007 – The Year of Women in Engineering: An Update on Women's Progress in the Australian Engineering Workforce* (Mills et. al. 2008). Key findings of this report included that female engineers enter the workforce in similar proportions to males (86% and 87%) and are also more likely to have postgraduate qualifications. However, the authors found that there are 'significantly higher percentages of women than men in the lower salary ranges and significantly more men than women in the top salary bracket. This was the case even when part-time workers were excluded from the comparison'. Other significant findings presented in this report included that: 87% of females and 93% of males work full-time; **42.3% of women reported that they had experienced discrimination while working as engineers and 22% report that they have been sexually harassed**; and 28% of women and 19% of men report bullying (2008, 1-2).

As outlined below comparable experiences are documented in a number of international studies of women in the SET workforce. Bakker (1996) argues that globalised labour markets generate 'the gender paradox of restructuring' in which workloads intensify as institutions downsize and those who remain carry an increased workload – the experience of many academics and researchers. This impacts on those with carer responsibilities in terms of their participation and success – Bakker refers to this as 'gender intensification'. Simultaneously more workers find themselves in poorly paid, part-time casual work. In our universities and research institutions these are largely female dominated roles associated with casual teaching and also research assistant roles – feminised roles where women, often paid lower wages, take jobs formerly filled by men (ibid 7).

## **Organisational culture of the workplace**

There is ample and consistent evidence that the organisational culture of the workplace plays an important role in retention and career advancement, especially for women. Due to the nature of scientific research as a male-dominated sphere, the work environment, the lack of role models and mentors, and the gendered notions of merit and promotion all arguably have a detrimental effect on the advancement of women in science. The Report from the ETAN Expert Working Group on Women and Science Institutions (EU 2000) concludes that: institutions that employ scientists tend to be behind the times in addressing the life-work balance and need to modernise; old-fashioned practices characterise employment and promotion procedures in some academic institutions; reliance on patronage, the 'old boys network' and personal invitations to fill posts cuts across fair and effective employment procedures; and the 'scientific elite' is characterised by narrowness especially in decision-making bodies (2000, viii-ix)

There is also evidence that the science workplace, whether that be in the private sector, government or universities is becoming more competitive, and increasingly demands international mobility. This context makes it difficult for women to contemplate or accommodate career breaks.

Dever et al (2008), in a study of PhD graduates five to seven years from graduation, found that female graduates were significantly more likely than male graduates to report that they pursued their PhD for such intrinsic motivations such as intellectual and academic development, interest in the discipline area, personal satisfaction, and interest in the thesis topic (2008, i). Perhaps this explains why the work environment is an important factor in the retention of women in



science. A study by Callister (2006) of 308 faculty members in science and engineering fields shows that as women place more value on departmental climate (the shared perceptions of the work environment) than their male colleagues, they are more likely than men to leave their position if the department climate is undesirable. Hatchell and Aveling (2008) report the experiences of women who found working in a masculinised environment to be problematic. Women seem to be disadvantaged if they act in an overtly feminine manner (and are thus treated as incompetent) or if they do not act in an overtly feminine manner (in which case they are regarded as too aggressive and arrogant) (Hatchell & Aveling 2008; Handelsman 2005; Valian 1999). This dynamic, which more often than not is perpetuated by more senior male staff, can be detrimental to women's self-esteem (Hatchell & Aveling 2008; Handelsman 2005). Even so, there are reports of women often being 'the harshest critics of other women they deem less than better than most faculty for fear that they will reflect badly on all women' (MIT 1999).

Gender discrimination is not the only form of discrimination in the workplace. Other covert discrimination includes the gender pay gap and promotions processes. Survey results reported in 'A Study on the Status of Women in Science at MIT', the survey showed that women academics received lower salaries, less space and resources and fewer awards compared to their male colleagues, despite having equal professional accomplishments (MIT 1999). In 2005, the Athena Survey of Science, Engineering and Technology (ASSET) reported that approximately 50% of women in universities felt disadvantaged in terms of salary and promotion with only 15% of male staff acknowledging that this is a problem for their female colleagues (Athena Project 2005).

## **Gender pay gap**

In 2008, a median annual starting salary of \$45,000 applied for new Australian resident bachelor degree graduates (approximately four months after the completion of their qualification) who were aged less than 25 and in their first full-time employment (<http://www.graduatecareers.com.au/content/view/full/24>). Between 1999 and 2005, salaries for females as a percentage of males' salaries grew from 92.3 % to 97.5 %. This trend ended in 2006 when the overall salary for females dropped to 95.2 % of male earnings. In 2007 this relativity fell to 93.3 % but in 2008 rose again to 95.7 %.

Graduate Careers Australia research suggests that male respondents have tended to be in the fields of education more highly ranked according to starting salary while females have tended to come from the middle ranked fields. Data from Gradstats 2008 shows that women aged less than 25 and in first full-time employment by field of study, earned \$43,400 per annum in biological sciences; \$45,000 in computer sciences and \$48,000 in mathematics. Women who majored in engineering earned \$55,000.

Consistent with the findings reported above, the APESMA findings and the evidence from Australian higher education, the gender pay gap seems to be entrenched. A study by Dever and colleagues (2008) on the gender differences in post-PhD employment of science graduates found that the net annual income of women was approximately \$8363 less per year than men.

In 1998, Probert and colleagues' study provided evidence that while men experience more years of full-time employment compared to women, the major constraint on women's careers was their family responsibilities. This constraint ultimately affects their income as they are more likely to have to reduce their working hours or delay the start of their careers (Probert et al. 1998, 61). Importantly, women are more likely to start at a lower level of appointment than men, mostly because they are less likely to have completed a PhD (the degree being a pre-requisite for appointment at Level B) (ibid, 62).

A new study on gender pay equity in higher education by Strachan and colleagues funded by the ARC (2009) and industry partners (UniSuper, NTEU and UAEW) is currently underway.

## Promotion

In Australian higher education, the promotions process is dependent on proven performance in research, teaching and service to the profession, university and community (Probert et al. 1998, 59). A gendered conception of merit which values a full-time, uninterrupted career trajectory and research success gives men a promotional advantage over women, since women are more likely to work part-time and take career breaks due to family responsibilities (Winchester et al. 2005). In addition, although there is contradictory evidence, compared to men it appears that women may place a greater weight on teaching and less on research, and spend more time on the 'invisible' and unrewarded work of student welfare and pastoral care compared to men (Probert 2005). Most universities place significant weight on research track record as evidenced by academic publications as a criterion in the promotions process. Research shows that women tend to publish fewer papers compared to men, but papers are of higher quality (that is papers published by women are cited more frequently than papers by 'more productive' men) (Borrego et al. 2009; Cervantes 2006; Long 1992).

Several reasons for women's lower publication rates have been cited. These include factors such as females being more likely to work in part-time and temporary positions, to be involved in activities that detract from research, to interrupt their career due to family responsibilities, and to be isolated and excluded from professional networks (Maske et al. 2003; Suitor et al. 2001). Interestingly, Maske and colleagues (2003) also believe that another factor in the disparity between men's and women's publications rates stems from discriminatory practices in the publication process. A study by Paludi and Bauer (1983) shows that papers for peer review were rated lower if the author's name was female. Even papers with initials were rated lower because they were taken as a hidden indication of a female author. A recent study showed that women's publication rates increased when using double-blind peer reviews, where both the authors' and reviewers' identities were hidden (Budden et al. 2008).

## Scientific Productivity

The problem with depending on publication output as a measure of scientific productivity in the promotions process is that scientific productivity is difficult to quantify. There are several commonly used measures to determine publication output, including total number of papers, total number of citations, number of citations per paper, number of significant papers (that is the number of papers with  $\geq y$  citations), and number of citations of the  $q$  most-cited papers (Hirsch 2005). However, each of these measures has its limitations. By taking only the total number of papers published, the importance or impact of papers is not considered. The total number of citations measures the total impact of papers but highly cited review articles can heavily bias it. The number of citations per paper would allow for the comparisons of scientists of different ages but also rewards low productivity and penalises high productivity. The number of significant papers may eliminate the disadvantages for the previously mentioned measures. However it is an arbitrary figure and has to be adjusted for different levels of seniority. The last measure, that of the number of citations of each of the  $q$  most cited papers, has the advantage that it overcomes most of the disadvantages of the previously mentioned measures. However,  $q$  is again an arbitrary figure and the calculation of this measure is difficult to obtain, as it does not produce a single number.

In an effort to characterise an individual's research output, Hirsch (2005) introduced the index  $h$ , defined as the number of papers with citation number  $\geq h$ . He suggests this index may provide a useful yardstick with which to compare, in an unbiased way, different individuals competing for the same resource when an important evaluation criterion is scientific achievement. However, Hirsch based his calculations on the publications and citations of physicists and as Kelly and Jennions (2006) argue, not only can the  $h$  index cannot be used 'to

compare the relative importance of researchers in disparate disciplines', and further, the h index also shows a gender effect (that is female scientists publish fewer papers which in turn affects their h index). Kelly and Jennions' findings concur with the study by Symonds and colleagues (2006) who also found that the h index disadvantages women scientists. Instead, Symonds and colleagues advocate an alternative metric to h, namely the residual h, which is the 'y-residual from the least-squares regression line of h on the number of publications'. In other words, individuals with a higher proportion of papers with significant impact will have a higher residual h. Nonetheless, while the residual h provides a method for removing gender-based bias, it is not without its drawbacks as the new metric is unfavourably affected by poorly cited papers (Symonds et al. 2006). Yet they conclude that:

Clearly, an assessment of a scientific career should not ultimately boil down to a single number. Nonetheless, our analysis illustrates the potential biases that exist within current research performance metrics. Our new metric provides a method for removing gender-based bias without recourse to socially divisive procedures such as setting different thresholds for men and women. Of course, some will argue that shifting the means by which we assess scientific performance is artificial and undesirable. However, until the career structure of science finds ways to assess females and males on a level playing field that takes into account the prevalent gender differences and imbalances (whatever their causes), we will continue to perpetrate inequality, and fail to maximise our intellectual capital.

(Symonds et al 2006, 4)

Publication output is one important facet of the promotions process. If taken as the most significant criterion of promotion, many potential candidates may be overlooked. Many scientists make significant contributions through teaching, mentoring and generosity with ideas, skills and time, not just through research and publications.

Even more disconcerting is what is termed 'passing off', or as Peter Lawrence names it, 'the annexation of credit from others'. This is the apparently not uncommon practice of women's contribution to a scientific outcome going without acknowledgment. The literature provides evidence of this in the university and the public sectors. (Hatchell & Aveling 2008; Harwood 2006)

It is due to these factors that the literature suggests women are less likely to apply for promotion, are more reticent in putting themselves forward and may be less successful in applying for promotions than men (Carrington & Pratt 2003). Interestingly, Winchester and colleagues (2006) report that women are more likely to be successful than men when they (finally) apply for promotion despite the greater weight they tend to place on teaching rather than research (Winchester et al 2005). However, the study reveals that women do indeed apply for promotion less often than men and their promotions are delayed.

## **Scientific Excellence**

There is a number of measures, in addition to publications, that may be employed to ascertain scientific excellence or esteem, or at least recognition of scientific excellence through peer assessment. In this report four measures are considered: ARC Discovery and Linkage Grants; the ARC Federation Fellow Scheme; admission to the learned academies of Science and Technological Sciences and Engineering; and the newly introduced ARC Future Fellows scheme.

Analysis of data on ARC grant schemes reveals some clear trends (refer A6.1 -A6.7). All grant schemes have seen significant increases in applications over recent years. Success rates for

male and female applicants are generally comparable. However participation rates for women are lower than for males – in the case of the Discovery and Linkage grants, significantly so.

Similarly women make up only 8.5% of ARC Federation Fellows (A6.7), the fellowships designed to attract world-class researchers and world-class research leaders to key positions. The Federation Fellow scheme has been in place since 2001, and there has been little annual variation in this figure.

In 2008 the Australian Government announced the creation of a new scheme, the ARC Future Fellowships. The scheme is intended to promote research in areas of critical national importance by giving outstanding researchers incentives to conduct their research in Australia. The aim of ARC Future Fellowships is to attract and retain the best and brightest mid-career researchers. Over a five-year period (2009 -2013), the ARC will offer four-year Future Fellowships of up to \$135,000 a year to 1,000 outstanding Australian and international researchers in the middle of their career. Results of the first Fellowship round have been announced. Women constituted 29% of applicants (283 of 975) and secured just under 29.5% of the Fellowships. (A6.5) But the largest number of successful female applicants (36 of 59) was clustered in the lowest band (Salary Level 1) (A6.6).

In the learned Academy of Science women constitute only 7% of Fellows. In this Academy there are 426 Fellows of whom 30 are women; just 1% more than five years ago (A7.1-A7.2). In the learned Academy of Technological Sciences and Engineering 6 % of Fellows are female. There are 45 female Fellows from a Fellowship of 788, compared with 5% five years ago. (A7.3-A7.4)

In this context it is encouraging to note that currently a number of key leadership roles are occupied by women: the Chief Scientist, the NSW Chief Scientist, the CEO of CSIRO and the CEO of the ARC to name but a few. Nonetheless, without depth in female seniority in the sector this profile of leadership, arguably based on individual achievement, is fragile.

It is salutary in this regard that the 2008 Equal Opportunity for Women in the Workplace Agency (EOWA) Leadership Census reveals that across all indicators, the proportion of women to men on corporate boards and in executive leadership roles in the ASX200 companies has declined since 2006. At the time of the Census, women chaired only four boards and held only 8.3% of board directorships (125 seats out of 1,505), down from 8.7% in 2006. On these measures, Australia has now fallen behind the United States, Canada, the United Kingdom and South Africa (2008, 3-5).

## **Role models and mentoring**

As discussed above, recent research suggests that (generally unintentional) gender bias in universities operates below levels of consciousness generating 'micro-inequities' that produce significant cumulative disadvantage (Valian, 1998; MIT, 1999; Morley, 1999). These 'micro-inequities' in tandem with outmoded institutional structures hinder the advancement of women (NAS 2007, Wylie et al 2007).

There is also a substantial body of evidence to suggest that role models and mentoring are important in women's careers. Yet there is also evidence that women may not always be well placed to develop relationships with influential mentors (Deane et al. 1996; NAS 2007)

Mentoring has received increasing attention over the past decade and there is a substantial body of literature that describes programs, approaches and dynamics of mentoring (Ragins and Kram 2007; [Chesterman 2003](#)). There is also a body of work that focuses on evaluation of mentoring programs, but much of this is case specific and not necessarily generalisable. There is a much smaller body of critical literature that focuses on the socio-political context of mentoring and the power relations of the mentoring relationship. There is also little that focuses on the experience of mentors ([Colley 2001](#)).

[Devos \(2005\)](#) argues that the growth of mentoring of women in Australian universities may be seen as linked to the development of the enterprise university ([Marginson and Considine 2000](#)) in which individualism and competitiveness are increasingly valued. [Pratt and Misra \(2002\)](#) argue that role models are important especially for women, as they are more relationship-oriented and find positive feedback invaluable. [Dever and colleagues \(2006\)](#) have found that while role models and mentors take diverse forms, they are often important to women's research success. The importance of role models and mentoring is twofold. For both mentor and mentee, the advantage of mentoring is the widening of their professional networks and contacts ([MacGregor 2000](#)). The knowledge, skills and values learned from the mentor are invaluable to the career development of the mentee ([Hale 2000](#)). For the mentor, they also gain the satisfaction of knowing that they are helping and nurturing the future generation of researchers ([Dever et al. 2006](#)).

## **Family responsibilities**

In a patriarchal society, it more often falls on the women to take the greater responsibility for family and household care. Women often have difficulty reconciling their professional career with their child rearing responsibilities. [Probert's \(2005\)](#) study found that the most persistent problem for women is the lack of childcare facilities, which often leads to women having to reduce their working hours. [Probert \(2005\)](#) also states that given the lack of representation of women in Levels D and E, where most women tend to be older and have teenage children, more focus should be given to considering the needs of women with older children who are less likely to be assisted through a focus on maternity leave and childcare.

Family responsibilities also have an effect on women's career mobility. Women who have primary care of their children have difficulty attending seminars and conferences both national and international ([Probert 2005](#)). In a study of 20 senior and executive level women, [Ezzedeen and Ritchey \(2008\)](#) categorised spousal support into six subgroups: emotional support; help with household; help with family members; career support; esteem support; and husband's career and lifestyle choice. They found that spousal support is a rich and multifaceted phenomenon that is critical for women's career development and advancement. [Probert \(2005\)](#) also agrees that more focus should be paid to the question of the impact men have on households and women's career choices.

Many look to women alone to change practices pertaining to gender. In 'Engaging Men in Gender Initiatives', [Prime and Moss-Racusin \(2009\)](#) explain that the barriers to men's support for gender initiatives are apathy, fear and ignorance. In their survey, they found that most men do not see any compelling reason for becoming involved in gender initiatives because they do not appreciate how they can gain from changing the status quo. Additionally, most men also fear: the loss of status and privileges because they believe that equality comes at the expense of men; making mistakes and inadvertently exposing themselves to criticism by women; other men's disapproval because acceptance by their male peers is a measure of masculinity ([Prime & Moss-Racusin 2009](#)). Most men also show perceived or real ignorance on the issue of gender equality. Men's lack of awareness of gender bias is the greatest barrier to their support for efforts to end it.

On a more positive note the second survey commissioned by the National Committee on Women in Engineering in 2008 (the first survey was done in 1999) found that many engineering employers have taken significant steps to try to improve the situation in terms of 'family friendly policies': 'the increased availability of family friendly practices represents the greatest shift in engineering workplaces'. Women reported that part-time work was available in 67.7% of work places. Men reported the availability of part-time work in 55.5% of workplaces. Paid paternity leave was available in more than 67.7% of workplaces and paid maternity leave was available in more than 70% of workplaces. However, both Engineers Australia membership statistics and this survey still indicate that women are leaving the profession at a high rate ([Engineers Australia, 2008, 1](#)).

## Section 3: What has been done

*SET is a killer area to be in - if you don't produce or have the contacts or stay current you are very soon left behind and it is a vicious downward spiral...I should also say men can also fall into this trap so it is not totally gendered.*

*Senior academic leader*

Considerable effort has been put into supporting the participation and retention of women in Science, Engineering and Technology disciplines. This section outlines some of the initiatives taken in the US, UK and Europe, and the initiatives of Australian universities to aid the advancement of women in science and technology are outlined.

### 3.1 International initiatives

#### Professional Opportunities for Women in Research and Education (POWRE)

In 1997, the US National Science Foundation launched the Professional Opportunities for Women in Research and Education (POWRE) program to support the development of scholarly and institutional leaders in research and education. The POWRE program was designed to increase the prominence, visibility and influence of women in all fields of academic science and engineering. POWRE sought to enhance women's professional advancement by providing them with funding opportunities that were not ordinarily available through regular research and education grants programs.

POWRE supported the individual women researchers by providing a one-time input grant of up to \$US 75,000 'at a critical stage in the Principal Investigator's career, so that she can take advantage of an opportunity that will contribute to a significant, identifiable advance in her career path' (National Science Foundation 1997) This support of individual researchers went against a growing sentiment that support for institutional and systemic approaches would be required to increase the participation of women in all levels of science and engineering (Rosser 2004). A survey of the POWRE awardees by Rosser (2004) found the need for institutional and systemic changes was underlined by the significant issues and challenges that women faced in their careers in science and engineering, the pressures in balancing career and family, the problems with low numbers of women in some disciplines, stereotypes held by others regarding gender, and the overt discrimination and harassment in the workplace.

#### ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers

In 2001, the National Science Foundation initiated the ADVANCE program to replace POWRE. The ADVANCE program was designed to improve the institutional climate, and the recruitment and retention of women faculty in science and engineering, and supports three types of projects:

- (i) Institutional Transformation (IT). This award is for projects in higher education institutions that support transformation of institutional practices and climate.
- (ii) IT-Catalyst. This award enables higher education institutions to perform self-assessment activities such as basic data collection and analysis and review of relevant policies and procedures in order to complete the groundwork necessary to undertake institutional transformation.

- (iii) Partnerships for Adaptation, Implementation, and Dissemination (PAID). This award supports higher education institutions, professional societies, and/or other STEM-related, not-for-profit organisations to undertake projects that vary in size and scope. Most PAID projects are designed to broadly share lessons learned from institutional transformation projects, and also to provide information and training about gender in academic careers.

Through ADVANCE, higher education institutions have implemented several strategies for improving institutional climate for women (Table 3.1). ADVANCE IT awardees also reported other benefits of undertaking institutional transformation in addition to creating a better climate for women. These include: improved situations for other under-represented groups (such as racial/ethnic minorities and persons with disabilities); also improved situations for men who now enter the workforce with greater interest in, and expectation of, work-life balance; increased savings from work-life programs as a result of improved faculty satisfaction and retention; and increased competitiveness in recruiting highly qualified and diverse faculty (National Science Foundation 2009).

**Table 3.1 Strategies for improving the climate of higher education institutions for women**

Category	Strategies
1. Institutional Structure	<ul style="list-style-type: none"> <li>a. Review, revise, and increase the transparency and effective implementation of policies and procedures (especially recruitment, promotion and tenure policies).</li> <li>b. Develop systematic and recurring institutional data collection and reporting of faculty data and climate surveys, disaggregated by demographics and rank, for use in decision-making.</li> <li>c. Incorporate equity and diversity responsibilities and accountability into institution-wide administrative positions, departmental leadership, and faculty to ensure equitable distribution of resources, responsibilities, and commitment.</li> </ul>
2. Work-Life Support	<ul style="list-style-type: none"> <li>a. Implement flexible career policies that address needs identified by the community.</li> <li>b. Develop career and life transition support programs.</li> <li>c. Establish dual-career hiring programs tailored to the institution and region.</li> <li>d. Encourage department and institutional flexibility and support for dependent-care responsibilities.</li> <li>e. Create institutional and departmental climates that encourage faculty to take advantage of work-life programs and ensure that there are no negative impacts on a faculty member's career for participating in the programs.</li> </ul>
3. Equitable Career Support	<ul style="list-style-type: none"> <li>a. Establish formal mentoring structures and provide recognition of service for the time and efforts of mentors.</li> <li>b. Develop mechanisms to recognise professional excellence of both female and male faculty.</li> <li>c. Provide workshops, training, and coaching on the tenure and promotion processes to all faculties.</li> <li>d. Implement leadership development, career coaching, and network building programs.</li> </ul>

4. Empowerment	<ul style="list-style-type: none"> <li>a. Provide faculty, department leaders, and institutional administrators with the tools and resources to address gender equity barriers.</li> <li>b. Provide training on effective strategies to reduce the stressors that result in a greater reliance on the implicit biases when making decisions, especially in search committees and promotion and tenure committees.</li> </ul>
<b>[extracted from NSF 2009]</b>	

### **Athena Project**

In 1999, the Athena Project, funded by a UK-based consortium, was established to increase the retention and advancement of women scientists in higher education employment (Bebbington 2002). Under the Athena Project, three ASSET surveys (from 2003 to 2006) were conducted on the career experiences of male and female scientists working in higher education and research in the UK. The data from these surveys showed that research culture, networking and provision of childcare were crucial to the retention of women researchers (Kingston-Smith 2008). The Athena Project actively engaged higher education institutions to promote understanding of employment and cultural practices common to the scientific community. Good practice guidelines were developed covering areas such as establishing personal and professional support (mentoring, networks and career development), having supportive departmental heads, establishing a departmental culture that supports work-life balance, etc.

Under Athena, the Athena Scientific Women’s Academic Network (SWAN) Charter was developed in 2005 to recognise and celebrate good employment practice for women working in science, engineering and technology (SET) in higher education and research. Higher education institutions intending to apply for the Athena SWAN awards must be committed to accepting and incorporating the Athena SWAN Charter principles into their action plans. Since the Athena Project ended in 2007, the Athena SWAN exists independently and is jointly funded by the UK Resource Centre for Women in SET and the Equality Challenge Unit (ECU). More information about the Athena Swan Charter can be found at <http://www.athenaswan.org.uk>.

### **Tham Professorships**

Some countries have used positive discrimination to increase the number of women in departments where there are few women faculty. For example, Sweden’s Equal Opportunity legislation specifies that if one sex is under-represented, the employer should ‘especially endeavour to recruit applicants of the under-represented sex and shall seek a gradual increase in the proportion of employees in that sex’ (Viefers et al. 2006). In line with that policy, Sweden introduced the Tham Professorships: special professorial positions for women which seek to increase the number of female professors. Viefers and colleagues (2006) argue that introducing positions for women have several drawbacks. First, by excluding male applicants one may be excluding candidates who are more competent for the position. Second selective recruitment may have adverse effects on women’s scientific reputation or self-confidence no matter their competence level. On the other hand, Viefers also points out that special positions for women may be the most transparent way to increase the number of females in science given that academic positions are commonly filled without true competition. That is, local candidates with the right contacts may be appointed for these positions. However, in Australia the use of quotas and positive discrimination is not permitted under the affirmative action legislation.



### **3.2 Australian initiatives**

There is a range of important initiatives relevant to women in SET in Australian universities. Below several examples are outlined to provide an indication of the strategies that are being developed and the steps that are being taken by professional associations, government and higher education institutions. This is not intended to be a comprehensive survey, but is rather indicative of possibilities.

#### **The AVCC Senior Women's Colloquium/Universities Australia Executive Women**

The AVCC Senior Women's Colloquium was established in 1995 under the auspices of the Australian Vice-Chancellor's Committee. It has since produced two action plans, a number of research reports (Winchester 2005; Bell and Bentley 2005; Dever 2008) and a workshop for women engineers (University of Wollongong 2009). The first Action Plan (1999-2003) identified the following imperatives:

- to exert the AVCC's leadership to promote the achievement of gender equity in Australia
- to develop strategies based on research for overcoming barriers to gender equity for university staff
- to refine the AVCC and university staff development services to target gender equity more effectively.

In the first Action Plan it was acknowledged that 'this work should include analysis of the position of women in those professional areas whose qualification basis is academic programs where women remain a significant minority'. In the Second AVCC Action Plan For Women Employed in Australian Universities (2006-2010) it was argued that:

...universities must draw more upon under-represented groups, particularly their women staff. They must attract, appoint and retain more women in professional and management positions. They must improve the participation, success, and leadership of women in research in order 'to capitalise on the intellectual capital and potential of significant numbers of successful female undergraduates, honours students and research higher degree students'. They must develop their staff to take on leadership positions which involve management of significant financial and human resources and working in a competitive entrepreneurial and political environment.

(AVCC, April 2006)

#### **Australian Technology Universities Women's Executive Development (ATN WEXDEV)**

Many Australian universities have leadership development programs for women. The Australian Technology Universities' Women's Executive Development (ATN WEXDEV) program is a strategic career development program designed by and for senior women on the academic and general staff. The objectives of this program are to: enhance personal professional development opportunities for senior women to gain appropriate skills and experience for emerging management opportunities; to support the growth of organisational cultures that value diversity and encourage improved representation of women in senior executive positions; to build on the tangible benefits of the collaborative network between ATN universities by providing significant cross-institutional activities for senior women; and to strengthen strategic alliances with other organisations, nationally and internationally (Chesterman 2000). This program provides women with opportunities for personal professional development, senior executive placements, and networking.

## **Smart Women – Smart State Strategy**

The Smart Women – Smart State Strategy (<http://www.women.qld.gov.au/work-and-life/smart-state-strategy/>) is the Queensland Government's commitment to enhancing women's participation in science, engineering and technology (SET). In 2005, the Queensland Government asked The Smart Women – Smart State Taskforce to consider strategies for improving education, training and employment for women in SET in Queensland (Queensland Government Smart Women – Smart State Taskforce 2006). The key findings of the Taskforce are summarised in Table 3.2.

In line with the Taskforce recommendations, the Smart Women – Smart State Awards were established to recognise the achievements and contributions of women in the fields of science, engineering and technology.

## **Women in Engineering (WiE)**

In 2000 the Careers Review of Engineering Women (CREW) project was initiated to investigate the issues surrounding women's retention, satisfaction and progression in the professional engineering workforce. A major aim of this study was to provide hard data about the issues surrounding women's retention and disadvantage in Australia's engineering workforce. Based on the findings from a literature review and a survey, the National Women in Engineering Committee made several recommendations to the government, employers and Engineers Australia regarding the strategies and programs to improve women's retention and advancement in the engineering workforce ([Roberts and Ayre 2002](#)). The key findings of this study are summarized in Table 3.2.

In 2007 Engineers Australia launched the Year of Women in Engineering and implemented many programs to attract more women into the field of engineering. Many of their programs have relevance to the current review and may be useful in attracting and retaining more women in Science and Technology. Among the many programs implemented by Engineers Australia, GirlTalk was developed and run by women engineers to attract more women into engineering. GirlTalk consisted of PowerPoint presentations that explained engineering as a career, the options available and subject choices (Engineers Australia National Committee for Women in Engineering 2007). GirlTalk was useful in addressing the concerns of young people, especially females, and illustrating the importance of engineering to the future.

Engineers Australia also introduced several initiatives for retaining women in Engineering that could be adapted for the field of Science and Technology. Among others these included: leadership workshops, seminars, conferences and networking events that provide women with the opportunity to network and meet other female professionals in the field; showcasing role model programs that provide women the opportunity to meet with leading women in their field; and assistance with implementing policies for women who want to re-enter the engineering profession after a career break.

**Table 3.2 Key findings of the Smart Women – Smart State Taskforce**

<b>Smart Women – Smart State Taskforce</b>
<ul style="list-style-type: none"> <li>• Approximately half of the students entering tertiary science courses are female, but fewer girls leaving school select tertiary engineering and IT courses. It is during these final years at school that it is vital to introduce girls to the possibilities of engineering and IT.</li> <li>• Time out of the paid workforce can have a significant impact on women’s ability to return to the paid workforce. During the career of a scientist, any break can mean falling behind one’s peers, with little opportunity to regain an equivalent ranking. Many scientists are employed on contracts and are reliant on short term funding. As a consequence, female scientists returning to the workforce may find it difficult to find funded employment suitable to their needs.</li> <li>• There were also notable gaps in the availability of accurate quantitative and qualitative data to provide a clear picture of women’s participation in the SET industries and aid in the monitoring of progress of women in SET.</li> </ul>

**Table 3.3 Key findings of the Careers Review of Engineering Women (CREW) project**

<b>Careers Review of Engineering Women (CREW) project</b>
<ul style="list-style-type: none"> <li>• Female engineers begin their careers with similar experiences and commitments to their male counterparts, and both male and female engineers join the engineering workforce in similar proportions after graduation (89% and 85% respectively). However compared to their male counterparts, female engineers tend to become clustered in lower paid and lower status positions as their careers progressed.</li> <li>• The age profiles of female and male engineers are strikingly different. The age profile of women engineers peaks at 51% in the 20-29 age group and steadily declines in the later age groups. In addition, only 15% of women are over 40 years of age. In contrast, the age profile of male engineers peaks in the 30-39 age group and then steadily falls up to retirement age. This age profile indicates that women over thirty are leaving the engineering profession.</li> <li>• Cultures of many engineering workplaces are female and family unfriendly. Women were reported to be more dissatisfied than their male counterparts with workplace culture and conditions, especially in areas such as promotions, recognition and rewards, and workplace communication and management. 50% of female engineers are reported to have experienced discrimination, harassment and paternalism in the workplace. In addition, females with primary childcare responsibilities report that their opportunities for interesting work and promotion are reduced because they are not considered to be committed to their work.</li> </ul> <p style="text-align: right;">Source: Roberts and Ayre 2002</p>

## **Women in Science Enquiry Network (Wisenet)**

WiseNet (<http://www.wisenet-australia.org/>) was established in 1984 to increase women's participation in the sciences and to link people in different branches of science with those working towards a more participatory and socially useful science. Objectives of WISENET are as follows:

- To build a supportive and active network of people interested in the objectives of WISENET and to liaise with other interested groups;
- To increase women's participation at all levels in the sciences where they are now under-represented;

- To provide comment on and to examine the education, training and employment structures which currently restrict women's opportunities in the sciences;
- To gather and disseminate data on women in science - the sciences here including the physical, social and life sciences, mathematics, computing, medicine, engineering and associated technologies;
- To explore linkages between the different disciplines and promote communication between scientists and the community on science related social and environmental issues;
- To promote research and technologies for the benefit of communities;
- To explore programs for change in the sciences and support more democratic and participatory systems as an alternative to the traditional models;
- To support appropriate action to achieve these objectives.

### **Women in Technology (WiT)**

Women in Technology, or WiT (<http://www.wit.org.au/>) was formed in 1997 and represents the interest of all women in the fields of Information Technology and Biotechnology. WiT aims to promote the achievements of women in the technology industries via relevant events, programs, awards and networks that also provide opportunities for WiT members to grow and develop their skills. Thus, Wit provides a range of industry programs, including:

- Career Management – a series of workshops such as How to Get that Job, Managing it All, Professional Networking, Industry Expectations
- Mentoring
- Technology Anywhere – a program that is delivered to girls from Years 6 to 12, showing how technology is now part of every business in every industry including movie lots, boardrooms and operating theatres. Technology Anywhere Workshops are fun, and interactive and offer the chance to talk to women working in a wide range of technology careers
- Regional Tours; taking the 'Technology Anywhere' program to North Queensland
- Scholarships; to recognise women in eight diverse categories, and
- Board Readiness Program – in 2005 seven women were successfully placed in paid board positions and not-for-profit organisations.

### **Monash University Schemes**

In support of equal employment opportunity for women, Monash University has established the University-Wide Mentoring Scheme for Women with the aim of increasing women's access to mentoring. This program is coordinated by the Women's Leadership and Advancement Scheme (Equity and Diversity Centre) and involves 'matching' individual women (academic and professional) with more senior staff members who then meet at regular intervals to discuss career-related issues and goals. Evaluations of the mentoring programs show positive results with almost half the mentees reporting career changes such as promotion, change of job with higher pay, moving from fixed-term to ongoing positions, and higher duties.

In addition to the Mentoring Scheme for Women, Monash University has also established arrangements for women who are pregnant and women planning pregnancy. Initiatives of this program include: revising the University's maternity leave policy to provide women with paid maternity leave comprising 14 weeks at full pay and a further 38 weeks at 60% pay on a pro rata basis; providing web-based information on pregnancy, childcare, health and wellbeing and superannuation; developing a return-to-work policy that allows staff to return to work on a part time or flexible work arrangement after parental leave; and the establishment of a \$15,000 'Populate and Publish' Grant from the Faculty of Science for female academics returning from

maternity leave to help them maintain the momentum of their research whilst they are on leave (<http://www.sci.monash.edu.au/research/maternity.html>). As a result of these initiatives, 92% percent of women have returned to work after maternity leave since 1992 (Monash University n.d.).

The University's 'When Research Works for Women' project ([Dever et al 2006](#)) is an important contribution to our understanding of the research environment as it focuses those factors contributing to successful research careers. The project used qualitative interviews to investigate the 'researcher biographies' of a select group of Monash University's leading women researchers. Researcher biographies provide information on patterns of research training, and the strategic choices researchers make in different research careers and career stages. Factors that were found to be critical to women's research performance were: the degrees of passion and excitement they felt for their research work; having good international connections and research networks; having effective mentors and supervisors; participating in collaborative or team research; developing effective grant seeking skills; supervising postgraduates; having a close teaching and research nexus; having the capacity to concentrate research and teaching time; high levels of flexibility in the workplace; regular access to study leave; improved maternity leave provisions and family friendly work units; moderate involvement in administration and having the capacity to seek help together with an effective working style.

Areas of policy or practice where potential for improvement was identified included: the fragmentation of research time; work-life balance; the research and career planning dimensions of performance management; substantial administrative loads for top performing researchers; communication of policy (especially in relation to promotion); job security for research-only staff on grant funding; isolation of research-only staff, career development and advising; administrative support and the provision of research facilities; and elements of gender discrimination.

Advice and strategies offered to other researchers to improve research productivity included: understand why you want to be a researcher; research what interests you; establish a track record early; have a clear plan about what is to be achieved; develop a profile both within and outside the University; use the opportunities presented; collaborate with others; make time and space for research activities; know when good enough is good enough and don't lose sight of the important things in life (Dever 2006, 1-6).

## **The Walter and Eliza Hall Institute of Medical Research (WEHI)**

In 2009 a fellowship to encourage outstanding female scientists to take up leadership positions in medical research was introduced by Professor Douglas Hilton, the new director of the Walter and Eliza Hall Institute, to help women reach senior positions. The fellowship is named after the institute's immediate past director Professor Suzanne Cory.

According to Professor Hilton the institute is 'acutely aware of the difficulties confronting women as they make the transition from post-doctoral scientist to laboratory head and, from there, to more senior roles'. Approximately 60% of WEHI's undergraduate and PhD students are women and about half of the post-doctoral scientists are women. At the laboratory head and division head level, the situation is much more sobering: 27% of lab heads are women, but none of the 10 division heads and only one of 16 professors is a woman. Professor Hilton notes that 'This situation is not unique to the Walter and Eliza Hall Institute nor is it a recent phenomenon. Indeed, women have made up the majority of biology undergraduates for decades, yet progress toward parity at senior levels has been glacial.'

Professor Hilton argues that removing barriers to women continuing in science would ultimately benefit the institute: 'As an institute, if we are to maximise our chances of making discoveries

that change the way scientists think about the world and improve the treatment of patients, we must use our entire talent pool'.

To redress the gender imbalance, the institute is piloting a number of initiatives:

- Childcare support. Support packages of up to \$15,000 per year are available to outstanding female postdoctoral fellows and female laboratory heads to assist with the cost of childcare for pre-school-age children.
- Family rooms. In 2011, a suite of offices will be renovated to serve as a family centre, comprising private rooms in which to breast-feed infants and express and store milk, and offices that parents can use for emergency/occasional care of their infants and children.
- Meeting and travel support. Support is available to enable outstanding female postdoctoral fellows and female laboratory heads with pre-school-age children to join peer-review committees, speak at scientific conferences and accept invitations to participate in other academic activities.
- Technical support while on maternity leave. Female post-doctoral researchers who are facing a period of potentially-reduced productivity while on maternity leave can discuss arrangements for additional technical support while on maternity leave.
- Additional time for contract renewal. The period between an initial five-year appointment as a laboratory head and renewal of this position often coincides with bearing and raising children. The institute will therefore afford such women an additional 12 months (per child) before they will be assessed for renewal of their appointment.
- Women In Science lectures and mentoring. Continuing the successful program initiated by Professor Suzanne Cory, three times a year from 2010 the institute will hold Women in Science lectures to showcase the performance of outstanding female scientists.

As well as these initiatives, several family-friendly and career development practices are already in place AT WEHI. These include:

- Leadership and skills training. Leadership workshops, presentation workshops and management workshops are offered to all postdoctoral fellows and junior laboratory heads, as well as business development and communication intern programs.
- Family-friendly meeting times. Institute meetings should begin after 9.15am and finish before 4.30pm to give staff with family responsibilities more opportunity to attend while still honouring their personal commitments.
- Flexible working hours. Parents are invited to propose working hours that strike a reasonable balance between attending key laboratory events while still catering to personal needs.

([www.wehi.edu.au/site/latest\\_news/new\\_initiatives\\_support\\_women\\_scientists](http://www.wehi.edu.au/site/latest_news/new_initiatives_support_women_scientists))

## Section 4: What We Don't Know

A significant focus of this report has been on the Australian higher education sector. This is a reflection of the importance of this sector to the science and technology workforce and points to our future capacity for productivity and innovation. It is also a pragmatic response reflecting the rich evidence base that is available, both in terms of accessible data and relevant literature. For the higher education sector, despite classificatory changes and data weaknesses associated with certain employment categories (such as casual and honorary staff) it is possible to construct reasonably robust longitudinal datasets that illustrate gendered patterns of participation, employment and employment status by disciplinary groupings. It is possible to paint a reasonable picture of trends in the science and technology disciplines.

However, as alluded to earlier in this report, there is a paucity of consistent data that would inform a nuanced understanding of SET graduate outcomes and career mobility between the academy, government, the not-for-profit sector and industry. Our understanding of the government sector and industry, limited in part by the modest scope of this report, is drawn from a combination of ABS census and labour force data, examples of statutory reporting, and professional association surveys. There does appear to be a significant absence of women from senior and leadership roles, suggesting barriers to success or possible attrition of women from the science and technology sector. The relative absence of women in these roles tells us nothing about the diversity of their career destinations, the push-pull factors of scientific organisational cultures, or the attractiveness of flexible and less linear career options compared to those in traditional research career paths (see Section 2 of this report). It also tells us nothing of the numerous non-research career paths that women with SET qualifications might pursue. It is hard to estimate the impact of a loss that remains largely unquantified.

At the *Australia 2020 Summit* the need for clearer and secure scientific career options was identified as a significant contributing factor to our capacity to retain and support graduates in research careers (Australian Government 2008, 161). This imperative was reiterated as a key priority at the workshop for this report's key stakeholders, held in September 2009 at Parliament House Canberra. To meet this aim more detailed analysis of these career paths is necessary. The full utilisation of existing data and the collection of new information could enhance the ability to map the interplay of participation in higher education, attraction, retention and success in employment, alongside employment classification and status, age and gender. Such research would help to identify future potential, changing graduate aspirations and emerging gaps. Improved data and research focussed on pathways will enable the Prime Minister's Science, Engineering and Innovation Council, and other committees and agencies to provide more robust strategic oversight to identify emerging issues and capabilities.

We know from the literature (Probert 1998; Hobson et al 2003; Stevens-Kalceff et al 2007) that women make strategic decisions about career and life options at critical points in their careers, particularly at the conclusion of doctoral studies. These may be seen as 'situationally' temporary but turn out to be career limiting (Hobson 2003). As Probert points out in her critique of proponents of human capital theory, women do not always have a choice in any meaningful sense: 'If they wish to pursue an academic career as vigorously as men do, they may feel that this is incompatible with responsible family life. In this sense women have to make a choice between work and family which men can avoid, and this renders the scope for "choice" incommensurate' (1998, 52). Following [Eagly and Carli \(2007\)](#) these 'choices' are made many times over as women negotiate complex career labyrinths. There is potential for in-depth study of critical decision-making processes, supported by the interrogation of existing datasets (such as the ACER/DEEWR 2008 Graduate Pathways Survey (Coates & Edwards 2009) data. This would enable not just the documentation of career pathways and patterns of mobility but the

development of highly nuanced strategies and interventions to improve the attraction, retention and success of women in science and technology.

It is also important to note that despite the numerous examples of initiatives to improve the position of women in science and technology, some of which are documented in Section 3 of this report, there has not been evaluation commensurate with the investment in interventions and support programs. If we ask the obvious question – what works? – the evidence is scant. However indications of what might make a difference can be gleaned from the literature. Common findings across the recent Australian and international reports, and confirmed by stakeholder input, emphasise the importance of:

### **Scientific Career Paths**

- Identifying barriers and the accumulation of disadvantage (NAS 2007; APESMA 2007; Queensland Government Smart Women – Smart State Taskforce 2006; Roberts and Ayre 2000)
- Accommodating and supporting flexible and non-traditional career paths, including transition support programs (APESMA 2007; NSF 2009; Queensland Government Smart Women – Smart State Taskforce 2006; OECD 2006; Winchester et al. 2005; Probert 2005)
- Recognising and rewarding professional excellence relative to opportunity (NSF 2009)
- Identifying biased and subjective evaluation criteria that impede progress (NAS 2007; APESMA 2007; NSF 2009; OECD 2006)
- Providing access to role models, mentoring and professional networks (OECD 2006; NAS 2007; NSF 2009; Athena Project 2005)

### **Institutional Cultures and Decision-Making**

- Acknowledging that workplaces are gendered environments (European Commission 2000)
- Addressing structural constraints and reframing expectations (NAS 2007)
- Addressing gender stereotyping and implicit bias (NAS 2007; APESMA 2007; NSF 2009; Roberts and Ayre 2000; OECD 2006)
- Developing supportive workplace cultures that are 'family friendly' for women and men (APESMA 2007; Queensland Government Smart Women – Smart State Taskforce 2006; Roberts and Ayre 2002; OECD 2006)
- Fostering collaboration rather than competition (NAS 2007)
- Acknowledging and cultivating passion and professional commitment even when colleagues are juggling competing demands (NSF 2009).

### **Evidence and Evaluation**

- Systematic and consistent institutional data collection to inform decision-making (NSF 2009; Queensland Government Smart Women – Smart State Taskforce 2006).



## **Leadership**

- Implement leadership development, career coaching, and network building programs (NSF 2009, Athena Project 2005)
- Access to leadership positions for women (OECD 2006)
- Leaders to initiate policy-change to ensure equity, diversity and innovation (NSF 2009)

These are neither onerous nor unrealistic expectations but they do require purposeful leadership – male and female leaders who are diligent models committed to enhancing productivity and innovation through diversity.

## Section 5: Conclusions and Recommendations

In this report the aim has been to address the systemic challenge of women's participation, retention and success in science by drawing on the evidence base of relevant national data and to inform analysis with reference to the literature in the field. The 1995 report 'Women in Science, Engineering and Technology' prepared by the Women in Science, Engineering and Technology Advisory Group was taken as a benchmark study. This enabled examination of the important question 'How Far Have We Come?' over the last decade and a half. International interventions have also been highlighted as possible models around which to structure interventions appropriate to the Australian context. The over-arching aim is to generate shared understanding and shared meaning about the issue and its possible solutions.

At the outset of the report it was acknowledged that examples of extraordinary individual achievement and leadership are cause for cautious optimism. Such achievement, plus the systemic change that has occurred at the secondary school level and in some disciplines at the undergraduate and postgraduate levels, provide evidence that such change can be achieved if a clear agenda is set and pursued.

This report suggests that this is an agenda that is currently only half prosecuted. It demands renewed attention if we are to maximise the outcomes in terms of productivity and innovation as well as equity.

It is time for a renewed focus on women in science and technology. This is a dynamic period in which a new federal government is pursuing a vigorous reform agenda. The Commonwealth government's response to the Bradley Review prioritises the social inclusion agenda (2008) and is generating new challenges and new opportunities in tertiary education. The Ministerial response (2009) to the Cutler Review (2008) promises to reinvigorate the innovation agenda, emphasising the need for creative and purposeful leadership. The Prime Minister's recent announcement of a review of the Public Service (2009) foreshadows the possibility of a more dynamic interface between the public and higher education sectors.

Such a dynamic policy environment is the ideal time to pursue systemic change that will enrich Australian science and society by capitalising on the expertise, skills and promise that women can more fully bring to the fields of science, engineering and technology.

That said I am also reminded (Sir David Watson personal correspondence) that we can and should act to remove barriers and equalise opportunity, but 'it's difficult to make the analytical shift from regretting choices people make (in this case about subjects and careers) to promoting "informed choice"...Young women may be making rational choices in the world as it exists, and reluctant to change these choices until the world itself changes.' This is a poignant reminder that when we document 'attrition' we are mapping accumulated disappointment, frustration and unrealised expectations, impacting significantly on individuals. In response I contend it is our responsibility is to change the professional world our young scientists are entering.

The recommendations flowing from this study are formulated with several purposes in mind:

- to reinforce the need for continuity where we have seen success (at the secondary school and in some disciplines in undergraduate and postgraduate participation)
- to identify and remove barriers to women's career progression and success
- to strongly focus on the role of (male and female) leaders in taking responsibility for creating and maintaining positive organisational cultures, in part to ensure that change is holistic rather than piecemeal

- to improve the evidence base, share best practice and ensure that interventions are appropriately framed and evaluated, and
- to address the participation of women in relevant policymaking and decision making processes.

## **Recommendations**

Following the approach of the US National Science Foundation (NSF), FASTS supports a multifaceted strategy to broaden participation in the science and technology workforce – in particular to realise the potential of women’s participation. FASTS encourages institutions of higher education and the broader science community (including government, professional societies, the learned academies, science and technology related industries and not-for-profit organisations) to address various aspects of science and technology organisational culture and institutional structure that may negatively affect women. The following recommendations have been drafted with the input of a range of key stakeholders.

### **Advancing the Agenda**

1. The Minister for Innovation, Industry, Science and Research takes a leadership role in ensuring the urgent prosecution of the agenda outlined in the following recommendations, including identifying and co-ordinating the appropriate responsible agencies.
2. Identify incentives for change including a stronger business case linking diversity with innovation.

### **Scientific Career Paths**

3. Clearly map scientific career paths with opportunities for leadership and mentorship identified in tandem with the systematic identification and elimination of barriers to women.
4. Address the mechanisms that will enable women to ‘thrive and excel’, not just ‘survive’, in science and technology careers, including supporting flexible, non-traditional career paths.

### **Institutional Cultures and Decision-Making**

5. Following the US ADVANCE program, support leadership and employers to implement policies and practices that generate positive organisational cultures which create contemporary family friendly and equitable workplaces that value diversity.
6. Following the EU example ensure that women constitute one third of policy-making, funding and decision-making boards.

### **Monitoring and Evaluation**

7. Improve the evidence base – institute consistent, systematic reporting of gender data in the sector on the part of the major research and research funding agencies (including CSIRO and the NH&MRC), the centres of excellence (the Learned Academies, the CRCs, the ARC Centres and Networks) and industry. Ensure that the ABS and Office for Women generate data sets that link participation to innovation in keeping with international practice.
8. Create a clearinghouse for best practice in the sector comparable with the UK’s Resource Centre for Women in Science, Engineering and Technology. The

responsibilities of the clearinghouse will include the monitoring and evaluation of SET initiatives.

9. Continue the monitoring and research in schools on gendered participation with a renewed emphasis on the four questions: Which girls? Which boys? Which disciplines? Why?

### **Leadership**

10. Empower leaders to address these issues through resources, interventions, and a robust policy and evaluation framework; and on an organised and ongoing basis identify high profile male and female individual and organisational champions.

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## **Appendix**

## Listing of Graphs:

### **A1.1 Occupation by Gender 1992**

Source: Women in Science, Engineering and Technology Report (Table 1) May 1995

### **A1.2 Occupation by Gender 2008**

Source: ABS Australian Labour Market Statistics (cat. no. 6105.0) October 2008

### **A1.3 Occupational Categories and Sub-Categories by Gender 1996**

Source: Women in Science, Engineering and Technology Report (Table 1) May 1995

### **A1.4 Occupational Categories and Sub-Categories by Gender 2009**

Source: ABS Labour Force, Australia, Detailed, Quarterly (cat. no. 6291.0.55.003) May 2009

### **A1.5 Industry of Employment by Gender 1992**

Source: Women in Science, Engineering and Technology Report (Table 2) May 1995

### **A1.6 Industry of Employment by Gender 2008**

Source: ABS Australian Labour Market Statistics (cat. no. 6105.0) October 2008

### **A1.7 Average Weekly Total Earnings for Professionals by Gender 1992**

Source: Women in Science, Engineering and Technology Report (Table 4) May 1995

### **A1.8 Average Weekly Total Earnings for Professionals by Gender 2006**

Source: ABS Employee Earnings and Hours (cat. no. 6306.0) May 2006

### **A1.9 Average Weekly Total Earnings for Para-Professionals by Gender 1992**

Source: Women in Science, Engineering and Technology Report (Table 4) May 1995

### **A1.10 Average Weekly Total Earnings for Associate Professionals by Gender 2006**

Source: ABS Employee Earnings and Hours (cat. no. 6306.0) May 2006

### **A2.1 VET Stream Enrolments by Gender 1993**

Source: Women in Science, Engineering and Technology Report (Table 8) May 1995

### **A2.2 VET Steam Enrolments by Gender 2008**

Source: Australian vocational education and training statistics: Students and courses 2008, published by NCVET

### **A3.1 Female Participation in Undergraduate Studies by Broad Field of Study/Education 1997-2007**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Level of Course, Broad Field of Study/Education and Gender 1997-2007

### **A3.2 Female Bachelors Honours Completions by Broad Field of Study/Education 1997-2007**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Level of Course, Broad Field of Study/Education and Gender 1997-2007

### **A3.3 Female Doctorate Research Completions by Broad Field of Study/Education 1997-2007**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Level of Course, Broad Field of Study/Education and Gender 1997-2007

**A3.4 Female Bachelors Pass Completions by Narrow Field of Study 1997-2000**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Narrow Field of Study and Gender 1997-2007

**A3.5 Female Bachelors Pass Completions by Narrow Field of Education 2001-2007**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Narrow Field of Education and Gender 1997-2007

**A3.6 Female Bachelors Honours Completions by Narrow Field of Study 1997-2000**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Narrow Field of Study and Gender 1997-2007

**A3.7 Female Bachelors Honours Completions by Narrow Field of Education 2001-2007**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Narrow Field of Education and Gender 1997-2007

**A3.8 Female Doctorate Research Completions by Narrow Field of Study 1997-2000**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Narrow Field of Study and Gender 1997-2007

**A3.9 Female Doctorate Research Completions (Numbers) by Narrow Field of Study 1997-2000.**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Narrow Field of Study and Gender 1997-2007

**A3.10 Female Doctorate Research Completions by Field of Narrow Education 2001-2007**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Narrow Field of Education and Gender 1997-2007

**A3.11 Female Doctorate Research Completions (Numbers) by Field of Education 2001-2007**

Source: DEST/DEEWR Selected Higher Education Student Statistics. Award course completions by Narrow Field of Education and Gender 1997-2007

**A4.1 Female Full-Time Staff by Academic Classification 1997-2000, Agriculture, Renewable Resources**

Source: DEST/DEEWR Special Report FTE for Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.2 Female Full-Time Staff by Academic Classification 1997-2000, Engineering, Processing**

Source: DEST/DEEWR Special Report FTE for Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.3 Female Full-Time Staff by Academic Classification 1997-2000, Mathematics, Computing**

Source: DEST/DEEWR Special Report FTE for Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.4 Female Full-Time Staff by Academic Classification 1997-2000, Sciences**

Source: DEST/DEEWR Special Report FTE for Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008



**A4.5 Female Full-Time Staff by Academic Classification 2001-2008, Agriculture, Environmental and Related Studies**

Source: DEST/DEEWR Special Report FTE for Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.6 Female Full-Time Staff by Academic Classification 2001-2008, Engineering and Related Technologies**

Source: DEST/DEEWR Special Report FTE for Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.7 Female Full-Time Staff by Academic Classification 2001-2008, Information Technology**

Source: DEST/DEEWR Special Report FTE for Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.8 Female Full-Time Staff by Academic Classification 2001-2008, Natural and Physical Sciences**

Source: DEST/DEEWR Special Report FTE for Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.9 Female Full-Time Academic Teaching and Research Staff by Academic Organisational Unit 1997-2000**

Source: DEST/DEEWR Special Report Table; Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.10 Female Full-Time Academic Teaching and Research Staff by Broad Field of Education 2001-2008**

Source: DEST/DEEWR Special Report Table; Academic Staff in selected AOU Groups by Gender and Broad Field of Study/Education 1997-2008

**A4.11 Female Full-Time Academic 'Research Only' Staff by Broad Field of Education 2001-2008**

Source: DEST/DEEWR Special Report FTE 'Research Only' Staff in selected AOU Groups by Work Contract, Gender and Broad Field of Study/Education 1997-2008

**A4.12 Female Fractional Full-Time Academic 'Research Only' Staff by Broad Field of Education 2001-2008**

Source: DEST/DEEWR Special Report FTE 'Research Only' Staff in selected AOU Groups by Work Contract, Gender and Broad Field of Study/Education 1997-2008

**A5.1 University Leadership Positions by Gender 2009**

Source: Collated data from Australian Higher Education Provider websites

**A5.2 Deans and Executive Deans by Broad Field of Education 2009**

Source: Collated data from Australian Higher Education Provider websites

**A6.1 Applications and Grants for ARC Discovery projects by Gender 2002-2009**

Source: ARC website [<http://www.arc.gov.au>] 2009

**A6.2 Success rates for ARC Discovery Projects by Gender 2002-2009**

Source: ARC website [<http://www.arc.gov.au>] 2009

**A6.3 Applications and Grants for ARC Linkage Projects by Gender 2002- Round 2 2009**

Source: ARC website [<http://www.arc.gov.au>] 2009

**A6.4 Success rates for ARC Linkage Projects by Gender 2002- Round 2 2009-09-02**

Source: ARC website [<http://www.arc.gov.au>] 2009

**A6.5 2009 ARC Future Fellowships**

Source: ARC website [[http://www.arc.gov.au/ncgp/futurefel/FT09\\_selection\\_rep.htm](http://www.arc.gov.au/ncgp/futurefel/FT09_selection_rep.htm)] 2009

**A6.6 2009 ARC Future Fellowship Recipients by Salary Level**

Source: ARC website [[http://www.arc.gov.au/ncgp/futurefel/FT09\\_selection\\_rep.htm](http://www.arc.gov.au/ncgp/futurefel/FT09_selection_rep.htm)] 2009

**A6.7 ARC Fellows by Gender 2002-2008**

Source: ARC website [[www.arc.gov.au/ncgp/fedfellows/ff\\_outcomes.htm](http://www.arc.gov.au/ncgp/fedfellows/ff_outcomes.htm)] 2009

**A7.1 Fellows of the Academy of Science by Gender 2004**

Source: Bell, S and Bentley R. 2005. Women in Research Discussion Paper. Prepared for the AVCC National Colloquium of Senior Women Executives

**A7.2 Fellows of the Academy of Science by Gender 2009**

Source: AAS website [<http://www.science.org.au/>]

**A7.3 Fellows of the Australian Academy of Technological Sciences and Engineering (ATSE) 2004**

Source: ATSE

**A7.4 Fellows of the Australian Academy of Technological Sciences and Engineering (ATSE) 2009**

Source: ATSE

## Explanatory Notes:

### Figure 1.3

Source: DEST/DEEWR Selected Higher Education Student Statistics 1983-2000

(a) Figures for years from 1985 to 1993 progressively include State-funded basic nursing students transferred from hospitals. (b) The field of study classification changed in 1987. The main effects were to transfer certain courses from Science to Health and from Business to Law, and hence to reduce Science and Business enrolments and to increase Health and Law enrolments. (c) Data from 1997 onwards were compiled in a different way to data for prior years to take into account the coding of Combined Courses to two fields of study. As a consequence, the total for some broad fields of study show larger increases than would be the case if data for only one field were to be counted. Counting both fields of study for Combined Courses means that the totals for each year may be less than the sum of all Broad Fields of Study.

### A1.2; A1.4: Occupational Data

Source: ABS • AUSTRALIAN LABOUR MARKET STATISTICS • 6105.0 • OCT 2008

Information on Australian Labour Market Statistics Publication:

Australian Labour Market Statistics brings together a range of ABS labour statistics to present a statistical summary of the Australian labour market. It has been developed primarily as a reference document, and provides a broad basis for labour analysis and research.

### A1.3 Occupational Data

Source: ABS • EMPLOYEE EARNINGS AND HOURS • 6306.0 • MAY 1996

The 1996 version of this report was used as an alternative to the 1992 report due to the ability of this report to be compared to contemporary data. Data collected from 1996 onwards runs on the Australian Standard Classification of Occupations (ASCO), Second Edition.

Please see the following explanatory notes on Occupation Classification of the 6306.0 Employee Earnings and Hours Report.

### OCCUPATION CLASSIFICATION

20 Each employee in the survey is classified to an occupation based on their job title and duties. The occupation classification used in this publication differs from previous publications. Data in previous publications of this series issued since 1996 are based on the Australian Standard Classification of Occupations (ASCO), Second Edition. This classification has since been replaced by the Australian and New Zealand Standard Classification of Occupations (ANZSCO).

### Figure 1.9: Occupational Data

Source: ABS Labour Force, Australia, Detailed, Quarterly (cat. no. 6291.0.55.003) May 2009, subsidiary of ABS • LABOUR FORCE • 6202.0 • JUL 2009

Information on Australian Labour Force Statistics Publication:

This publication contains estimates of the civilian labour force derived from the Labour Force Survey component of the Monthly Population Survey. The full time series for estimates from this publication are also available electronically. More detailed estimates are released one week after this publication in various electronic formats - see Labour Force, Australia, Detailed - Electronic Delivery (cat. no. 6291.0.55.001) and Labour Force, Australia, Detailed, Quarterly (cat. no. 6291.0.55.003).

Information on Labour Force, Australia, Detailed, Quarterly Publication:

Data from the monthly Labour Force Survey are released in two stages. The Labour Force, Australia, Detailed - Electronic Delivery (cat. no. 6291.0.55.001) and Labour Force, Australia, Detailed, Quarterly (cat. no. 6291.0.55.003) are part of the second release, and include detailed data not contained in the Labour Force, Australia (cat. no. 6202.0) product set, which is released one week earlier.

#### **A1.6: Industry of Employment Data**

Source:

ABS • AUSTRALIAN LABOUR MARKET STATISTICS • 6105.0 • OCT 2008

Information on Australian Labour Market Statistics Publication:

Australian Labour Market Statistics brings together a range of ABS labour statistics to present a statistical summary of the Australian labour market. It has been developed primarily as a reference document, and provides a broad basis for labour analysis and research.

#### **A1.8; A1.10: Average Weekly Total Earnings**

Source:

ABS • EMPLOYEE EARNINGS AND HOURS • 6306.0 • MAY 2006

Information on Employee Earnings and Hours Publication:

This publication contains estimates from the 2006 Survey of Employee Earnings and Hours. The survey was conducted in respect of May 2006 and collected information from a sample of employers about the earnings, hours paid for, and selected characteristics of their employees.

Note:

The 2006 version of the Employee Earnings and Hours Report (ABS) was used as an alternative to the more recent 2008 data due to the ability for 2006 data to be compared to the 1992 data of the Women in Science Engineering and Technology report.

For an explanation on the classification system used by this report, see explanatory note for A1.3 above, as well as the following below:

21 Occupation data from the 2006 Survey of Employee Earnings and Hours are available on both ASCO second edition and ANZSCO basis, as an aid to analysis.

The ASCO version of the 2006 data was used in this report as the original 1992 Average Weekly Total Earnings data also runs on the ASCO classification system.

#### **A2.2: VET enrolment data**

Source:

Australian vocational education and training statistics: Students and courses 2008, Published by NCVER

Information on Australian vocational education and training statistics Publication:

This work has been produced by the National Centre for Vocational Education Research (NCVER) as a joint initiative of the Australian Government, and state and territory governments, with funding provided through the Department of Education, Employment and Workplace Relations.

#### **A3.1 - 3.11: DEST/DEEWR Selected Higher Education Student Statistics**

In 2001 a new Field of Education classification was introduced to replace the Field of Study classification for university courses

([http://www.dest.gov.au/archive/highered/he\\_report/2002\\_2004/html/appendix\\_a.htm#1](http://www.dest.gov.au/archive/highered/he_report/2002_2004/html/appendix_a.htm#1))

The 'Broad Fields of Study' classification divided university studies into 10 broad fields of study as follows:

- 01 Agriculture, Animal Husbandry
- 02 Architecture, Building
- 03 Arts, Humanities and Social Sciences
- 04 Business, Administration & Economics
- 05 Education
- 06 Engineering, Surveying
- 07 Health
- 08 Law, Legal Studies
- 09 Science
- 10 Veterinary Science

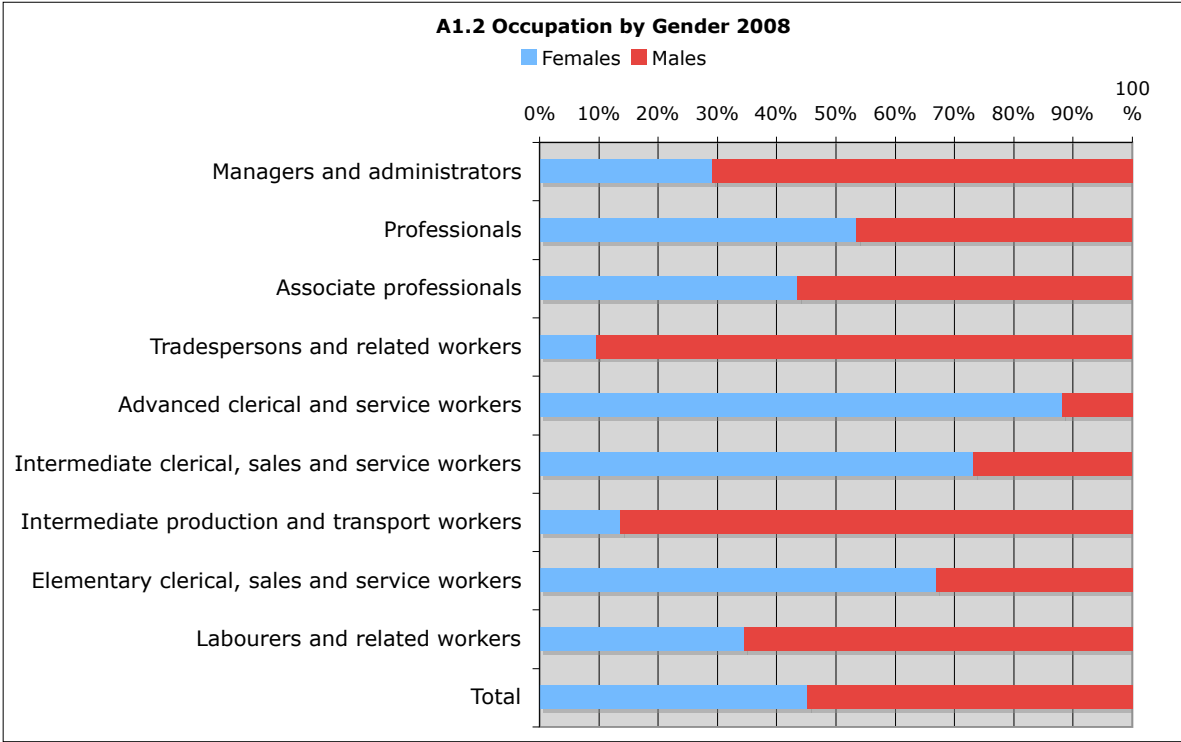
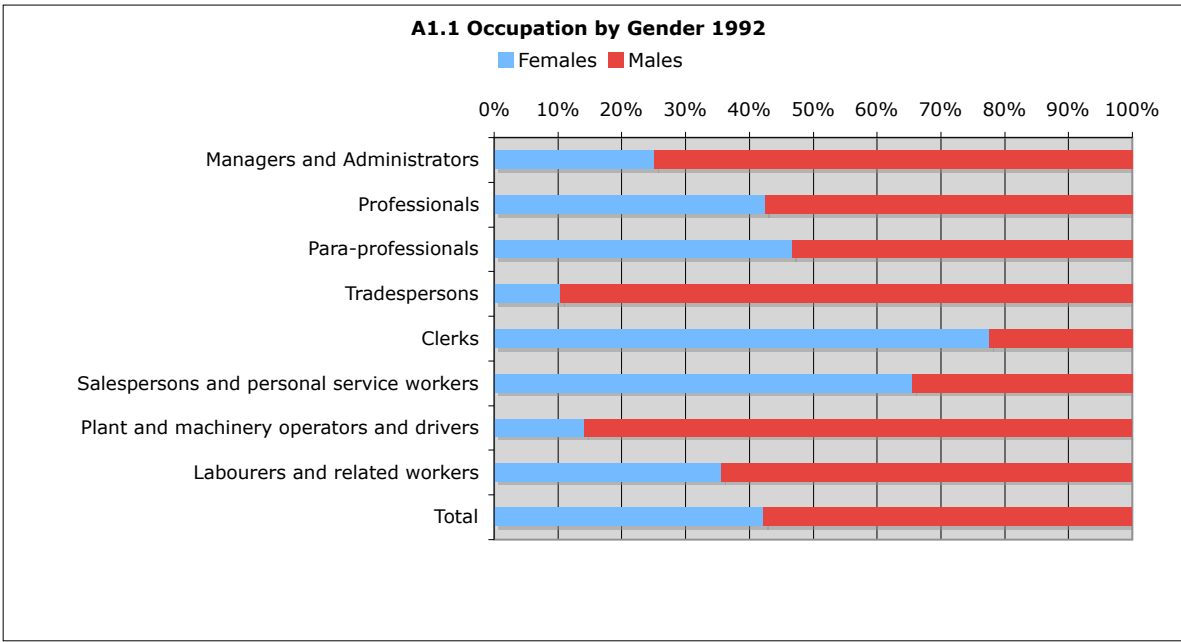
The 'Broad Fields of Education' classification, from 2001 onwards, divides university studies into 12 broad fields of education as follows:

- 01 Natural and Physical Sciences
- 02 Information Technology
- 03 Engineering and Related Technologies
- 04 Architecture and Building
- 05 Agriculture, Environmental and Related Studies
- 06 Health
- 07 Education
- 08 Management and Commerce
- 09 Society and Culture
- 10 Creative Arts
- 11 Food, Hospitality and Personal Services
- 12 Mixed Field Programmes

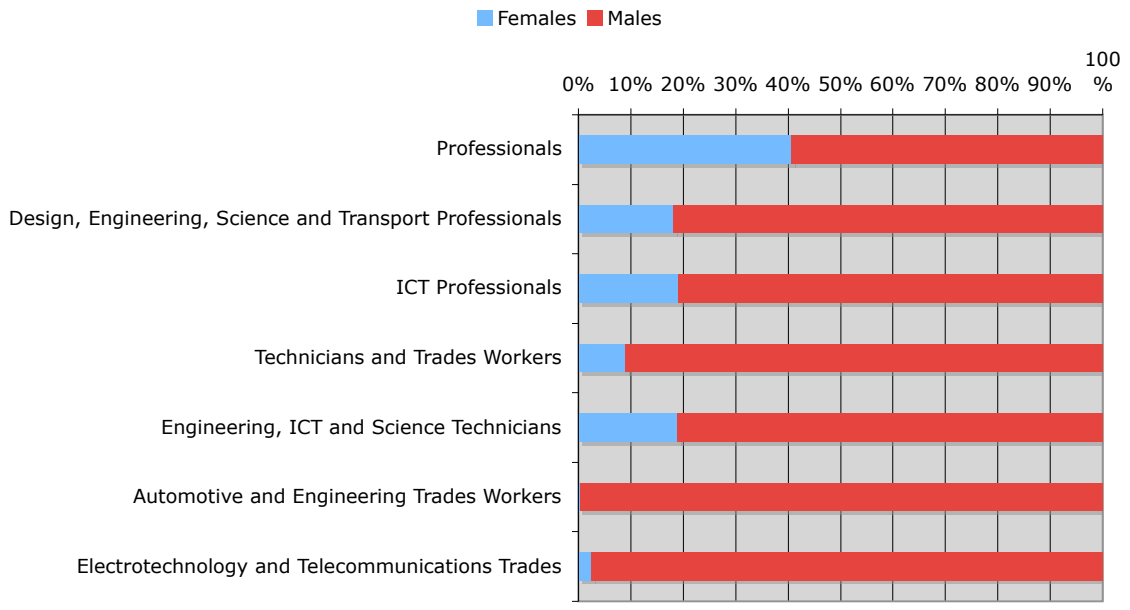
#### **A4.1 - 4.12: DEST/DEEWR Statistics – Staff Data**

Staff prior to 2001 are classified under 'Academic Organisational Units' rather than 'Broad fields of Study'. These are DEST/DEEWR (rather than ABS) classifications.

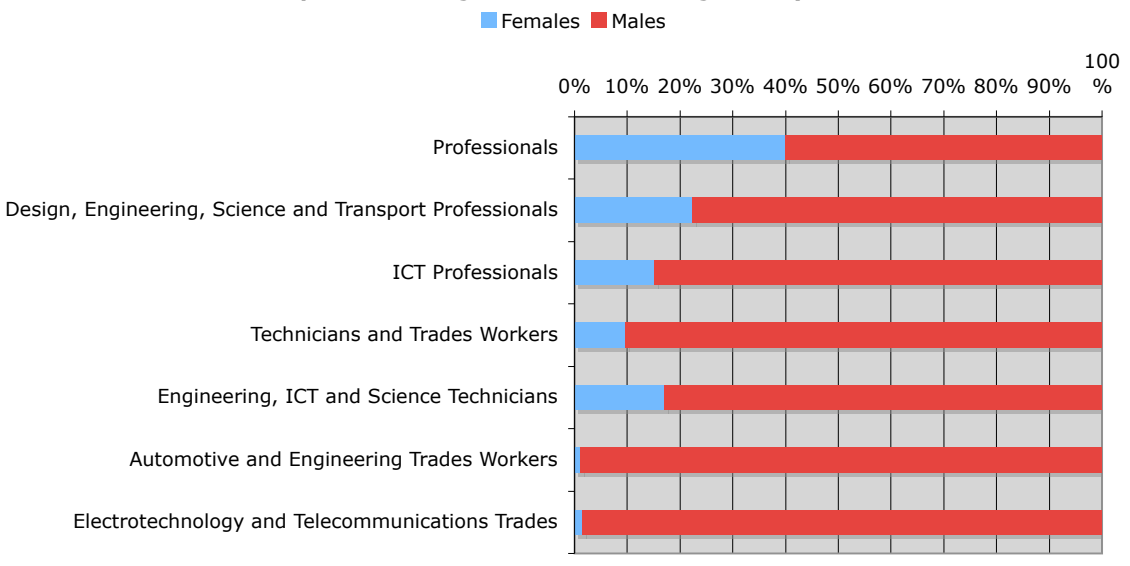
These Academic Organisational Units are: Humanities, Social Studies, Education, Sciences, Mathematics, Computing, Visual/ Performing Arts, Engineering, Processing, Health Sciences, Administration, Business, Economics, Law, Built Environment, Agriculture, Renewable Resources.

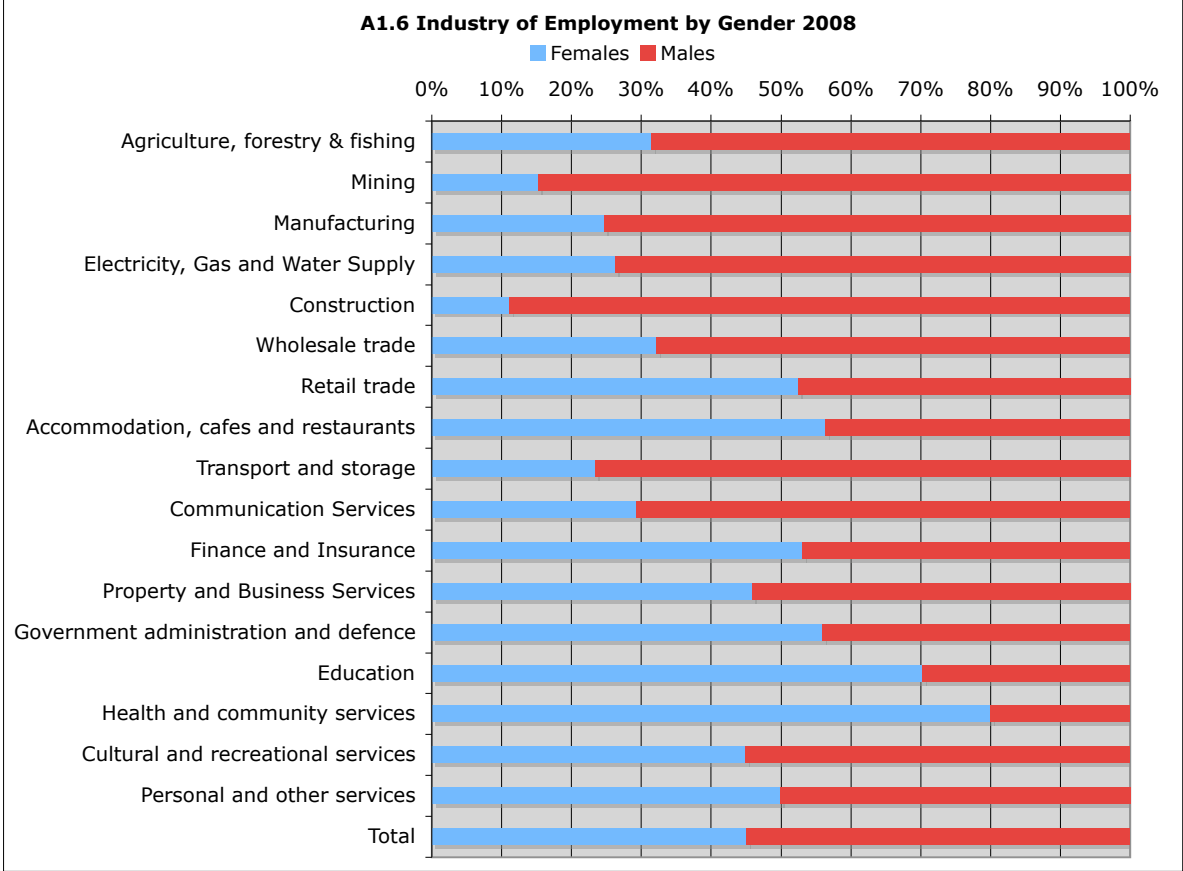
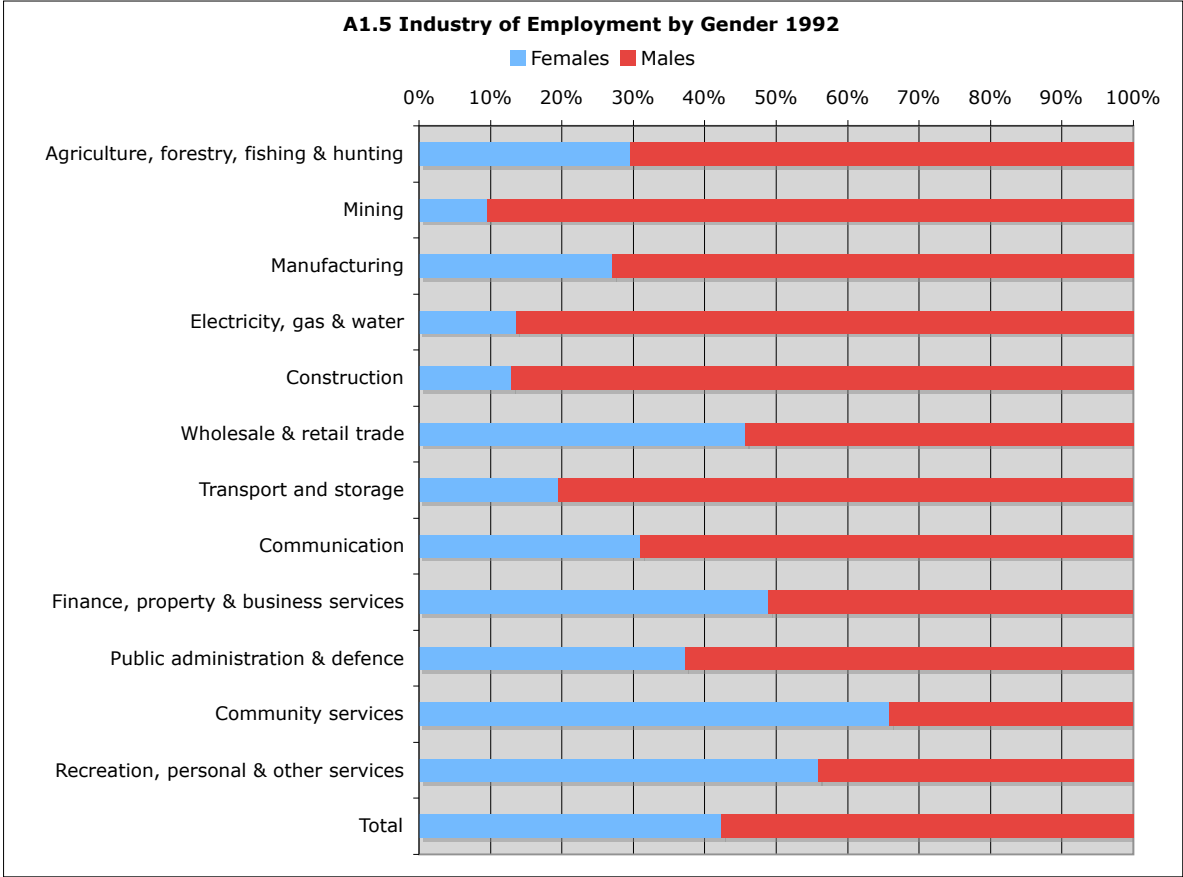


### A1.3 Occupational Categories and Sub-Categories by Gender 1996



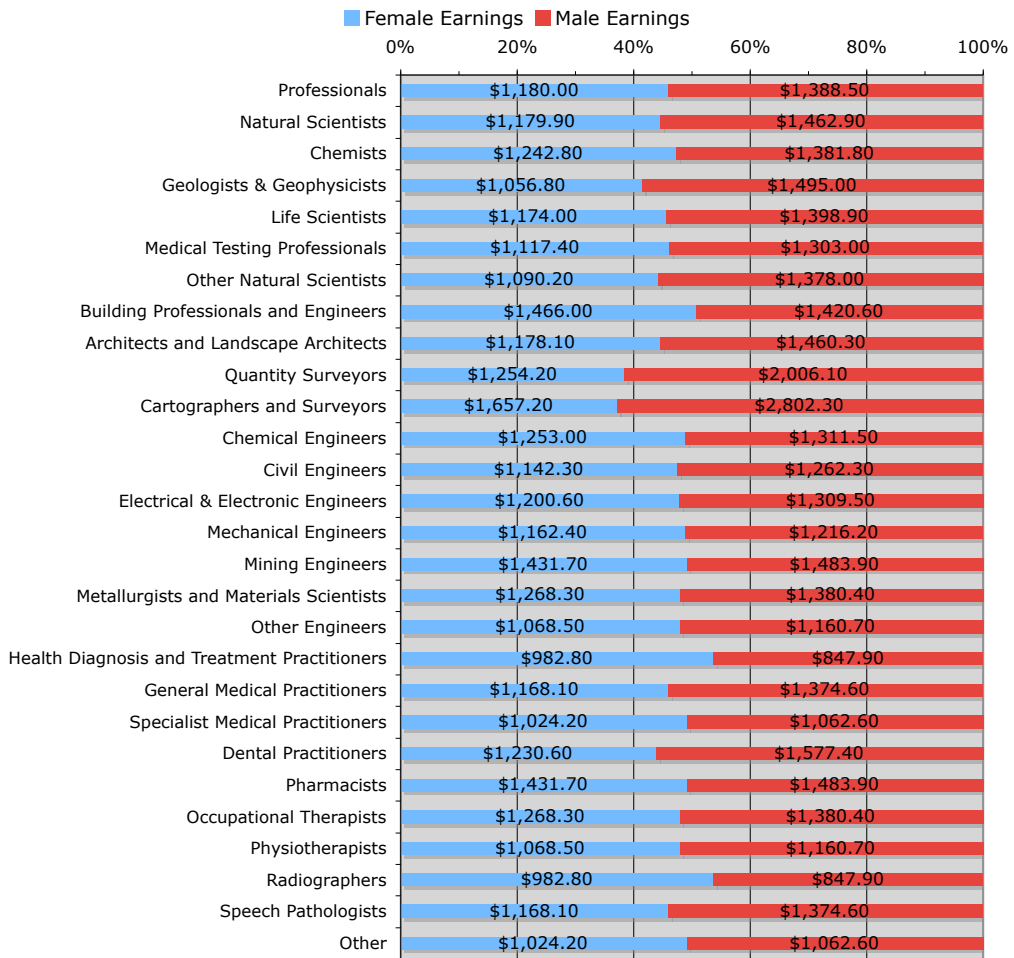
### A1.4 Occupational Categories and Sub-Categories by Gender 2008



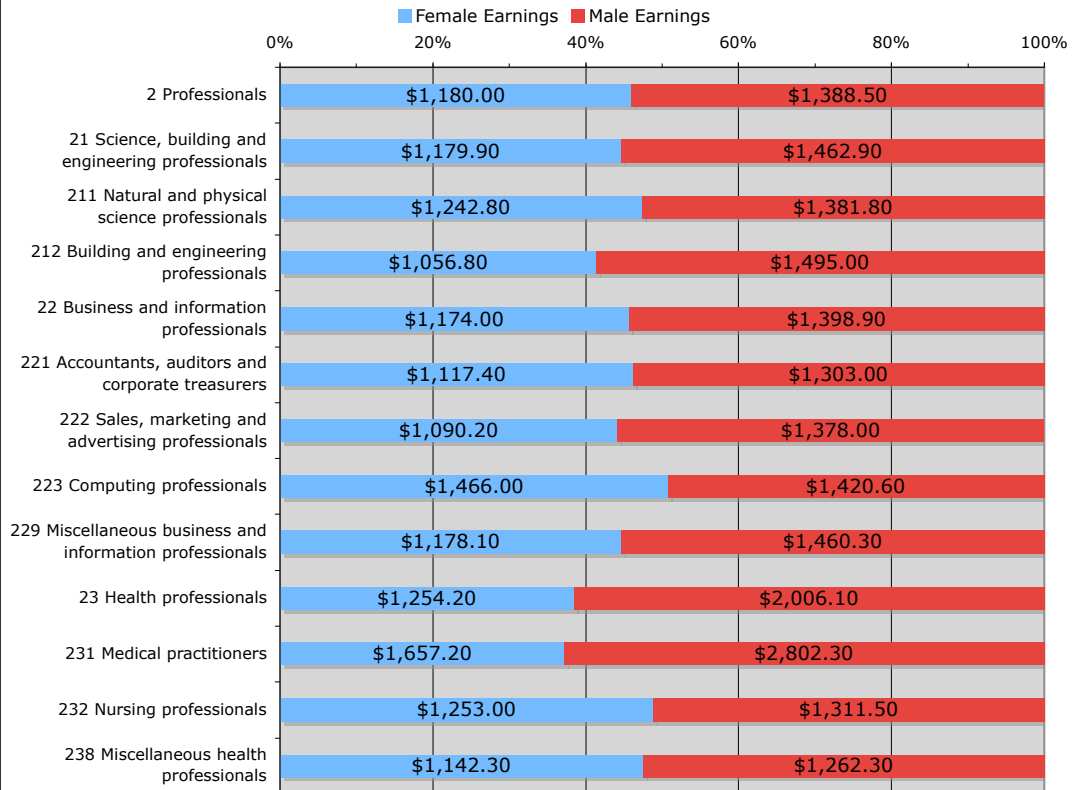




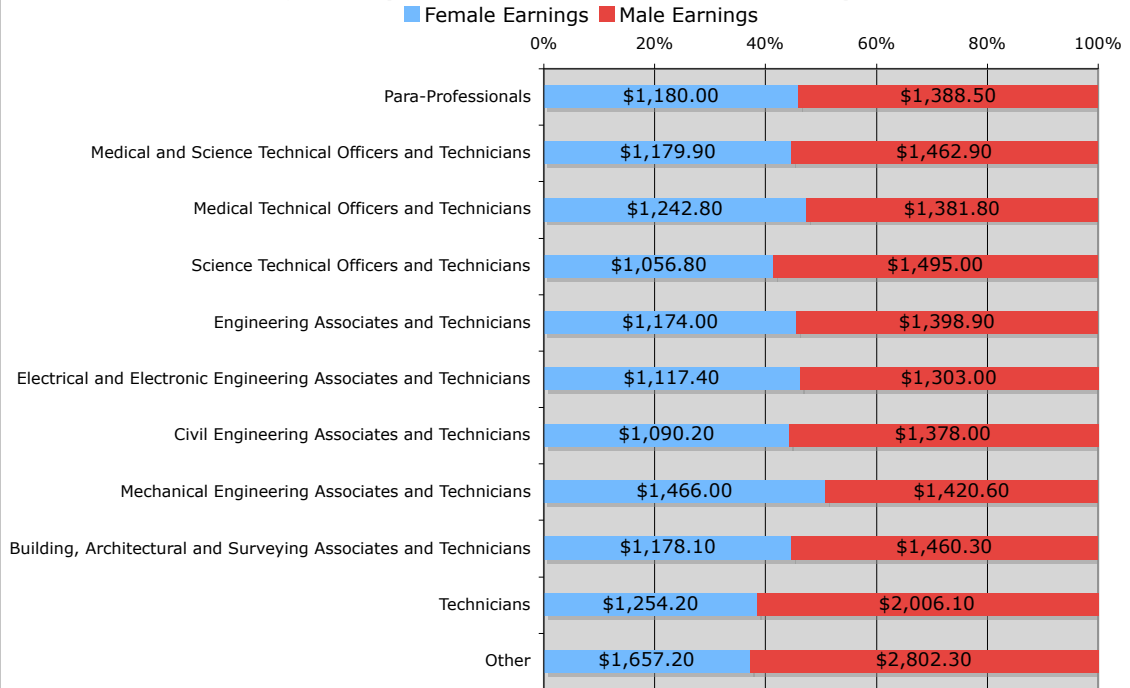
### A1.7 Average Weekly Total Earnings for Professionals by Gender 1992



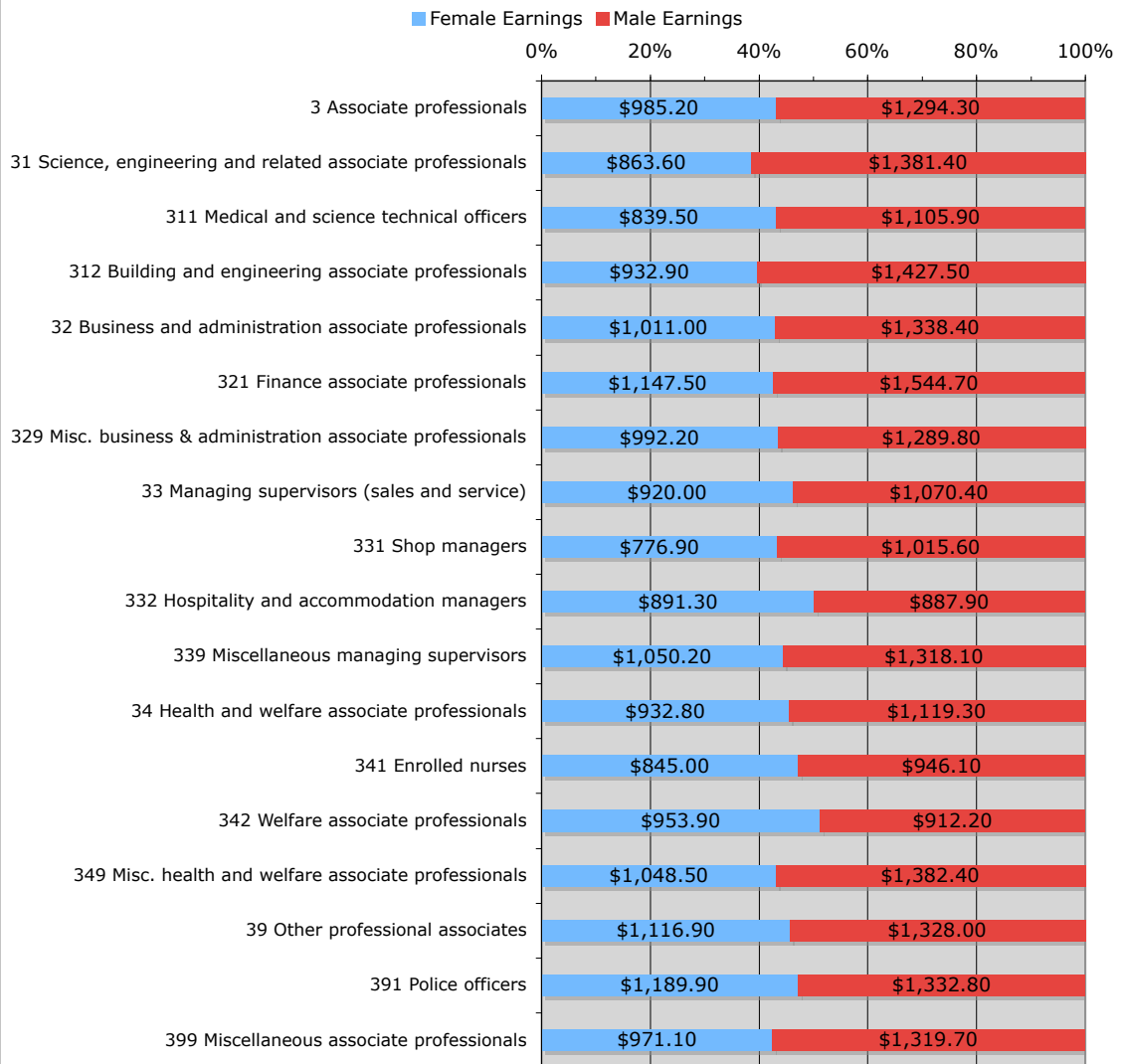
### A1.8 Average Weekly Total Earnings for Professionals by Gender 2006



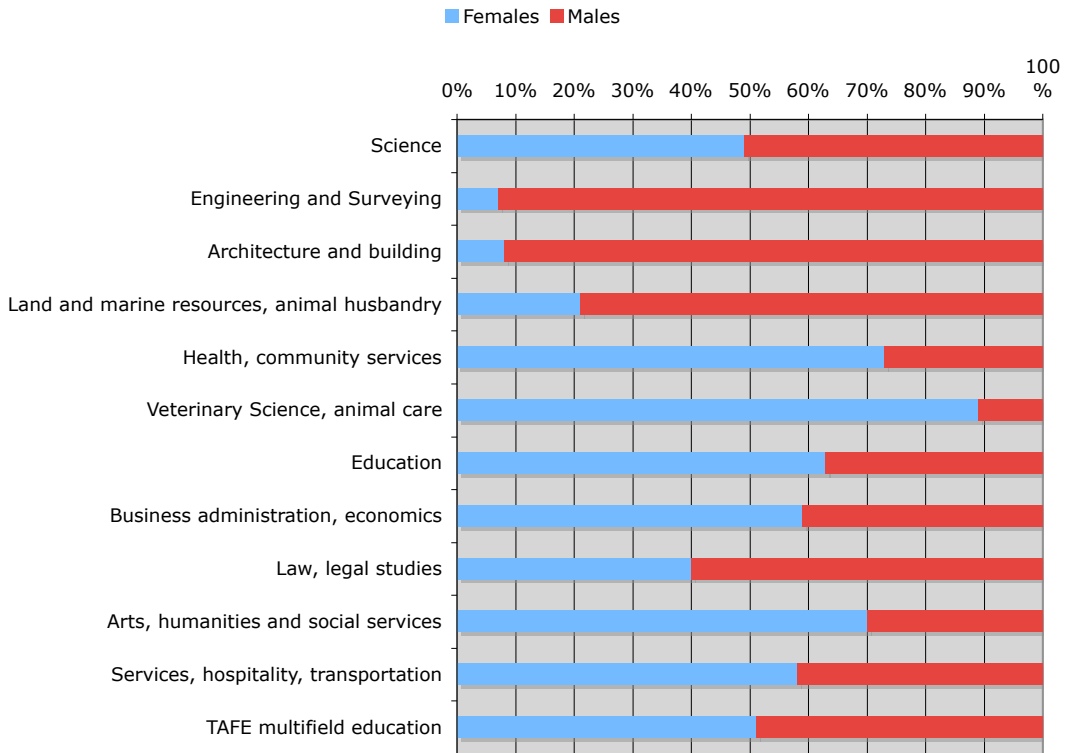
### A1.9 Average Weekly Total Earnings for Para-Professionals by Gender 1992



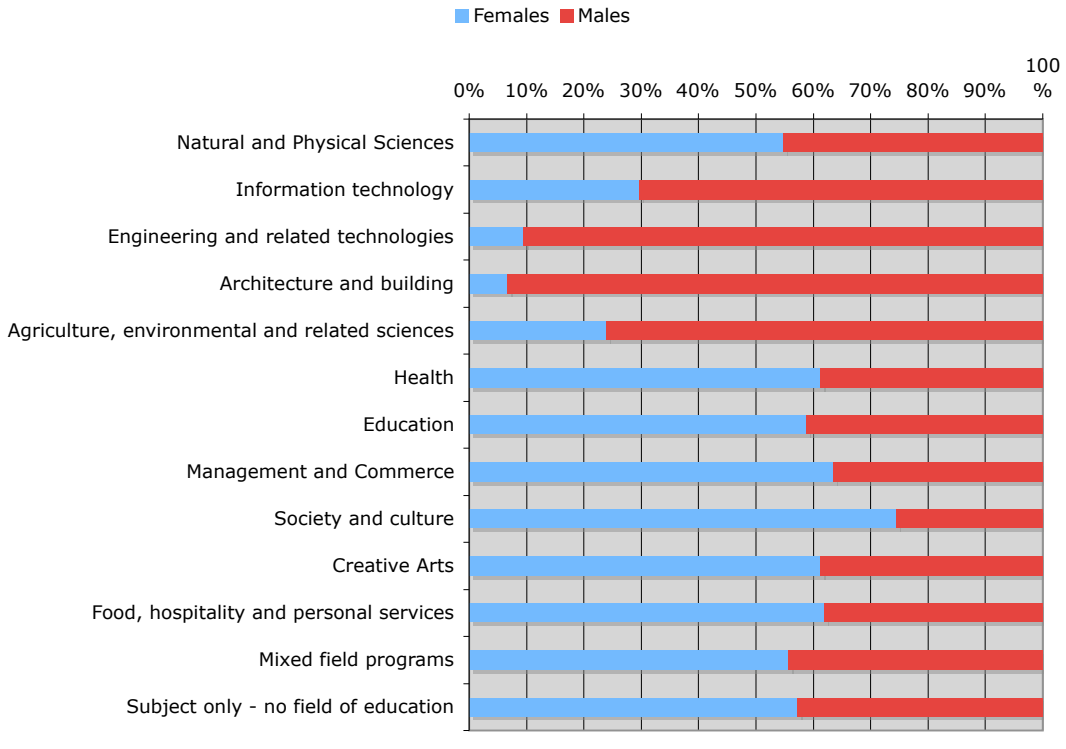
### A1.10 Average Weekly Total Earnings for Associate Professionals by Gender 2006



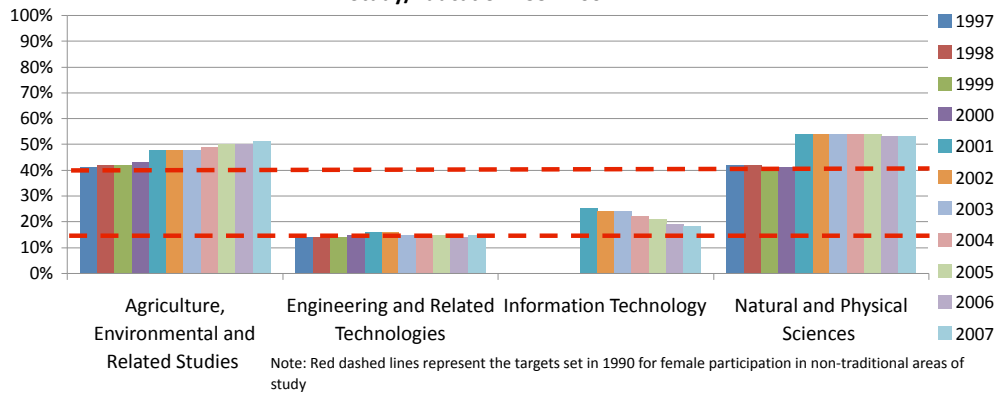
### 2.1 VET Stream Enrolments by Gender 1993



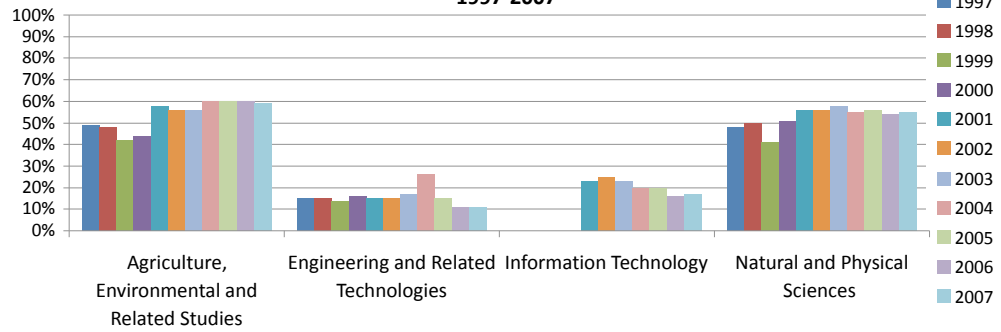
### 2.2 VET Stream Enrolments 2008



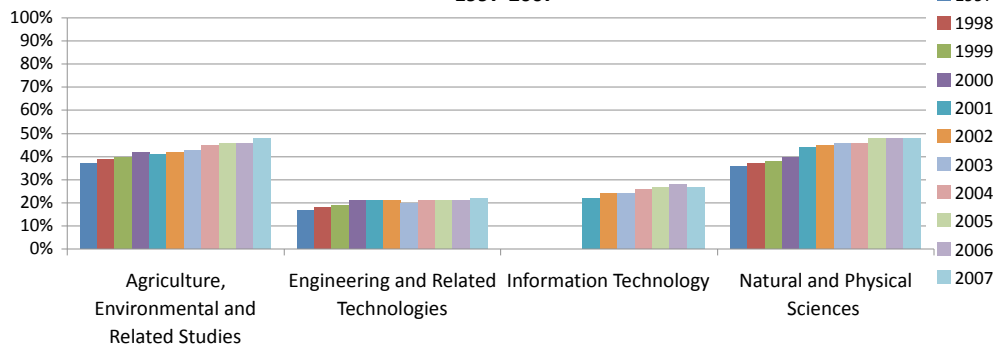
**A3.1 Female Participation in Undergraduate Studies by Broad Field of Study/Education 1997-2007**



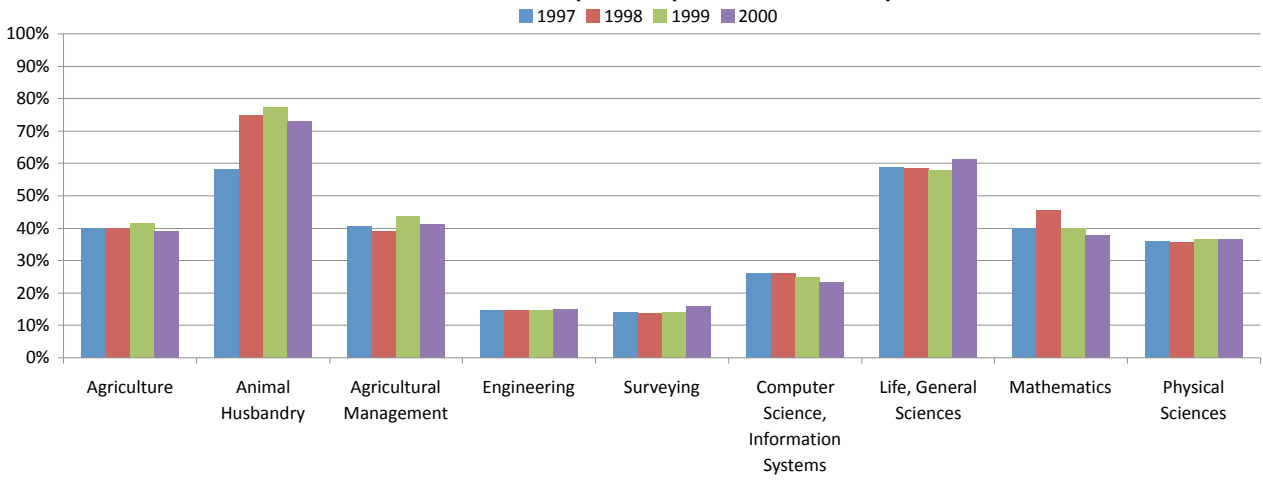
**A3.2 Female Bachelors Honours Completions by Broad Field of Study/Education 1997-2007**

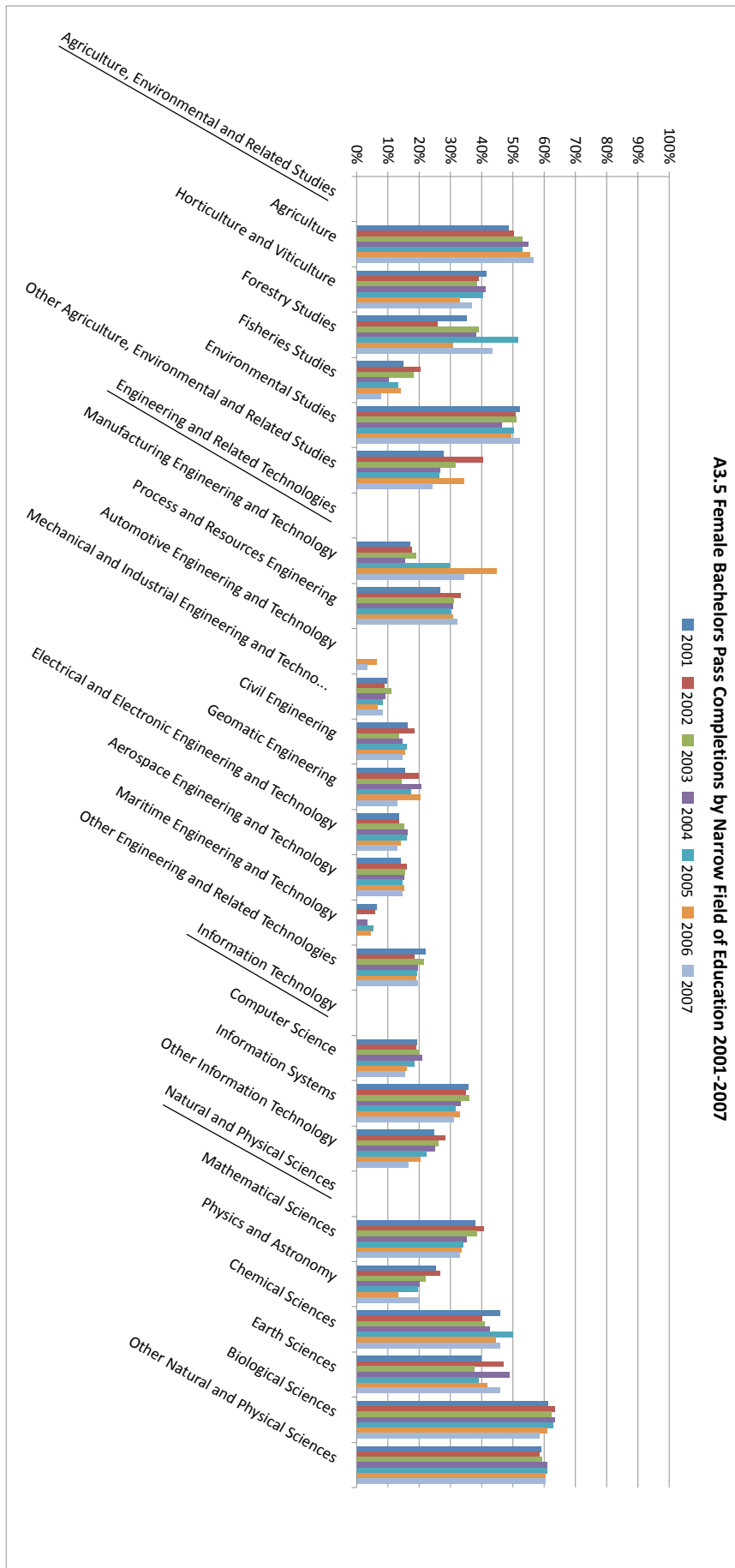


**A3.3 Female Doctorate Research Completions by Broad Field of Study/Education 1997-2007**

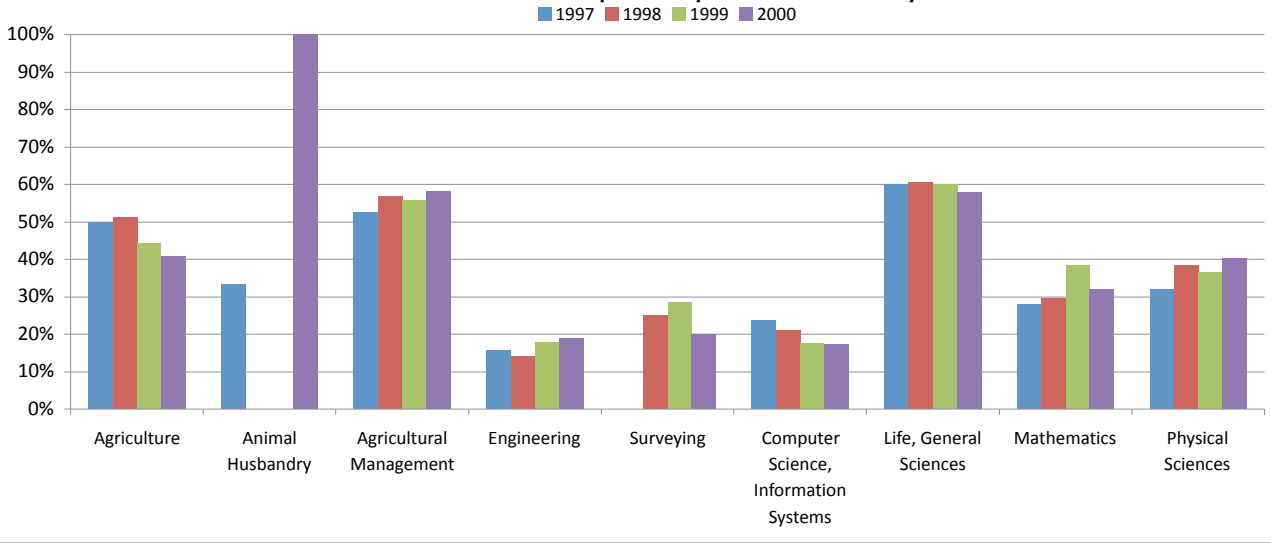


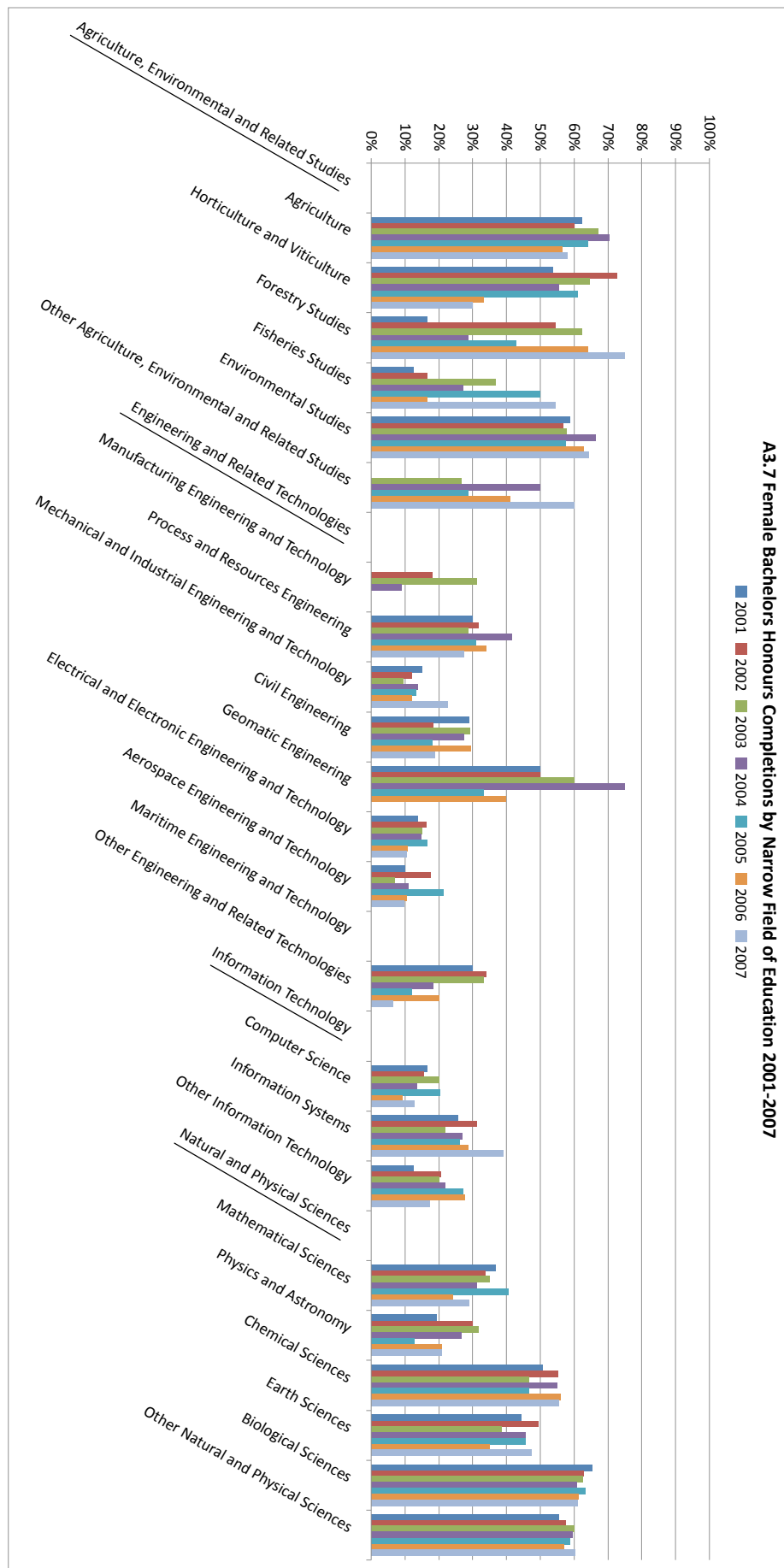
**A3.4 Female Bachelors Pass Completions by Narrow Field of Study 1997-2000**



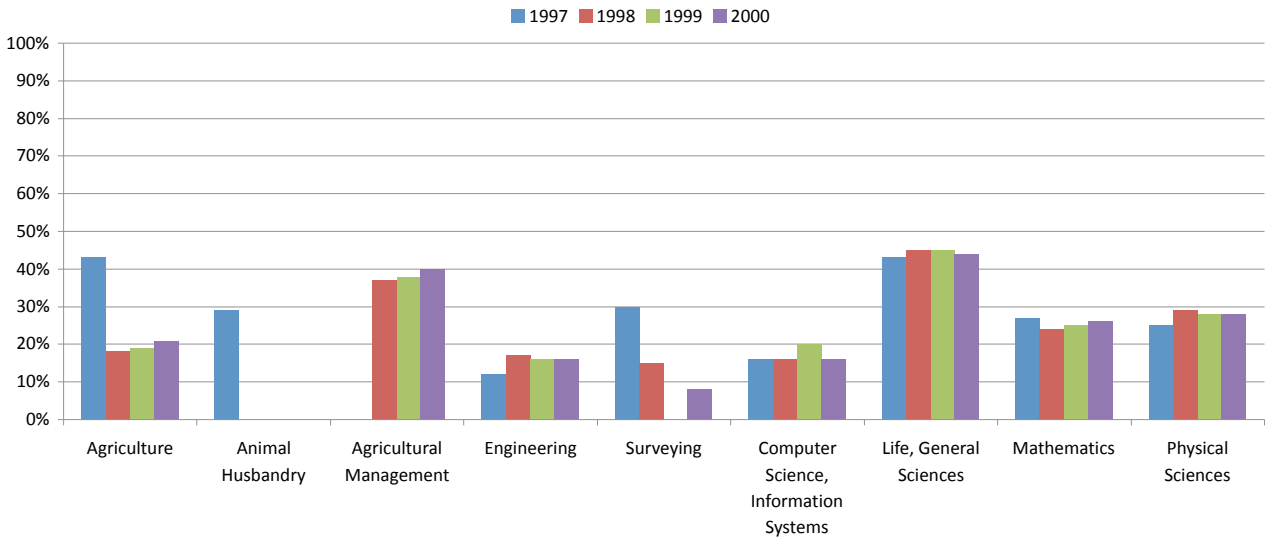


**A3.6 Female Bachelors Honours Completions by Narrow Field of Study 1997-2000**

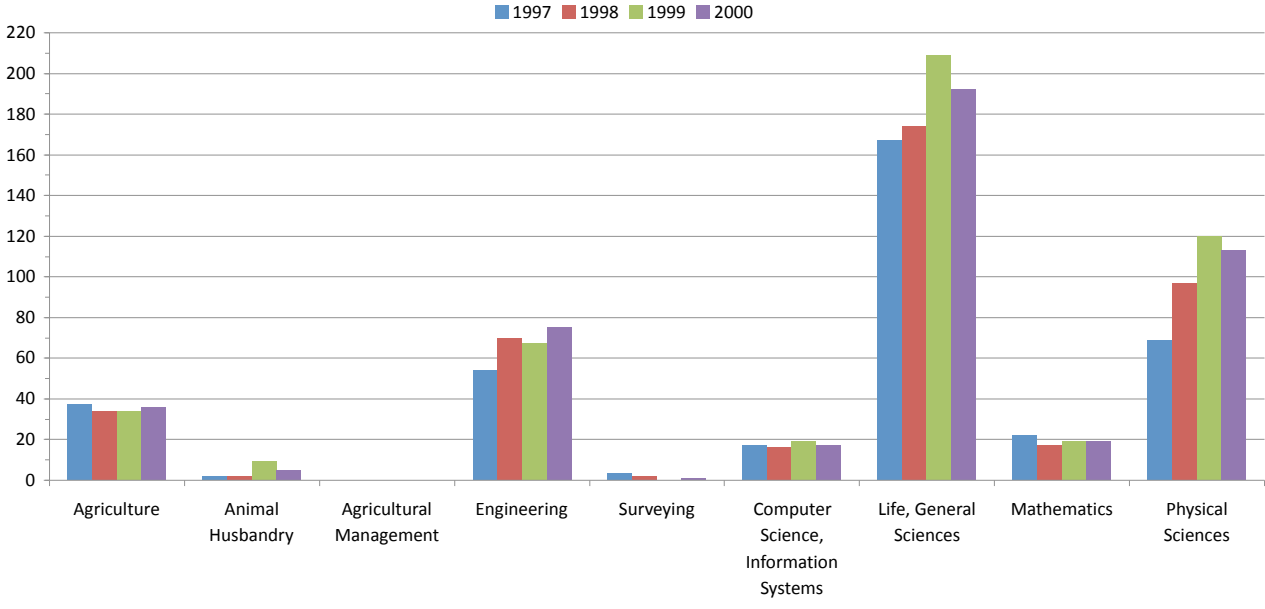




**A3.8 Female Doctorate Research Completions by Narrow Field of Study 1997-2000**

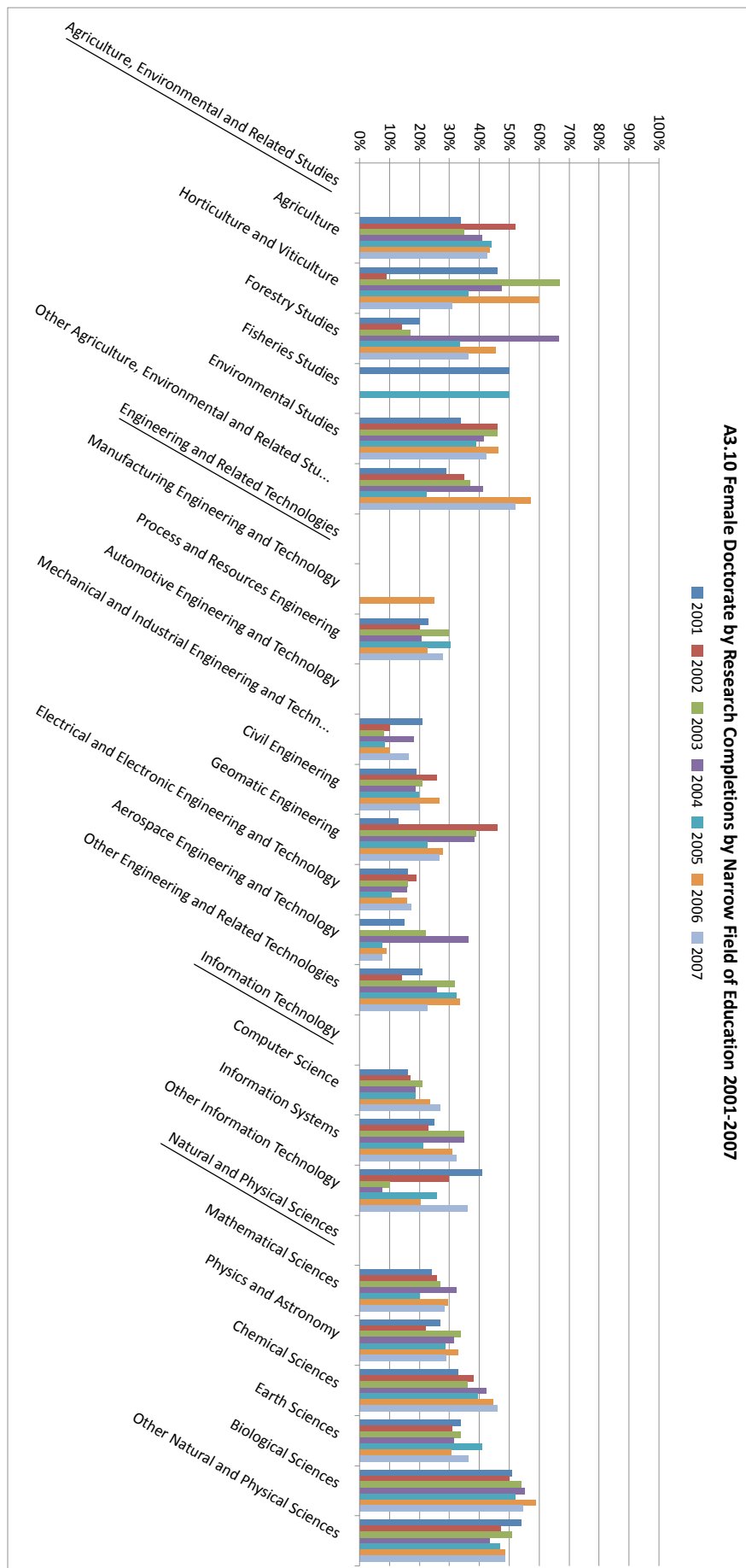


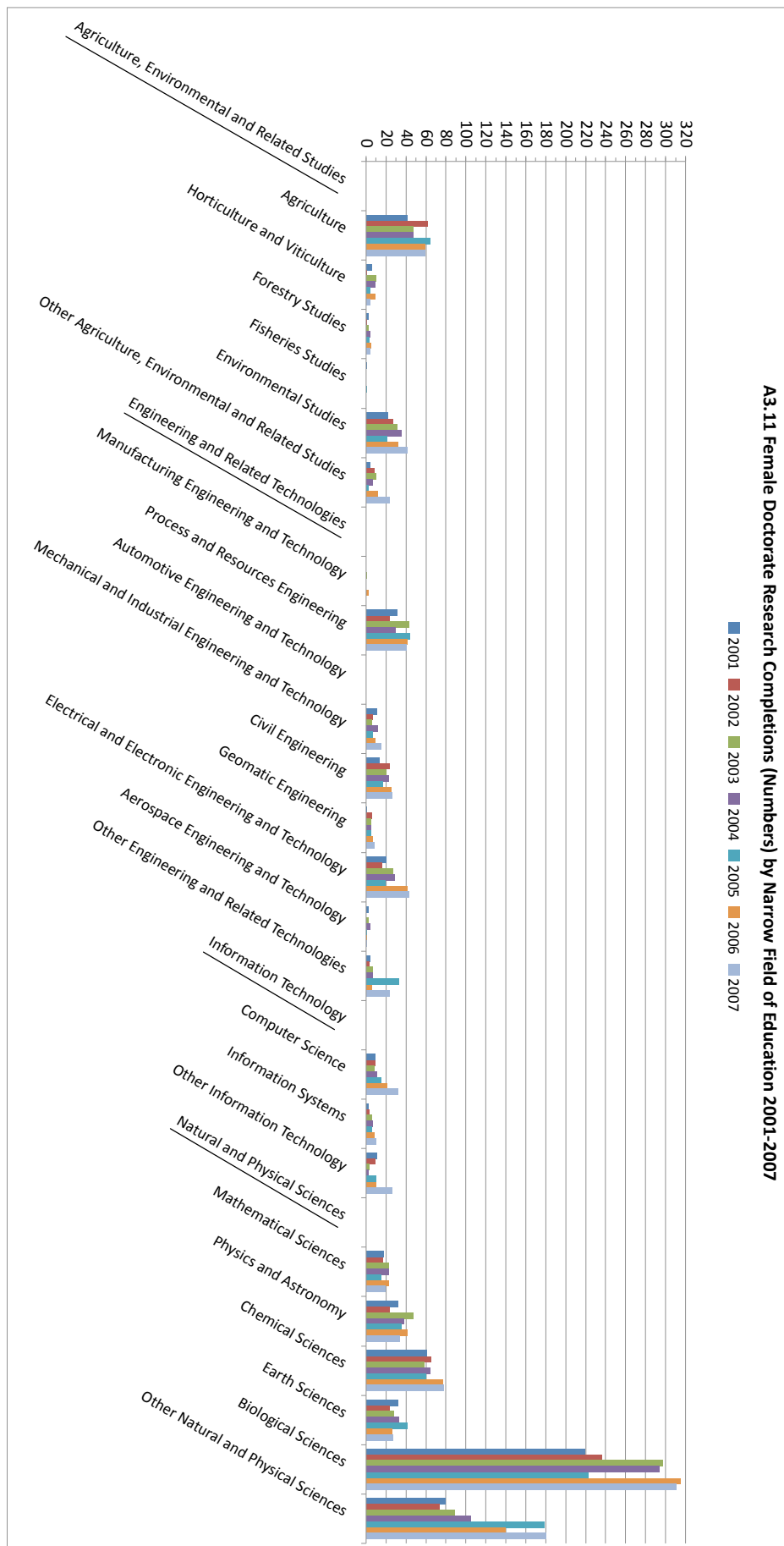
**A3.9 Female Doctorate by Research Completions (Numbers) by Narrow Field of Study 1997-2000**

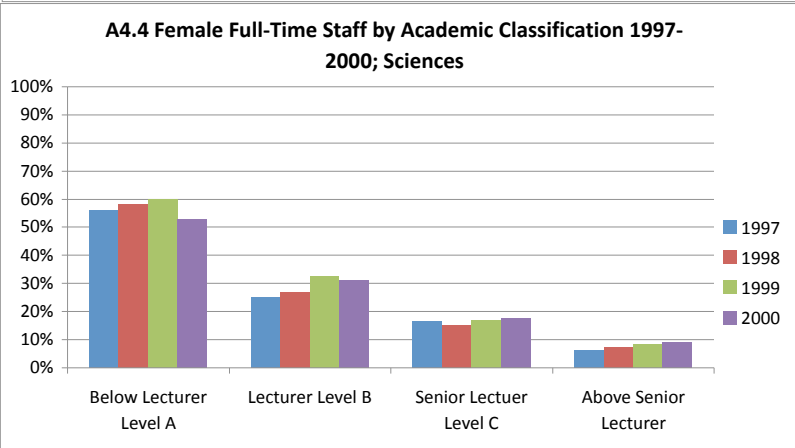
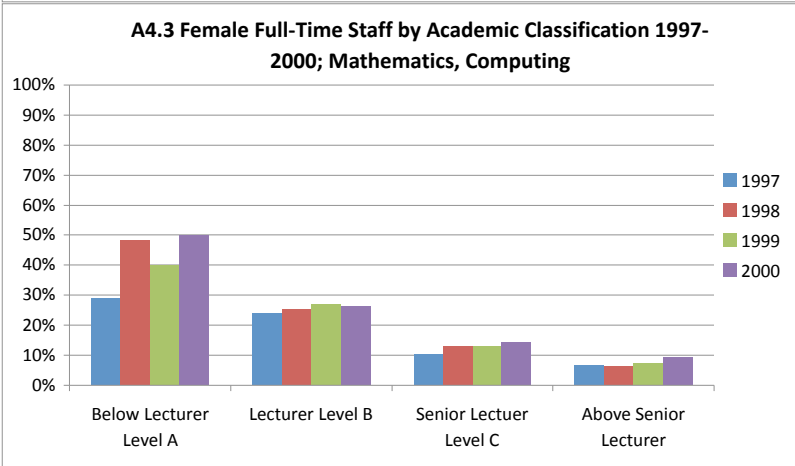
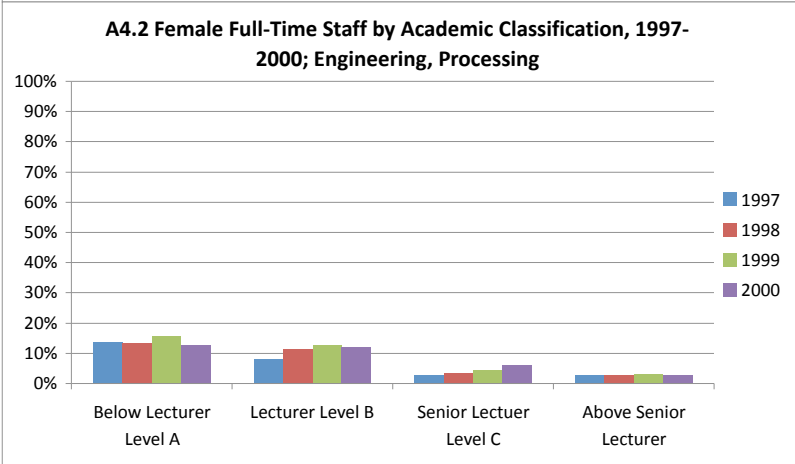
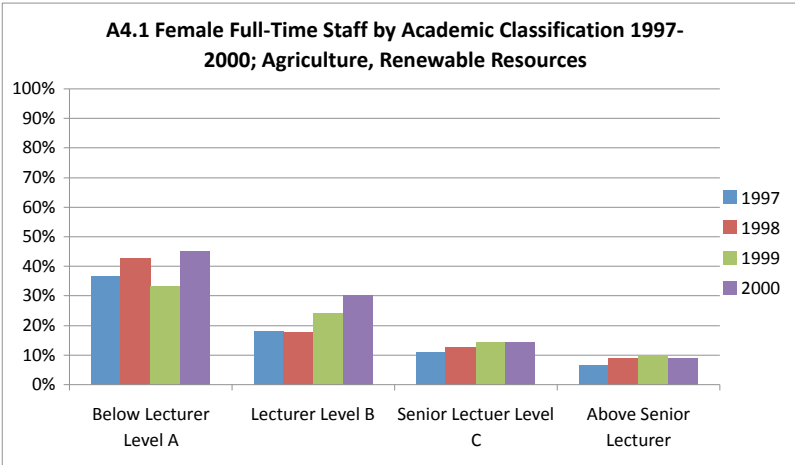


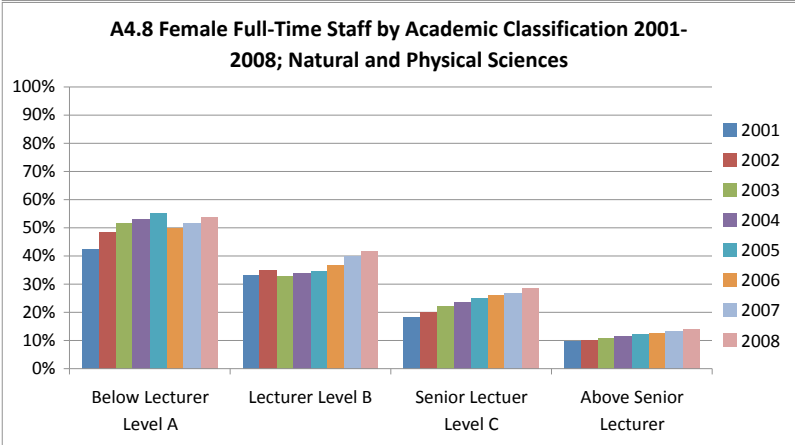
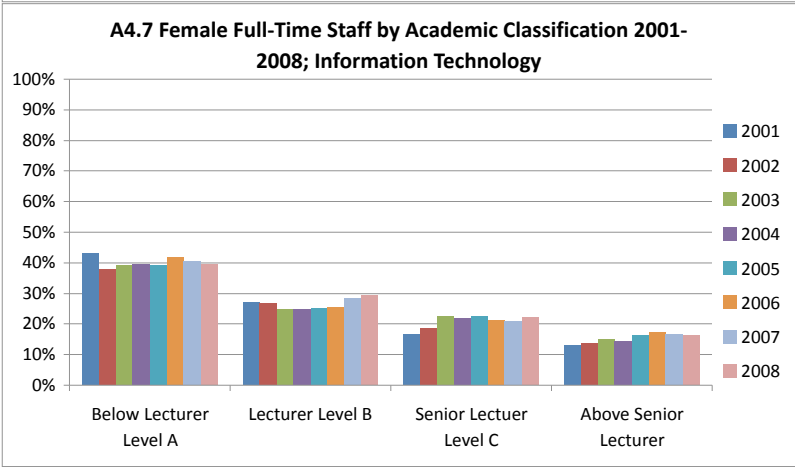
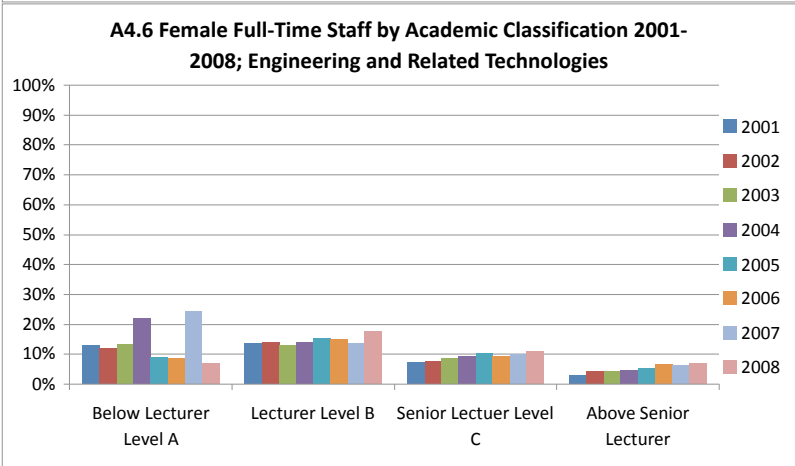
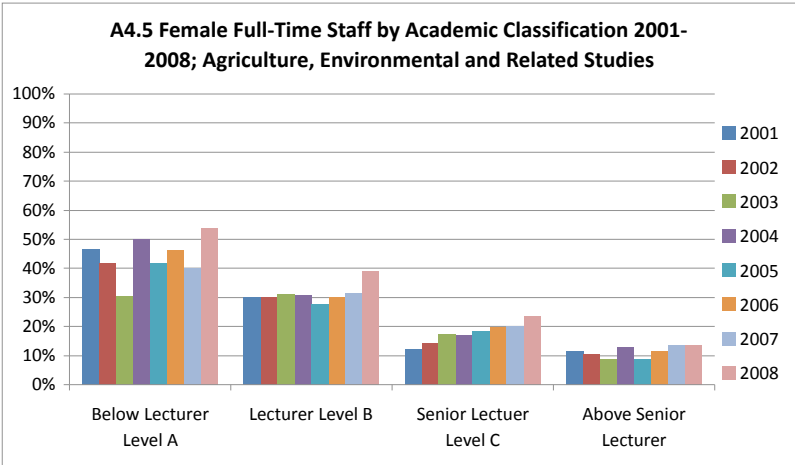


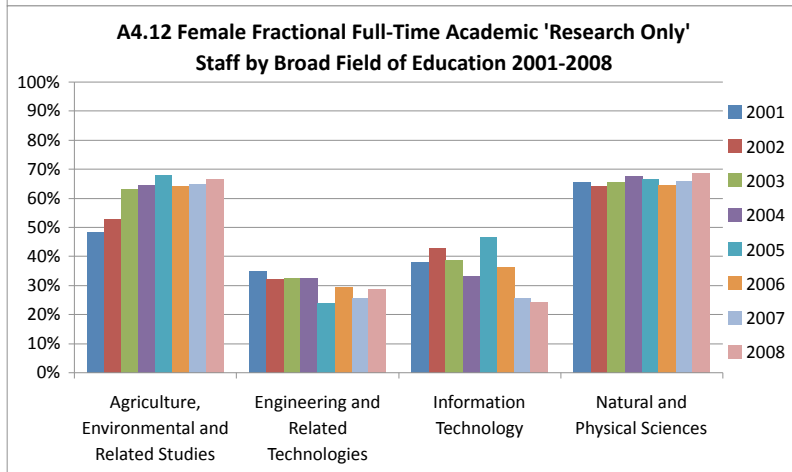
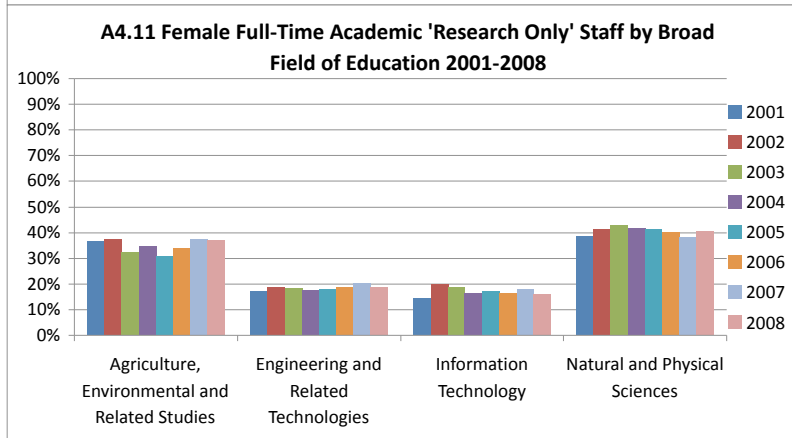
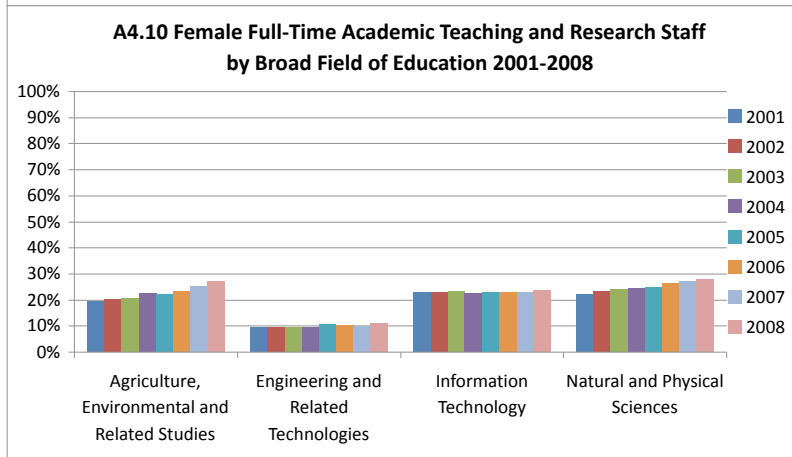
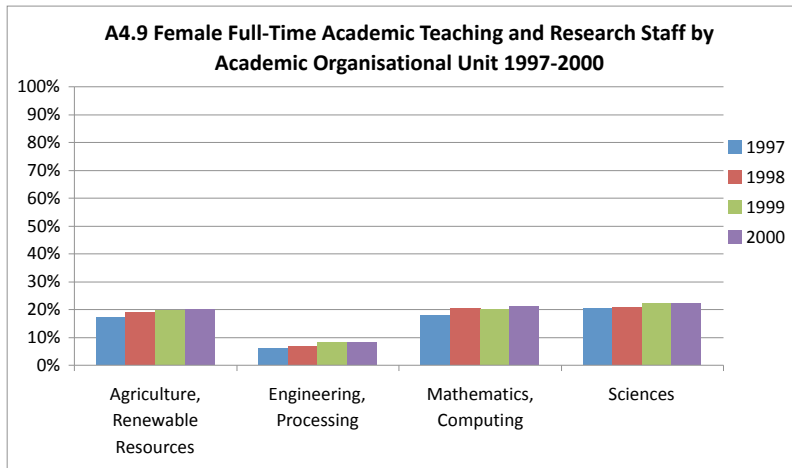
**A3.10 Female Doctorate by Research Completions by Narrow Field of Education 2001-2007**



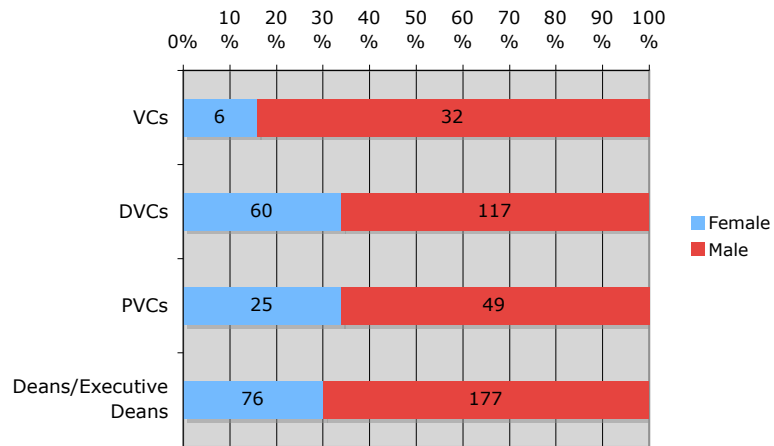




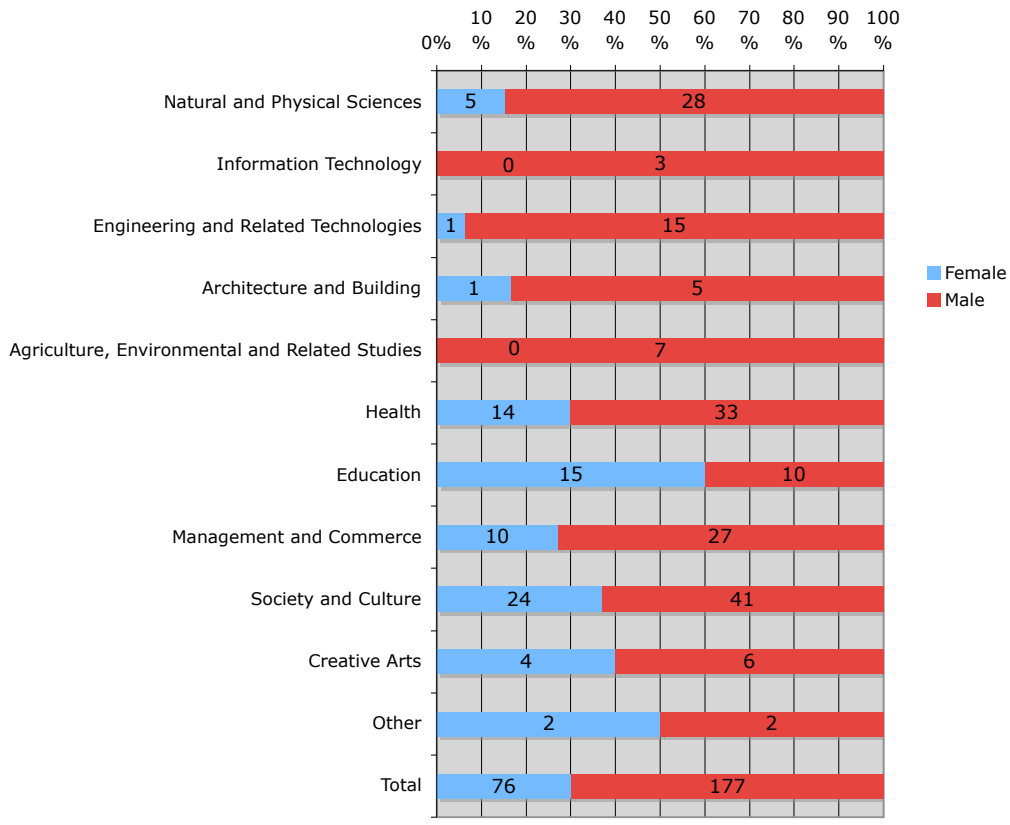


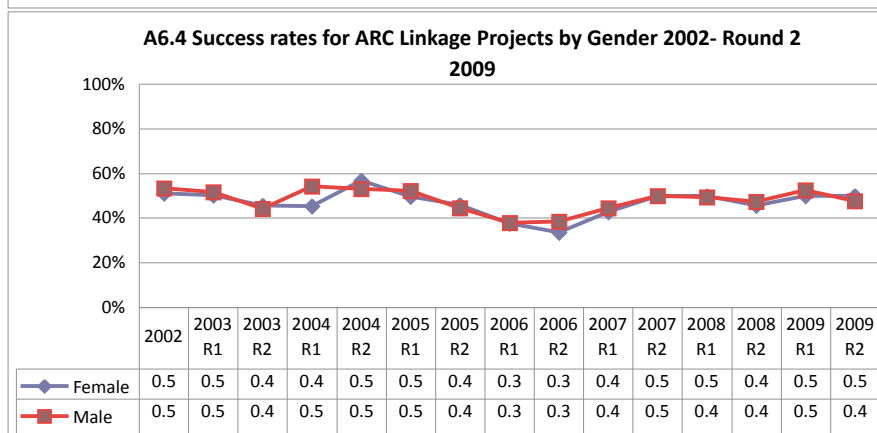
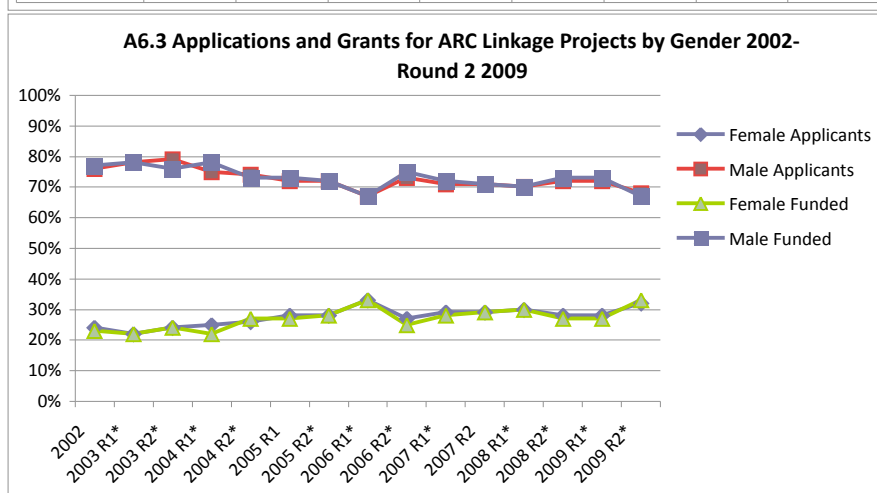
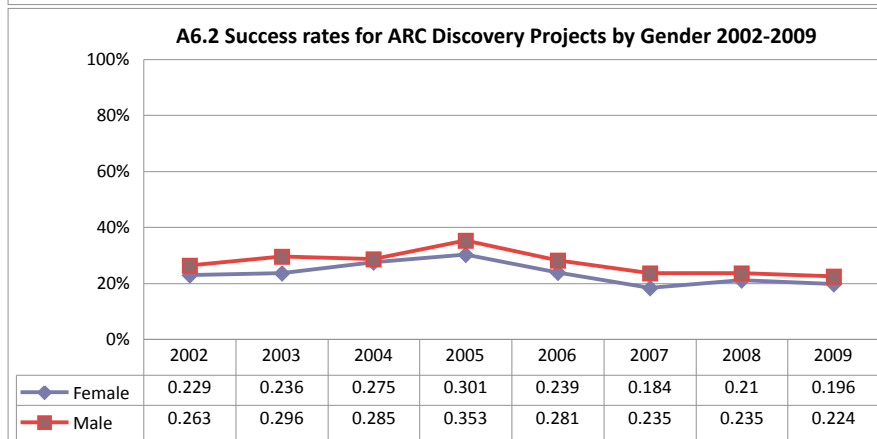
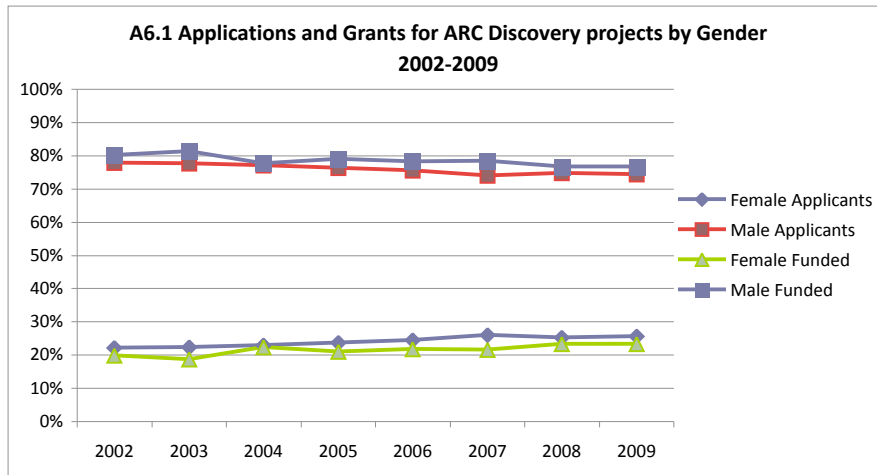


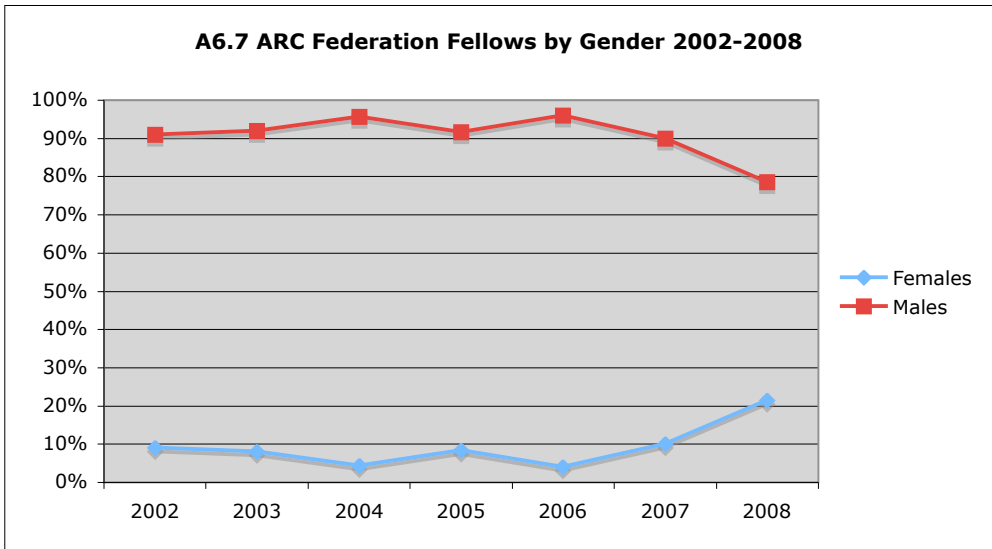
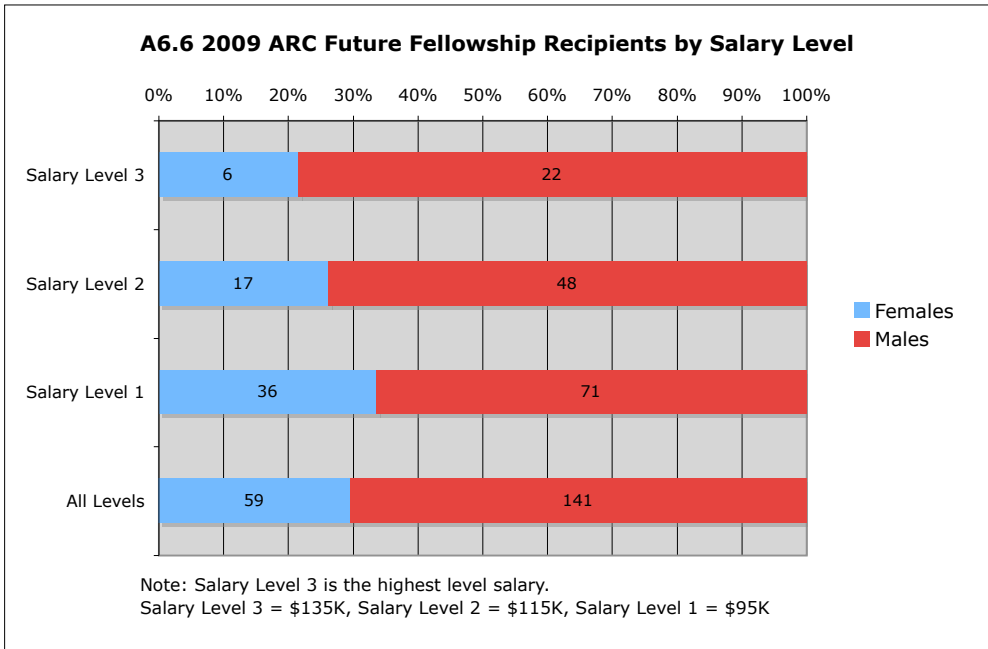
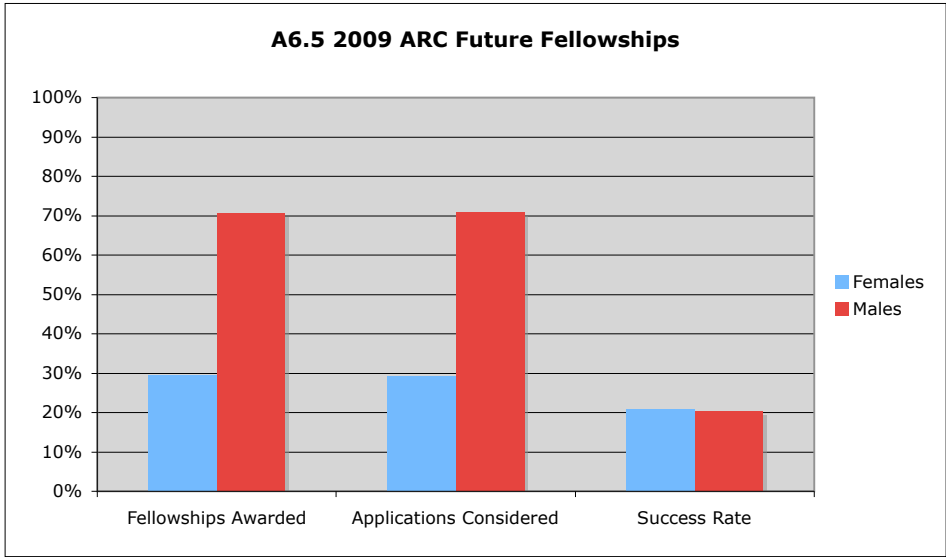
### A5.1 University Leadership Positions by Gender 2009



### A5.2 Deans and Executive Deans by Broad Field of Education 2009

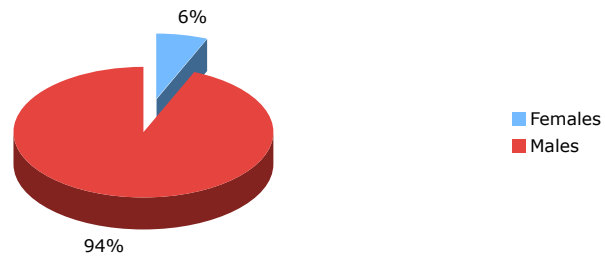




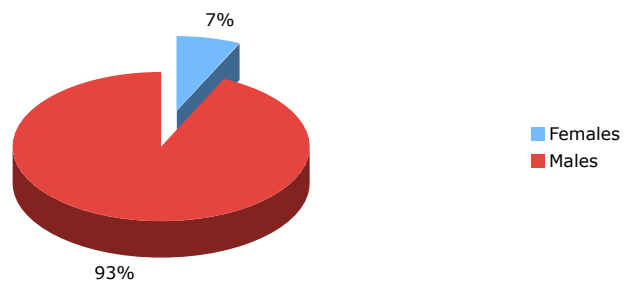




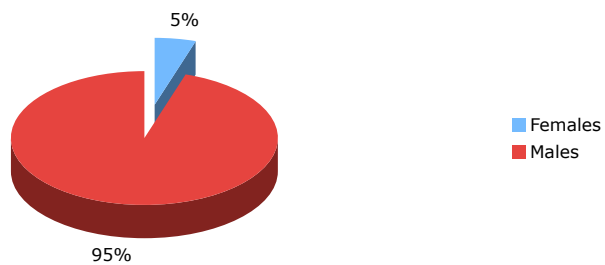
**A7.1 Fellows of the Academy of Science by Gender 2004**



**A7.2 Fellows of the Academy of Science by Gender 2009**



**A7.3 Fellows of the Australian Academy of Technological Sciences and Engineering (ASTE) 2004**



**A7.4 Fellows of the Australian Academy of Technological Sciences and Engineering (ATSE) 2009**

