Female participation in STEM study and work in South Australia 2012

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Abbreviations

ABS	Australian Bureau of Statistics
ANZSCO	Australian and New Zealand Standard Classification of Occupations
DFEEST	Department of Further Education, Employment, Science and Technology
IB	International Baccalaureate
SACE	South Australian Certificate of Education
SACE Stage 2	Equivalent of Australian Secondary School Year 12
SATAC	South Australian Tertiary Admissions Centre
STEM	Science, Technology, Engineering and Mathematics
VET	Vocational Education and Training

Executive Summary

This report provides a comprehensive analysis of female participation rates in science, technology, engineering and mathematics (STEM) fields of learning, undertaken in South Australia.

This report is unique in that it looks across the learning-work continuum from 2008-2011, and provides a detailed analysis of the critical transition points where females are more likely to move away from STEM-related study and/or work[1].

From this perspective, the analysis provides information that can assist policy makers and stakeholders (government, schools and tertiary education providers) to develop targeted strategies that address the participation, retention and success of women in STEM.

At the beginning of the STEM learning-work continuum, females are represented equally alongside males, albeit with a stronger bias toward Allied Health STEM. It is at the first transition point where the interest of female students, as reflected in their university applications, moves away from Prime and Allied Economic STEM, strengthening their bias toward Allied Health STEM.

At university, females maintain their interest in terms of converting their application to an enrolment, and further on to a graduation, where overall, they represent the majority of STEM graduates. Females are more likely to convert their enrolment in Prime STEM to graduation than males.

The point from university to work is however the second problematic transition, where females represent a smaller part of the STEM workforce than proportion of female STEM graduates, a trend that is particularly apparent in Prime STEM occupations.

The findings of this study highlight the importance of transition points and thus timing of interventions along the learning-work continuum. Policy responses can thus be driven by the greater understanding provided through this report.

Section 1: Scope of the Study[2]

The study is a time-based snapshot and draws on data from 2008-2011. The following diagram describes the data types and sources used in the analysis. South Australian Certificate of Education (SACE) Stage 2 data included subject completions with a C-grade or better, as this is the minimum prerequisite for university entrance. The International Baccalaureate (IB) data used includes subjects where a diploma was obtained.

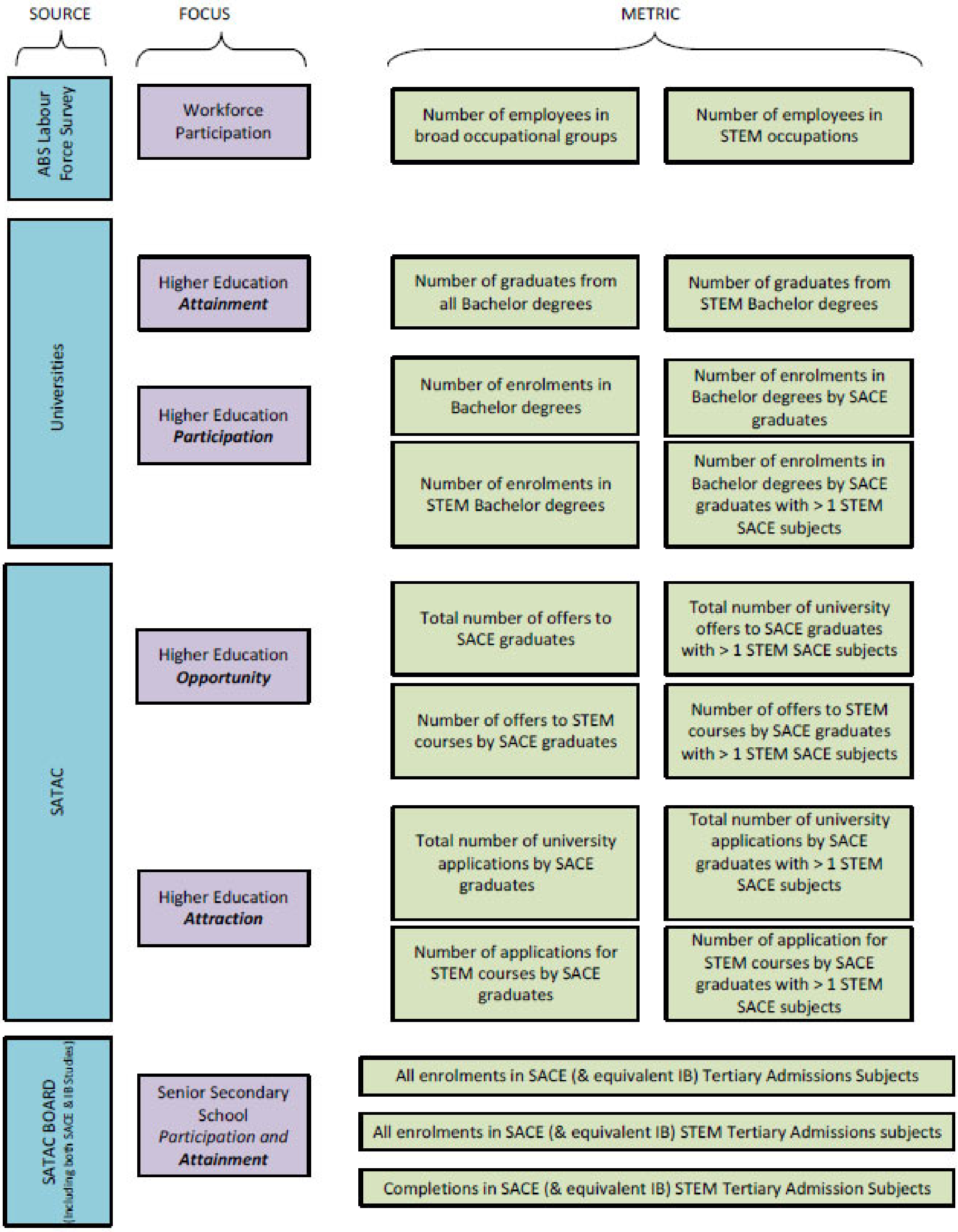

Figure 1: Purpose of data used in this report including types sources

Main Findings

The figure below is a diagrammatic representation of the changing profile of female and male participation as individuals move from senior secondary school, through university, and on to work in STEM-related fields (NB: Classification of school subjects, university fields of education and employment groups into Prime STEM, Allied Economic STEM and Allied Health STEM categories are summarised in Appendix 1.)

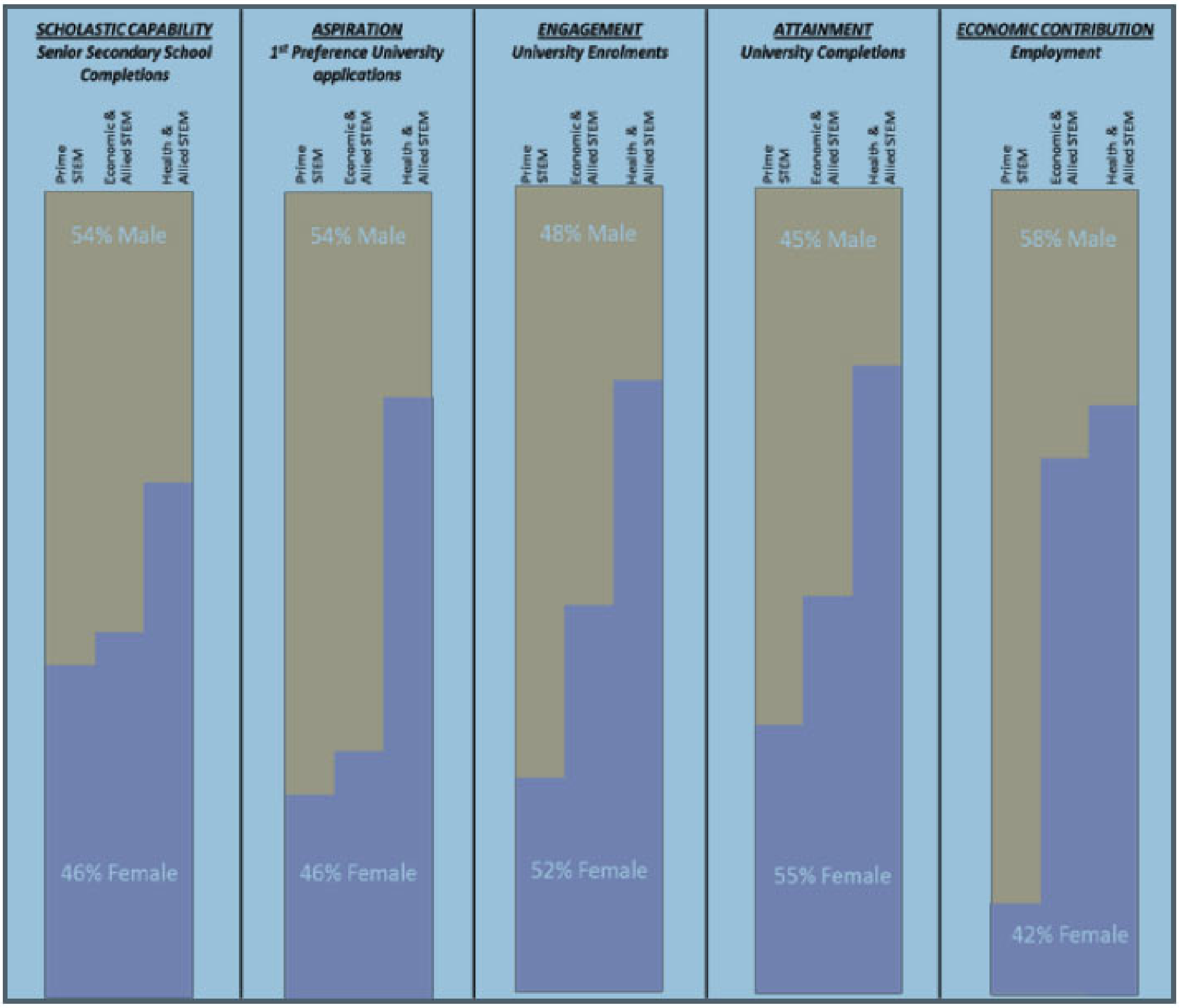

Figure 2: Representation of females in three STEM domains from success (C-grade or higher) at SACE Stage 2 or IB through higher education to workforce participation (aggregated data: 2008-2011)

Females represent nearly half of all STEM SACE Stage 2 or IB subject completions.

As shown in the left hand column, of the 36% of students who successfully completed any STEM subject (Prime, Economic and Allied or Health and Allied) as part of their SACE Stage 2 or IB diploma, just under half (46%) were female. Although the gender balance represented here is equal, even at this early stage, the self-selection of females towards Allied Health STEM studies is evident.

This latter observation becomes more pronounced when considering what students want to study at university and what they subsequently go on to study. This is shown in the second column of Figure 2, where female participation, taken at the broad level, appears to convert into STEM-related applications for university study, but does not hold up when looking at the conversion rates for Prime STEM.

Many females studying Prime STEM in secondary school do not aspire to study Prime STEM at university.

Females comprise 45% of Prime STEM school students compared to 25% of Prime STEM university applicants.

So what appears to be a promising pattern of equal numbers of school-aged males and females going on to enrol in university STEM courses, when more closely analysed, shows that female preferences for STEM degrees trend heavily toward Allied Health STEM, while males incline toward Prime STEM and Allied Economic STEM.

These first two phases of the learning-work continuum emphasise the first major point of difference between males and females – that females aspire to different STEM goals than their male counterparts, and that these aspirations are carried through to actual study in those STEM areas.

Females have a better enrolment to graduate ratio than males in Prime STEM degrees.

For university completions, the study found that almost half of successful bachelor degree graduations are in STEM degrees, which indicates good attainment in overall STEM studies. However, when disaggregated, only 17% of total successful bachelor degrees are in Prime STEM, 13% in Allied Economic STEM and 19% in Allied Health STEM.

In Prime STEM, the proportion of females employed is lower than the proportion of female graduates.

When looking at transitions to work, the study found that 23% of workers in South Australia are employed in STEM occupations, of which 42% are female. In addition to an overall loss of females from the STEM stream between university completion (55%) and employment (42%), the remaining female STEM employment is skewed toward Allied Health STEM fields (73% of workforce, 78% of graduates) and Allied Economic STEM fields (67% of workforce, 50% of graduates). Male employment is correspondingly skewed towards Prime STEM fields (88% of workforce, 67% of graduates).

Despite the fact that females comprise over half of completions for overall STEM university study, only 42% of workers in STEM occupations in South Australia are female, a figure that is significantly lower for Prime STEM (12%). Deeper analysis of the relative impact of various influences on this trend is required, from which the most effective policy opportunities may be identified.

Policy Implications

To address STEM skills needs, the South Australian Government has implemented a range of initiatives through its *STEM Skills Strategy*. While much of this work targets the 'supply chain' of skills, future policy will need to consider demand-driven factors to make study, training and careers in STEM more attractive. This work has already commenced for women through the *Government's Women at Work Strategy*, which focuses specifically on encouraging women to access training in high-demand, non-traditional industries such as mining, defence and construction. The findings of this report confirm the appropriateness of both of these initiatives.

An important theme that has been raised in the broader literature on women in STEM is the need to widen the pool of women who can potentially step onto the STEM learning-work continuum. One of the opportunities identified is the need to widen the focus from the school-university pathway to include pathways from VET to university through supported STEM pathways for women. Females comprised up to 30% of Prime STEM and Allied Economic STEM VET completions between 2002 and 2010 in South Australia however, as observed anecdotally, the attrition rate of both genders from VET STEM studies is unusually high leading to a small overall pool of graduates. The reverse was true for Allied Health STEM VET completions where females were the dominant group.[3]

The provision of practical support and other incentives for women in STEM is also an important priority. In 2011, the South Australian Government provided professional development scholarships, each valued at $15,000, to a number of female STEM researchers in the early stage of their careers. A further 75 scholarships, each valued at $5,000, are provided on an annual basis for students to undertake full time defence related Honours qualifications at South Australian institutions. The uptake of these scholarships by females is being monitored to identify further actions that could be taken to encourage female students.

However, one of the most crucial interventions is to have strong advocacy and leadership that can take responsibility for advancing the women in STEM agenda on a state-wide basis. A number of recommendations were agreed at the *Women in Science Symposium*, and have been referred to the State's Chief Scientist, the *Premier's Science and Industry Council*, and the *Premier's Council for Women* for further consideration.

These recommendations include:

- Securing a pool of women who can and are willing to act as champions for attracting more women into STEM areas of study and work
- Establishing a network of women leaders to advance the women in STEM agenda at the state level and to provide advice on any further action in this area
- Identifying incentives for change including mechanisms that will allow more women to continue or return to STEM study and from there into work in STEM related industries
- Compiling an inventory of current initiatives and programs currently available for supporting women working in STEM related areas.

Addressing the issue of women's low participation in STEM is not the responsibility of government alone. All parties, including government, schools, tertiary education providers and industry need to join forces and work together to identify opportunities and examples of good practice that can be maximised to benefit women and ultimately the state.

Background

Female participation and retention in STEM fields of learning and work is a longstanding national and international issue. However, unlike many other countries, which over the last few years have launched major initiatives to retain and promote females in STEM[4] the issue in Australia has, until very recently, fallen off both the equity and productivity agendas[5].

The need to revisit female participation in STEM is being driven from a larger concern about Australia's low productivity and key skill shortages that are putting the country's innovation and economic competitiveness at risk[6]. The gender dimension to this looming problem is a simple one. At a time when industry is demanding STEM professionals (engineers, physicists, technologists)[7] to support the resources and mining boom and to re-build Australia's manufacturing sector, we cannot afford to be turning away half of the potential workforce, especially in an environment where there is already a chronic shortage of STEM skilled graduates.

Although this argument is in itself a straightforward one, the gender-STEM issue is complex. Australian science is reported to be in good shape with more females studying science at university than males[8]. There have also been significant advances in female participation in STEM at the secondary school level, which demonstrates that systematic change at that level, and in many STEM disciplines at the undergraduate level, can and is being achieved. Set alongside these improvements, however, is a lack of women in senior STEM positions both in academia[9] and in industry[10]. Putting these observations together it might be assumed it is just a matter of time before the top end of the pipeline fills out.

However to make this assumption is to both miss and misunderstand the complexities of the problem. First, the pipeline is not filling out evenly across the STEM spectrum of learning areas and, second, female representation in post-educational Prime STEM employment is low. This is most obvious in key STEM areas such as engineering and technology, which are direct pathways to high-level, high skilled jobs that Australia needs to sustain its future prosperity.

The situation in engineering illustrates the problem. Despite an almost 2% increase in female participation in the engineering workforce since 2006, only 22% of that workforce is currently female[11], while the unemployment rate for female professional engineers is twice as high as it is for male engineers[12]. The combination of this data suggests study-to-workforce transitional difficulties are being experienced by female engineering graduates.

This low participation of highly trained females is economically damaging to our state and to our country. The comparatively high unemployment rate of female engineers is inefficient in terms of investment in education and training and suggests a lack of diversity in the workforce. Nearly 25% of female scientists and engineers surveyed in 2009-2012 expected to have left their profession in five years' time while almost 70% expected their career progression to be significantly impaired by taking parental leave[13].

When women leave the workforce or are employed in positions below their skill set, hundreds of thousands of dollars of investment in their education and training goes with them or is underutilised. Women have the potential to deliver 50% of our country and state's future workforce needs, and thus supporting and retaining them along the STEM learning-work continuum, should be a policy priority.

The future of South Australia is reliant on the defence, minerals and resources sectors, agriculture, and advanced manufacturing industries, all of which are embedded in strong education, training and career development in STEM. Women have the potential to contribute substantially to these industries, not just in numbers, but in highly specialised skills, knowledge and experience. Retaining females already in the learning-work continuum is therefore a priority for this state as is the goal of attracting more into the system. Such outcomes require strategic intervention and the implementation of practical solutions that are based on sound, reliable data. This report provides the evidence on which South Australia can build those interventions.

Section 2: School to University - University Readiness

In the early nineties, 90% of students in Year 12 studied science. In 2010 that figure had been reduced to half of the Year 12 cohort (51%)[14]. There is no doubt that fewer students are studying science than ever before. It has also been a long standing view that STEM curriculum needs to meet the needs of students who will become scientists and engineers or be involved in science-related professions. This does not discount the need for scientific literacy as a life skill, but it does re-direct attention to the broader issues around Australia's future economic prosperity.

The current study found that 36% of SACE Stage 2 subjects completed (C-grade or higher) and IB subjects (diploma obtained) were related to STEM, of which 48% were female students. In this respect, females are holding their own albeit in a much reduced pool of students, which can be seen by comparing this recent data by subject with student data in the early nineties provided by the *Australian Academy of Science*. The study also found that the proportion of SACE Stage 2 completions (C-grade or higher), and IB completions (diplomas obtained) as a proportion of IB subject registrations, were both higher for females than they were for males, illustrating that females are performing well.

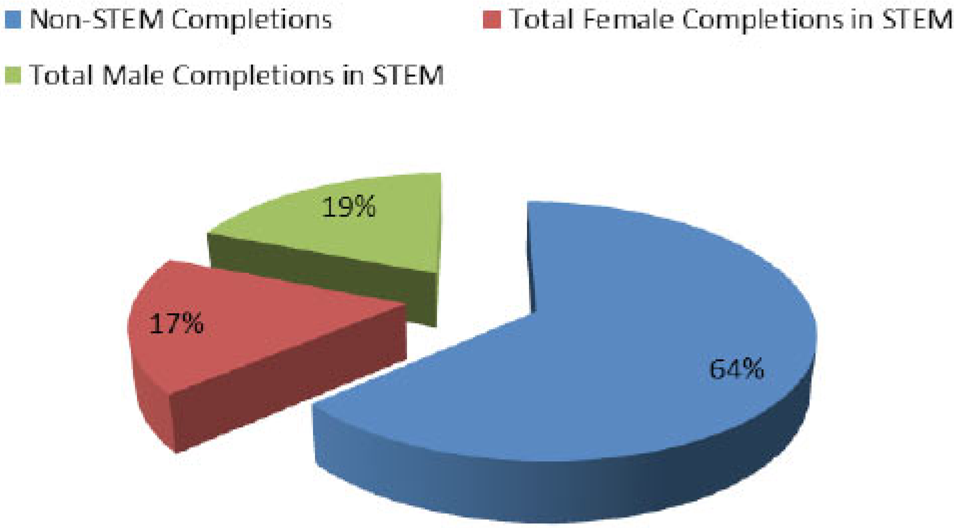

Figure 3: SACE Stage 2 and IB students completing STEM subjects (aggregated data: 2008-2010)

Within the cohorts of males and females successfully undertaking STEM subjects at SACE Stage 2, females were approximately twice as likely to engage in Allied Health STEM subjects as are males. Interestingly, the percentage of male and females who studied Allied Economic STEM subjects were almost identical, meaning that the excess of female students in Allied Health STEM subjects is exclusively to the detriment of the pool of females studying Prime STEM subjects.

These observations confirm a trend of the last two decades, which has seen significant increases in female participation in STEM at the senior levels of school. It also gives credit to previous equity policies aimed at encouraging girls to study science and to pursue careers in non-traditional fields[15]. However, as noted by Sharon Bell, it is also an outcome that has in recent times found expression in newer equity policy that gives prominence to the differential achievements of boys in education on the basis that boys appear to be failing[16]. The effect of this has been a shift away from female participation in STEM as an equity issues, to a broader economic argument.

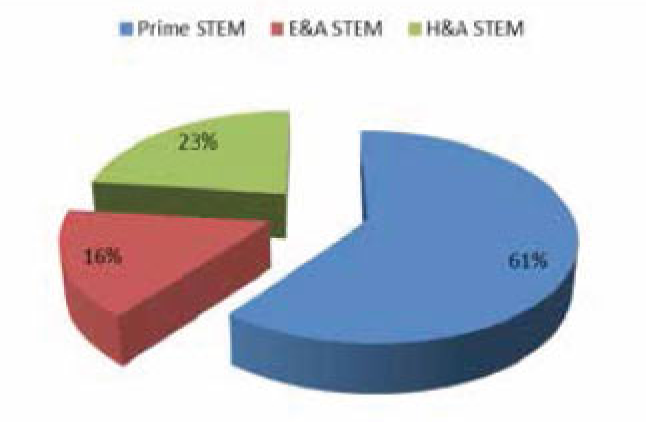

Figure 4: Female STEM Completions at SACE/IB

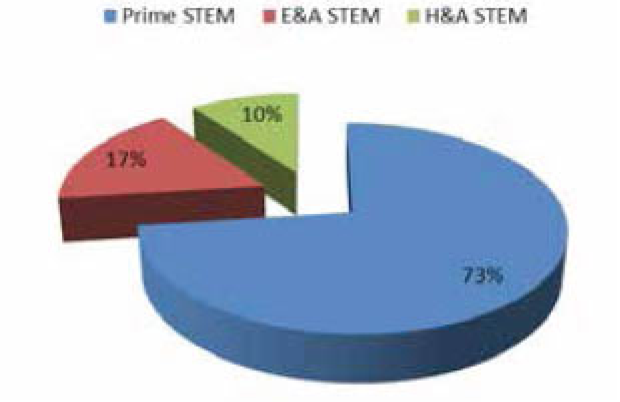

Figure 5: Male STEM Competions at SACE/IB

School to University – Female Aspirations

Moving along the learning-work continuum, the study examined the transition from high school to university, and noted that there was a significant decline in female participation in STEM study at this transition point.

The main observations included:

- Female students who studied at least one SACE Stage 2 or IB STEM subject accounted for 53% of university applicants to STEM courses
- The likelihood of a student making a first preference application for a STEM university course was lower for females than for males
- 10% of female university applicants that studied at least one SACE Stage 2 or IB STEM subject made a first preference application for a STEM university course (36% for males)
- 22% of female university applicants that studied at least two SACE Stage 2 or IB STEM subjects made a first preference application for a STEM university course (52% for males)
- 33% of female university applicants that studied at least three SACE Stage 2 or IB STEM subjects made a first preference application for a STEM university course (66% for males).

The study finds a strong correlation between the number of SACE Stage 2 and IB STEM subjects studied, and first preference applications to STEM university study. This is consistent with the findings of a longitudinal study undertaken at the University of Southern Queensland which indicated that students are more likely to be successful in their first year engineering studies if, in addition to Mathematics B, they studied two or more STEM subjects (Physics, Chemistry, Mathematics C, and Information Processing and Technology) while at school[17].

Female aspiration to study at university in any field of study is clearly not an issue as they represent 58% of all applicants. It is equally clear that successful completion of at least one SACE Stage 2 or IB STEM subject is a major indicator for student university aspirations in general.

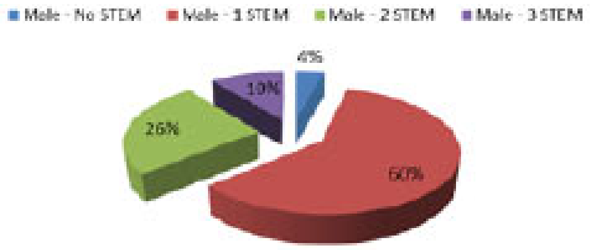

Figure 6:Male Applications to University by STEM Experience (aggregated: 2008-2010)

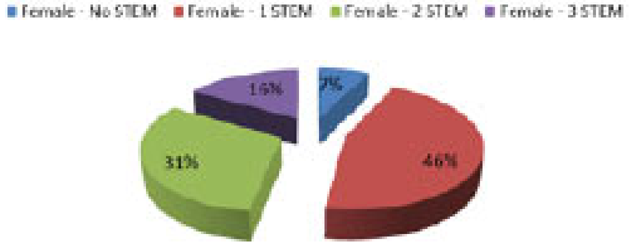

Figure 7: Female Applications to University by STEM Experience (aggregated:2008-2010)

University Attainment – Enrolments and Completions

Prime STEM accounts for around 20% of total university enrolments, while the broader definition of STEM represents almost half of total enrolments. Despite female students accounting for more than half of university enrolments, they only represent around 25% of enrolments in Prime STEM university courses.

The female share of university enrolments for all STEM courses is just over half, which is an improvement on Prime STEM figures but still below the female share of total university enrolments.

Specific results from the study for enrolments showed:

- From 2009-2011, 17% of university enrolments were for Prime STEM Bachelor level studies. Female students accounted for 27% of these Prime STEM university enrolments despite representing 58% of total enrolments
- From 2009-2011, 8.8% of university enrolments were for Allied Economic STEM bachelor studies. Female students accounted for 48% of these Allied Economic STEM university enrolments (still below the female share of total enrolments)
- From 2009-2011, 19% of university enrolments were for Allied Health STEM bachelor studies. Female students accounted for 76% of these Allied Health STEM university enrolments (well above the female share of total enrolments)
- From 2009-2011, 45% of university enrolments were for STEM bachelor studies (all definitions). Female students accounted for 52% of these STEM university enrolments (below the female share of total enrolments).

The success of tertiary students can be measured by the conversion from enrolments to completions. The completion to enrolment ratios for students engaged in university study related to STEM is higher than their non-STEM peers. Furthermore, these ratios are higher for females studying STEM university courses than they are for males.

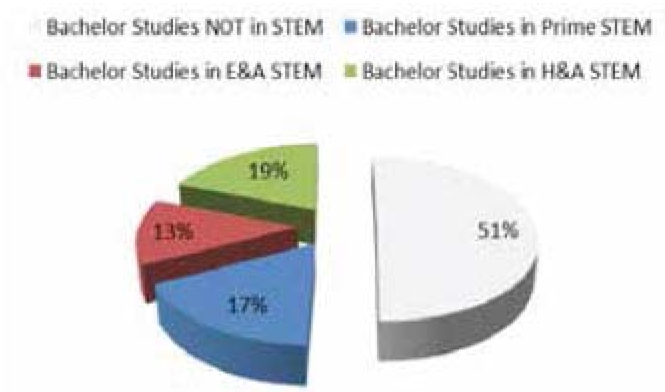

Figure 8: University Undergraduate Completions

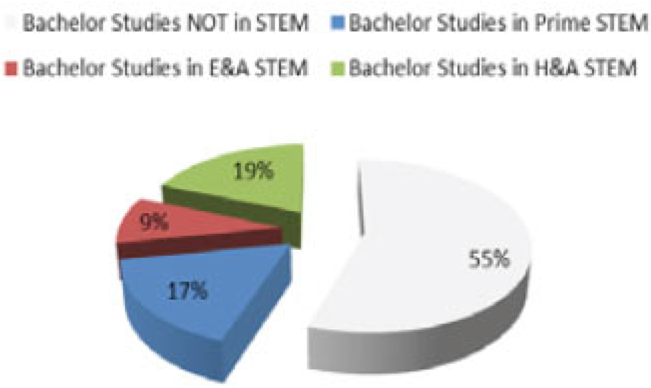

Figure 9: University Undergraduate Enrolments

Specific results from the study for completions showed:

- From 2009-2010, the completion to enrolment ratio was 22% for Prime STEM bachelor studies, which is higher than their non-STEM peers (20%). The completion to enrolment ratio was 27% for female students engaged in Prime STEM bachelor studies, higher than the ratio for all female students (22%) and for male students engaged in Prime STEM bachelor studies (21%)
- From 2009-2010, the completion to enrolment ratio was 26% for Allied Economic STEM bachelor studies, which is higher than their non-STEM peers (20%). The completion to enrolment ratio was 30% for female students engaged in Allied Economic STEM bachelor studies, higher than the ratio for all female students (22%) and for male students engaged in Allied Economic STEM bachelor studies (24%)
- From 2009-2010, the completion to enrolment ratio was 22% for Allied Health STEM bachelor studies, which is higher than their non-STEM peers (20%). The completion to enrolment ratio was 23% for female students engaged in Allied Health STEM bachelor studies, slightly higher than the ratio for all female students (22%) and for male students engaged in Allied Health STEM bachelor studies (20%)
- From 2009-2010, the completion to enrolment ratio was 24% for STEM bachelor studies (all definitions), which is higher than their non- STEM peers (20%). The completion to enrolment ratio was 25% for female students engaged in STEM bachelor studies, slightly higher than the ratio for all female students (22%) and for male students engaged in STEM bachelor studies (23%).

Prime STEM accounts for about a fifth of total university completions, while the broader definition of STEM represents half of the total. Despite female students accounting for 60% of university completions, they represent only a third of completions in Prime STEM university courses. The female share of university completions for courses related to the broader definition of STEM is just over half, which is an improvement on Prime STEM figures, but still below the female share of total university completions.

Other results from the study for completions included:

- From 2008-2010, 17% of university completions were for Prime STEM bachelor studies. Female students accounted for 33% of these prime STEM university completions despite representing 60% of total completions
- From 2008-2010, 13% of university completions were for Allied Economic STEM bachelor studies. Female students accounted for 50% of these Allied Economic STEM university completions (still below the female share of total completions)
- From 2008-2010, 19% of university completions were for Allied Health STEM bachelor studies. Female students accounted for 78% of these Allied Health STEM university completions (well above the female share of total completions)

- From 2008-2010, 50% of university completions were for STEM bachelor studies (all definitions). Female students accounted for 55% of these STEM university completions (below the female share of total completions).

University to Work – Women's Transition to the STEM Workforce

As shown in the Figure 8, 23% of workers in South Australia are employed in STEM occupations and of these 42% are female, the bulk of whom are employed in the Health and Allied Occupations[18]. 11% of the STEM workforce is Prime STEM, of which 12% are women.

Many of the barriers to women's participation in STEM occupations are well known, and many industry groups are now implementing proactive strategies to address the situation[19]. The Prime Minister, Julia Gillard, has lent support to these efforts by calling for an increase in the number of females in the resource and construction industries with a target of 7% by 2020[20]. In addition, the Federal Government recently established a *Parliamentary Friends of Women in Science, Maths and Engineering Group*, to shine a spotlight on existing opportunities for women in STEM industries and how these opportunities can be boosted to help Australia achieve its full potential.

The Group will also help promote careers in science, celebrate the achievements of women in industry, foster relationships between industry and political representatives and consider other barriers to participation.

With regard to South Australia's key STEM industries, the most recent analysis of women's participation was undertaken by the *Resources and Engineering Skills Alliance (RESA)*[21]. The findings of this particular report provide additional cause for concern as it highlights the vulnerability of South Australia's labour market in meeting the skill needs of the sector, now and into the future. As pointed out in the report, while the ratio of male to female employment in the mining industry has increased significantly over the last two decades, the main beneficiaries of this growth are Western Australian, New South Wales and Queensland which collectively account for 85% of the total female employment in this sector. This is not good news, as these states are South Australia's major competitors for skilled labour and for as long as tight labour market conditions remain, *'South Australia will need to work hard if it is to maintain the momentum of increasing female participation. This is the challenge facing industry in South Australia'*[22].

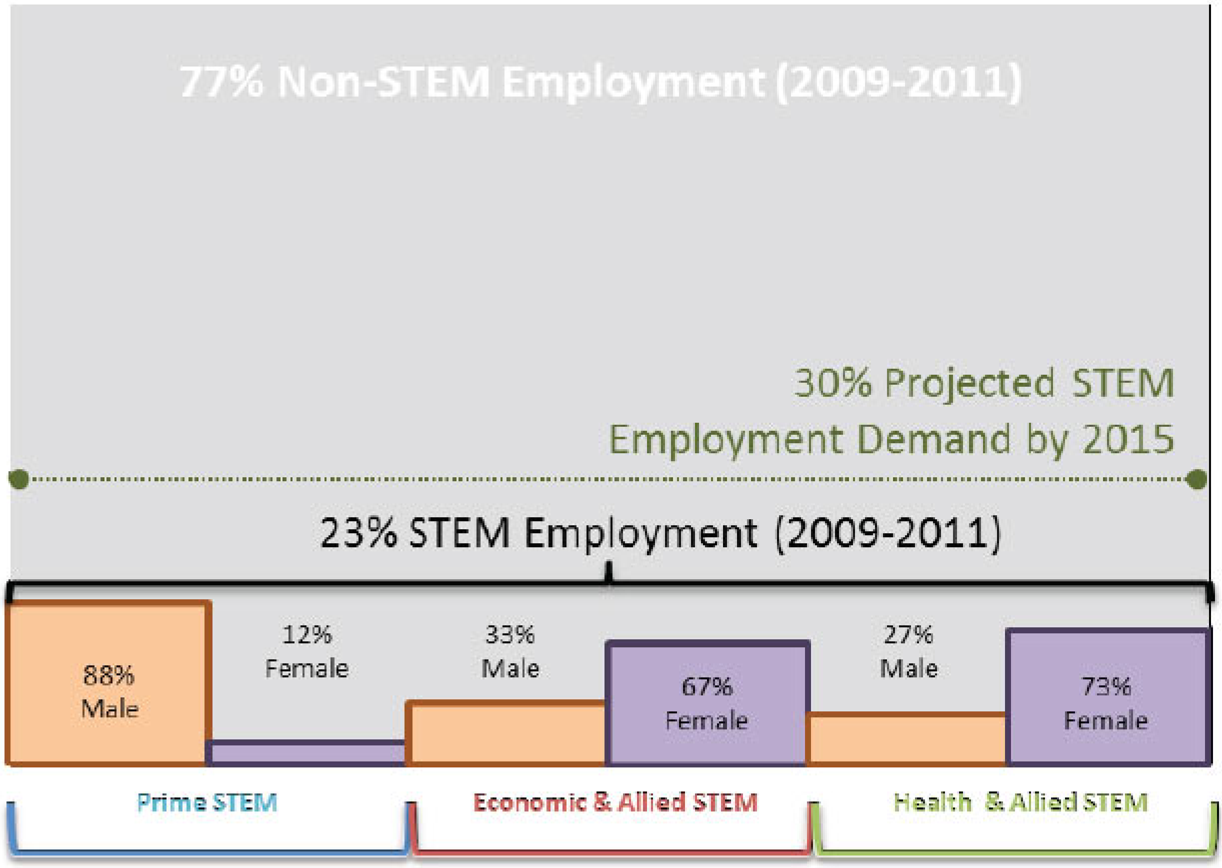

Figure 10: Participation of women in the STEM workforce and of STEM employees in the SA workforce

A further point noted in the RESA report is the potential impact of new technologies on increasing women's participation in the sector. For example, some of the barriers preventing women entering the mining industry are operational conditions and job flexibility, which is built largely on fly in-fly out rosters. However, newer process control technologies will enable mines and plants to be controlled and the data analysed remotely, which of itself will enable more employees to remain in capital cities and/or work from home. Although it is too soon to measure the impacts these new technologies will have for women, it will be critical that they are managed and promoted for the benefit of women.

Section 3: Conclusion

This study shows that gender is an important moderator in how students' educational abilities translate into aspirations and from there to actual study and work. It has been argued that the gender difference observed in STEM is driven primarily by female preferences for working with people, as opposed to things[23]. Interesting as this may be, what needs to be explained is why this preference arises when females move from school to university. A critical piece of work would be to undertake a qualitative analysis that looks at female preferences at either side of the Year 12-university transition point.

This report also demonstrates that while females move away from Prime STEM, they are not being lost to the broader STEM learning-work continuum. Those students who leave STEM bachelor programs, are more likely to move to a non-STEM bachelor program than drop out of study altogether[24]. One of the challenges is to develop strategies that effectively target females in the broader STEM fields and even beyond, to non-STEM fields of study and redirect them to Prime STEM pathways.

There has been a strong view that in terms of attraction to STEM courses, the decline starts at the primary level of education and thus any counter-prevailing interest in STEM must be cultivated prior to this point. It might be assumed that by the time study choices are made at the tertiary level they are fixed and there would be little value in attempting to increase female participation at the undergraduate level. This assumption has been challenged in an overseas study and reported on by *Universities Australia*, where researchers found that 'approximately half of those students who earned a STEM-related or non-STEM degree would have been candidates to pursue a STEM degree, thereby increasing the pool of potential STEM students by as much as a factor of four'[25]. Whether this would be the same for Australian students would need to be tested but it is an important area to investigate, especially if we wish to increase the levels of female participation in Prime STEM.

Widening the pool of potential STEM graduates is one of the recommendations put forward by in the RESA report. One potential avenue, which has not received a lot of attention, is the vocational education and training sector. Up to now, the focus has been on STEM professional occupations where a university qualification is required. However, there are many STEM technical and trade occupations that require Certificate III or IV level with an increasing demand for higher level qualifications such as diplomas and advanced diplomas. These latter qualifications provide transition pathways into university degrees.

The situation of women in STEM-related VET is not encouraging. In 2010, females accounted for just 9.5% of students undertaking VET courses in science, mathematics and engineering covering areas such as mechanical and industrial engineering, automotive engineering and technology, electrical and electronic engineering and others. An important area of future work would be to examine the comparatively low levels of female enrolments in STEM-related VET and consider how this might be addressed with the view to supporting them into VET and onto university STEM courses.

One further area that has not been addressed in this report is female participation in STEM at the post graduate level. While a similar pattern of participation is expected, it is an important area to address for several reasons. First, STEM research training programs are critical in developing new knowledge for our key industry sectors. Research trained STEM postgraduates, including many working outside universities, are also likely to be leaders in developing creative and innovative solutions to many of our emerging challenges. However, current STEM enrolment trends coupled with the strong international demand for high quality STEM researchers, pose considerable risks to Australia's research capacity and for research-led enterprises in these areas.

End Notes

[1]A more limited study was undertaken in 2007 in response to the work of the then Thinker in Residence, Baroness Susan Greenfield, this study however focussed primarily on women's experience of working in STEM fields and the nature of their career paths.

[2]The scope of this study has been confined to available sources of data and we are grateful to the SACE Board, the South Australian Tertiary Admissions Centre (SATAC) and the state universities for supplying their most recent data.

[3]NCVER VET Completions data 2002-2010.

[4]For example, the UK Government through its Resource Centre for Women in Science, Engineering and Technology aims to have by 2030 "an environment in UK SET employment in which women contribute to, participate in and share the benefits equally with their male counterparts". This target is seen as essential if the UK economy is to thrive and maintain its competitiveness. The European Union has also embarked on a ten-year program of increasing STEM graduates and reducing the gender imbalance in STEM courses (see Hamer et al, 2005, Stimulating Science and Technology in Higher Education: An International Comparison of Policy Measures and Their Effectiveness. Santa Monica, CA: RAND Corporation).

[5]For example, female participation was not addressed in either the Cutler Review of Australia's Innovation System, nor the Bradley Review of Higher Education although it was addressed in the Chief Scientist's report on the Health of Australian Science.

[6]Pipeline or Pipe Dream?:Securing Australia's Investment Future, 2012, Business Council of Australia.

[7]Australian Education, Employment and Workplace Relations References Committee, 2012, The Shortage of Engineering and Related Employment Skills.

[8]Australian Government, Office of the Chief Scientist, 2012, Health of Australian Science. Retrieved from http://www.chiefscientist.gov.au/2012/05/health-of-australian-science-report-2/

[9]Federation of Australian Scientific and Technological Societies, Women in Science in Australia: Maximising Productivity, Diversity and Innovation, 2009.

[10]Australian Government, Equal Opportunity for Women in the Workplace Agency, 2010 EOWA Australian Census of Women in Leadership.

[11]Australian Government, Education, Employment and Workplace Relations References Committee, The Shortage of Engineering and Related Employment Skills, 2012.

[12]Dr Sally Male, Proof Committee Hansard, 26 March 2012.

[13]The Association of Professional Engineers, Scientists and Managers, Australia (APESMA), Women in the Professions: The State of Play 2009-10.

[14]Australian Academy of Science, The Status and Quality of Year 11 and 12 Science in Australian Schools, 2011, p.11.

[15]In 1990, A Fair Chance For All established the Commonwealth's equity framework for participation in higher education with a similar focus adopted for schools. One of the six equity group identified in the framework was women in non-traditional areas of study. This equity framework treated an equitable outcome as 'one in which there is parity between percentage group representation in education and in the general population'. The exception to this was women in non-traditional disciplines where the target was set at 40% participation for science and 15% participation in engineering and Information Technology. These targets were to be met through a range of strategies, many of which were aimed at girls in secondary schooling.

[16]While the concern around the achievement gap relates more to Year 12 retention rates than to participation in STEM, it has become more pronounced because performance among females is going up faster than their male counterparts.

[17]Dowling and Burton, 2005, In The End of the Pipeline: Profiling Commencing Students To Ease Their Transition into an Engineering School.

[18]The quantitative data for this section was gathered from ABS labour force data. Annual averages for employment within each occupation (at the 4 digit ANZSCO level) were calculated for 2009, 2010 and 2011 by gender. Definition of STEM employment was based on the occupations defined to be STEM for the purpose of the analysis. The workforce data and the university completions data are not connected. The university data shows completions in STEM university courses for the most recent three years and the ABS data shows levels of employment in STEM occupations for the most recent three years.

[19]For example, Rio Tinto's priority for 2011 was to improve the representation of women in senior management and the pipeline of female talent over the next 5 years. Oz Minerals set quotas in 2011 of one Board Member and a target of 25% women across a number of employment bands by June 2011. In January 2011 the Academy of Technological Sciences and Engineering approved the Gender Equity Policy which commits to actively promoting gender diversity within the Academy and its activities, as well as broadly across Australia.

[20]Announced as part of an address to the Women in Mining and Resources in Queensland held at the Moranbah Community Centre.

[21]Resources and Engineering Skills Alliance, 2012, Increasing the Involvement of Women in the South Australian Resources Sector: The Business Imperative.

[22]Ibid. page 9.

[23]Diekman et. al., 2010, Seeking congruity between goals and roles. Psychological Science, 21(8), 1051. Retrieved from http://pss.sagepub.com/content/21/8/1051.short

[24]Universities Australian Report, 2012, STEM and non-STEM First Year Students, p.8.

[25]Nicholls, Wolfe and Besterfield-Scare, 2010, Predicting STEM degree outcomes based on eight grade data and standard test scores, 2010, cited in ibid. p.12.

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Appendices

Appendix 1: STEM subjects at the senior secondary level

Table 1: Classification of SACE and IB subjects

PRIME STEM		ECONOMIC AND ALLIED STEM		HEALTH AND ALLIED STEM	
Chemistry	SACE	Accounting Studies	SACE	Biology	SACE
Chemistry	IB	Business and Management	IB	Biology	IB
Computer Science	IB	Business Services B	SACE	Community Services and Health B	SACE
Contemporary Issues and Science	SACE	Business Studies	SACE	Health Studies	SACE
Geology	SACE	Economics	SACE		
Information Technology B	SACE	Economics	IB		
Information Technology Studies	SACE	Financial Services B	SACE		
Information Technology Systems	SACE				
Mathematical Studies	IB				
Mathematical Applications	SACE				
Mathematical Methods	SACE				
Mathematical Studies	SACE				
Mathematics	IB				
Physics	SACE				
Physics	IB				
Specialist Mathematics	SACE				
Systems and Control Products A	SACE				
Systems and Control Products B	SACE				

Appendix 2: Definitions of STEM at university

STEM at the university level was defined as follows:

Prime STEM courses: those in which a fundamental knowledge base in one or all of science, technology, engineering and mathematics are taught and applied.

Allied Economic STEM courses: those in which some aspects of science, technology, engineering and mathematics are taught and applied in an economic context.

Health & Allied STEM courses: those in which some aspects of science, technology, engineering and mathematics are taught and applied in health and medical contexts.

The table below provides a breakdown of the learning areas as defined by the official Fields of Education (Narrow Field classification) from the Australian Bureau of Statistics. They do not reflect individual university Bachelor Degree offerings, or individual university Bachelor Degree majors.

Table 2: Classification of Higher Education Fields of Education

PRIME STEM	ECONOMIC AND ALLIED STEM	HEALTH AND ALLIED STEM
Natural and Physical Sciences*	Management and Commerce*	Biological Sciences
Mathematical Sciences	Accounting	Health*
Physics and Astronomy	Banking, Finance and Related Fields	Medical Studies
Chemical Sciences	Economics and Econometrics	Nursing
Earth Sciences		Pharmacy
Other Natural and Physical Sciences		Dental Studies
Information Technology*		Optical Science
Computer Science		Veterinary Studies
Information Systems		Public Health
Other Information Technology		Radiography
Engineering and Related Technologies*		Rehabilitation Therapies
Manufacturing Engineering and Technology		
Process and Resources Engineering		
Automotive Engineering and Technology		
Mechanical and Industrial Engineering and Technology		
Civil Engineering		
Geomatic Engineering		
Electrical and Electronic Engineering and Technology		
Aerospace Engineering and Technology		
Maritime Engineering and Technology		
Other Engineering and Related Technologies		

*NFD – Not Further Defined

Appendix 3: Definitions of STEM in the workforce

STEM in employment was defined as follows:

Employment categories were defined against ANZSCO (Australian and New Zealand Standard Classification of Occupations) classifications. They do not reflect individual employment contracts or titles.

Table 3: Classification of Employment Groups

PRIME STEM	ECONOMIC AND ALLIED STEM	HEALTH AND ALLIED STEM
Human Resource Managers	Finance Managers	Life Scientists
Construction Managers	Accountants	Medical Laboratory Scientists
Engineering Managers	Auditors, Company Secretaries and Corporate Treasurers	Veterinarians
ICT Managers	Financial Brokers	Medical Imaging Professionals
Other Specialist Managers	Financial Dealers	Occupational and Environmental Health Professionals
Air Transport Professionals	Financial Investment Advisers and Managers	Optometrist and Orthoptists
Chemical and Materials Engineers	Actuaries, Mathematicians and Statisticians	Pharmacists
Civil Engineering Professionals	Economists	Other Health Diagnostic and Promotion Professionals
Electrical Engineers	Land Economists and Valuers	Chiropractors and Osteopaths
Electronics Engineers	Accounting Clerks	Complementary Health Therapists
Industrial, Mechanical and Production Engineers	Bookkeepers	Dental Practitioners
Mining Engineers	Payroll Clerks	Occupational Therapists
Other Engineering Professional Agricultural and Forestry Scientists	Bank Workers	Physiotherapists
Chemists, and Food and Wine Scientists	Credit and Loans Officers	Podiatrist
Environmental Scientists	Insurance, Money Market and Statistical Clerks	Speech Professionals and Audiologists
Geologists and Geophysicists		Generalist Medical Practitioners
Other Natural and Physical Science Professionals		Anaesthetist
ICT Business and Systems Analysts		Internal Medicine Specialists
Software and Application Programmers		Psychiatrists
Database and Systems Administrators, and ICT Security		Surgeons
Computer Network Professionals		Other Medical Practitioners
ICT Support and Test Engineers		Midwives
Telecommunications Engineering Professionals		Nurse Educators and Researchers
Agricultural Technicians		Nurse Managers
Science Technicians		Registered Nurses
Architectural, Building and Surveying Technicians		Multimedia Specialists and Web Developers
Civil Engineering Draftspersons and Technicians		Medical Technicians
Electrical Engineering Draftspersons and Technicians		Ambulance Officers and Paramedics
Electronic Engineering Draftspersons and Technicians		Dental Hygienists, Technicians and Therapists
Mechanical Engineering Draftsperson sand Technicians		Diversional Therapists
Other Building and Engineering Technicians		Enrolled and Mothercraft Nurses
ICT Support Technicians		
Metal Casting, Forging and Finishing Trades Workers		
Sheetmetal Trades Workers		
Structural Steel and Welding Trades Workers		
Aircraft Maintenance Engineers		
Metal Fitter and Machinist		
Precision Metal Trades workers		
Toolmakers and Engineering Patternmakers		
Electricians		
Air-conditioning and Refrigeration Mechanics		
Electrical Distribution Trades Workers		
Electronic Trades Workers		
Telecommunications Trades Workers		
Other Miscellaneous Technicians and Trades Workers		
Other Machined Operators		
Crane, Hoist and Life Operators		
Drillers, Miners and Shot Firers		
Engineering Production Systems Workers		
Other Mobile Plant Operators		
ICT Trainers		