NCVER

From STEM to leaf: Where are Australia's science, mathematics, engineering and technology (STEM) students heading?

A Anlezark, P Lim, R Semo & N Nguyen
NCVER

Final report [Aug 2008]

Contents

Tables and figures

Executive summary

Declining participation in post-compulsory science, technology, engineering and maths (STEM) subjects, particularly 'enabling sciences of physics and chemistry, and higher mathematics' (Tytler 2007), is a cause of concern for government, industry and educators in Australia and internationally. Despite a labour market increasingly driven by, and reliant on, technology, many contend that Australia's workforce is now facing general skills shortages in these areas which will only get worse over time. Underlying shortages of suitably qualified teachers of science and maths are also currently an area of particular focus. National and state governments are keen to understand the reasons behind this apparently broad decline in interest, with considerable attention focused on how to encourage more students to undertake these subjects throughout their school and post-school studies.

The purpose of this research report is to provide policy-makers with information to assist understanding of the pathways students take from STEM school subjects to commencing post-school study of STEM, and whether this then translates into STEM occupations.

The report uses data from the well-established Longitudinal Survey of Australian Youth (LSAY), which provides information on the subject choices of Australian youth in Year 12 and allows analysis of those undertaking STEM subjects in school, those commencing post-school study, and those who are working in STEM careers.

The key findings from the study are:

- Despite over half of all school students studying two or more STEM subjects in Year 12, less than a third of these then go on to post-school STEM study. Only one in eight (12%) of all school students are working in a STEM career by their mid-twenties. Indications from the analysis suggest that while the numbers of students studying STEM subjects in school and in commencing post-school study are on the decline, the proportions of individuals moving into STEM careers is holding steady. This suggests that there may be no shortage of supply of people with the potential to undertake STEM occupations.
- Overall, 45% of students at age 15.5 years aspire to a STEM career, with no gender differences. Interestingly, 16% of students who do not aspire to a STEM career are working in a STEM career in their mid-twenties. Among all students, 13% of males and 11% of females work in a STEM career at this age.
- The greatest leakage from STEM is the pathway from commencing post-school STEM study into a STEM occupation. Two-thirds of those who undertake post-school STEM study, as well as STEM study in Year 12, do not go on to work in a STEM career. This is an area which could warrant further research to determine if there are distinct areas of post-school STEM study which are not leading directly to STEM occupations.
- Almost half of those working in STEM careers are from the highest maths achievement quartile but only around one in five of these are in a STEM career.
- Of those who work in a STEM career, over three-quarters have a linear pathway to their final occupation; that is, they studied STEM in Year 12, then studied a STEM course post-school, and then moved into a STEM career.
- There are wage benefits from studying post-school STEM and following a STEM career. At 24 years, those who work in STEM occupations earn on average over $100 per week than those who are employed in non-STEM occupations. Having post-school STEM study gives further wage premiums for those working in a STEM occupation.

- There are a number of key drivers to following the pathway of undertaking STEM in Year 12, studying it post-school, and finally working in a STEM occupation. These include self-motivation and the desire to work in a STEM career (based on questions asked in Year 9), performing well academically in STEM subjects, and the attitudes of the school and, in particular, science teachers. This suggests that motivations for post-school STEM study and STEM careers are well developed before students make subject choices for Year 12.
- Self-motivation is slightly stronger for males than females, with males less likely to be influenced by others and tending to rely more on their self-assessment of academic strength in STEM subjects than females. Having good science teachers in high school is seen as an important motivator for pursuing post-school STEM study for almost three-quarters of young people. These teachers are perceived as being more influential in deciding young people's post-school STEM study than their actual science experiences in high school, and more influential than advice given by parents and careers advisors.
- The relationship between strong performance in STEM subjects at school and post-school STEM study is highlighted in the analysis of students in the highest maths achievement quartile. These students are twice as likely to be working in a STEM career at age 24 or 25 as those who have lower maths achievement in Year 9.
- By comparing the importance given to careers advisors on decisions whether or not to study STEM subjects, it seems that careers advisors are perceived by young people as more influential in steering young people away from, rather than into, STEM careers.
- There is a difference in the uptake of STEM careers by higher performing students[1], compared with the general LSAY population. It is these high performing students that form the major labour supply for STEM occupations. It may, therefore, be possible for more of these high achievers to be steered towards a career in STEM to help meet the demand of future STEM employers. This may be achieved through the better promotion of STEM careers in the early years of high school, and through the better training and education of careers advisors in informing students about STEM career opportunities.

[1] LSAY contains a measure of achievement taken at Year 9, or 15 years of age. High performing = upper maths achievement quartile.

Introduction

Background

In Australia, there is a keen policy interest in identifying and understanding issues relating to the formation of skills for Australia's workforce, including those underlying the critically important science, mathematics, engineering and technology (STEM) workforce. STEM skills are behind the growing global reliance on technology and innovation, and increasing Australia's productivity levels requires a workforce with sufficient STEM skills to match or exceed international competitors.

This study analyses data obtained through the Longitudinal Surveys of Australian Youth (LSAY). Conducted annually since 1995, some 49 000 young Australians aged 15 to 25 years have already taken part in LSAY research, which is designed to enhance understanding of young people's school-to-work transitions and the factors which influence them. Due to the longitudinal nature of the data, the large national representative samples, and the coverage across several cohorts of young people between 15 and 25 years, changes over time can also be tracked. This means that LSAY has an important role to play in making sense of the changing nature of these transitions, monitoring and evaluating young people's progress towards their stated occupational goals, and identifying what works well and what doesn't in assisting them to achieve these goals.

There are currently four cohorts in LSAY. The first comprises students who were in Year 9 in 1995 (Y95), the second those who were in Year 9 in 1998 (Y98), the third those who were aged 15 years in 2003 (Y03), and the fourth those who were aged 15 in 2006 (Y06). This provides an appropriate dataset for pathway analysis because it enables us to follow individuals from school to post-school destinations. The older cohorts provide information across an individual's school to employment transition, including their school subject choice, commencing post-school study, and occupational destination.

The Y98 and Y95 LSAY cohorts[2] are used to follow students from 15 to 26 years (inclusive) in the Y95 cohort, and 15 to 24 years (inclusive) in the Y98 cohort. The analysis contained in this report uses the most recently collected waves of data, which include 2007 data for the Y98 and Y03 cohorts and 2006 data for Y95—the final year in which data was collected for this cohort.

The Y03, Y98 and Y95 cohorts are used to look at changes in STEM subject participation in Year 12 and post-school over time. Answers to a series of additional questions on commencing post-school STEM study collected from the Y03 cohort in 2007 provide information on factors which influence post-school STEM subject choice.

It is important to consider males and females separately in any such analysis, as there are known to be strong gender differences in the types of STEM careers in which young men and women work. For example, the Department of Employment and Workplace Relations (DEWR) report in their *Australian Jobs 2007* publication that the health and community services industry comprises 78% females, compared with the construction sector (which includes engineers), which is dominated by males (88%). Similarly, NCVER statistics demonstrate that 90% of students studying engineering and related VET courses are male, while 57% of students studying VET health courses are female.

[2] LSAY cohorts are referenced by their commencement year. The Y95 cohort provides a national sample of students who were in Year 9 in 1995; similarly, the Y98 cohort is a national sample of students who were in Year 9 in 1998. The Y03 and Y06 cohorts were aged 15 years in 2003 and 2006 respectively. The commencement sample sizes were: Y95 n=13 613, Y98 n=14 117 and Y03 n=10 370.

Women clearly favour study and occupations in the social and health sciences, whereas men dominate the engineering and physical science occupations and related courses.

In this pathway analysis we have also taken advantage of the ability testing conducted in Year 9 in the Y95 and Y98 LSAY cohorts, to define a group most likely to work in STEM careers[3]. We know from the literature (Adamuti-Trache 2006) that stronger academic performers, particularly in maths, are better able to deal with, and are more likely to study and work in, a career in the STEM fields.

Finally, a note about definitions[4]. There is much discussion about skills shortages in a wide range of STEM occupations. For the purpose of this analysis, we are interested in higher-level qualifications and occupations which require higher-level STEM skills. For STEM school study, the definition is that students are undertaking at least two STEM school subjects in Year 12. For post-school STEM study, the definition is based on field of education using the Australian Bureau of Statistics (ABS) standard ASCED classification[5], which incorporates both vocational education and training (VET) and higher education qualifications. STEM occupations are defined using the ABS standard classifications for occupations[6]. For example, building and engineering associate professionals, or medical and science laboratory technicians, are occupations which can be reached using a VET qualification and are included in the definition of STEM occupation, while carpenters and joiners are excluded. It should also be noted that in the LSAY data it was not possible to differentiate between teachers who teach mathematics and science, and teachers of other subjects, and so teaching is not considered a STEM occupation for the purposes of our analysis.

Issues to be addressed through the research

The strategic objectives of this research are to use LSAY data to better understand participation in STEM subjects at school, and to look at post-school destinations of this group, with consideration for gender differences. The specific research questions are:

1. For the Y95 & Y98 cohorts, what are the pathways from school to further education (VET and university) and employment for students who studied STEM subjects in Year 12?
    a. How do they compare with students who did not study STEM subjects in Year 12?
    b. What were their career aspirations in Year 9?

2. For the Y95 and Y98 cohorts, for individuals who are currently in a STEM career, what are the distinguishing features which differentiate them from those who are not in STEM careers?

3. For the Y03 cohorts, for students who undertook STEM subjects in Year 12 and were studying post-school STEM courses in 2007:
    a. Are they currently studying a science, engineering, mathematics or information technology (IT)-related course post-school and, if so, what are they studying?
    b. How important was a series of factors on the decision to study STEM subjects post-school?

---

3 Defined as those individuals who perform in the upper quartile for numeracy in the Y95 and Y98 cohorts.
4 A more comprehensive description of STEM definitions is provided in appendix A.
5 Australian Standard Classification of Education (ASCED) (ABS 2001). Refer to appendix A for a more detailed description.
6 Refer to Appendix A for a more detailed description.

c. How important was a series of factors on the decision *not* to study STEM subjects post-school?

d. What factors would need to have been changed to consider studying STEM subjects post-school?

4. What are the changes over time (using the Y03, Y98 and Y95) in the proportion of students who are studying STEM subjects in Year 12 and post-school?

Approach

The National Centre for Vocational Education Research (NCVER) has taken a predominantly descriptive approach to this analysis, but also draws on results from logistic regression analysis. Regression analysis allows us to better understand the factors explaining the uptake of STEM study and working in a STEM career, by measuring the impact of contributing factors such as background characteristics. Where appropriate, LSAY data is used from the 1995 (Y95), 1998 (Y98) and 2003 (Y03) LSAY cohorts. All analysis is conducted with consideration for gender, and weighted to the respective original sample populations where appropriate.

This research report is in four key sections. Firstly, we use data from the Y95 and Y98 LSAY cohorts to look at pathways from school into STEM occupations. We look at leakages between school and commencing post-school study, as well as pathways into STEM occupations at age 25 (Y95 cohort) and age 24 (Y98 cohort). A separate analysis is conducted for a sub-group of those individuals who are considered to be most likely to follow a STEM career. We also look at career aspirations of school students when they were in Year 10 (average age 15.5 years).

Secondly, we look at the pathways taken by those who are in a STEM occupation at age 25 or 24 years, using data from the Y95 and Y98 cohorts. Again, a separate analysis is conducted for a sub-group of those individuals who are considered to be most likely to follow a STEM career. The regression analysis adds depth to the general discussion by identifying the characteristics of those who go into STEM occupations, compared with those who do not.

Thirdly, we use data from the Y03 cohort which contains an additional series of questions in the 2007 interviews about factors which influence the decision whether or not to study STEM subjects.

Finally, we look at changes over time in the proportions of students who study (school and post-school) and work in STEM occupations. Data is utilised from the Y95, Y98 and Y03 LSAY cohorts.

Methodological considerations

Definition of STEM

Our literature review of other work in this area led us to conclude that most definitions of STEM post-school qualifications are those requiring diploma-level or higher qualifications. This is also consistent with current government policy to assist students financially through lower annual student contribution amounts for those studying STEM courses at universities (Gillard 2008).

For the purposes of this project, the following definitions have been used.

STEM school subjects: Any student studying two or more subjects in the broad categories of science, maths, and computing/information technology in Year 12.

STEM post-school qualifications: Derived from a thorough assessment of the Australian Standard Classification of Education (ASCED), codes 01 to 06 (ABS 2001). The focus here is on qualifications which matched our occupational definitions.

STEM occupations: Derived from a thorough assessment of the ABS standard classifications of occupations for the relevant years for which each LSAY cohort was asked about career aspirations and destinations. For example, the Australian Standard Classification of Occupations (ASCO second edition) was used to classify the final occupational data in 2006 of the LSAY 1995 cohort at age 25 years, while ASCO (first edition) was used to classify their career aspirations asked in 1999 at age 16 years.

Appendix A contains a description of the qualifications (defined by ASCED) and occupations (defined by ASCO) which we have assigned to be related to STEM post-school qualifications and occupations.

Regression methodology

Logistic regressions were undertaken using a two-level response variable. The response variable of interest is whether or not a respondent was in STEM. The explanatory variables are generally two level (yes/no) or multi-response nominal variables. The logistic regression model is

$$\log it\left(\frac{\pi_i}{1-\pi_i}\right) = \alpha_i + \boldsymbol{\beta}_\mathbf{i}\mathbf{x}_\mathbf{i} + \boldsymbol{\varepsilon}$$

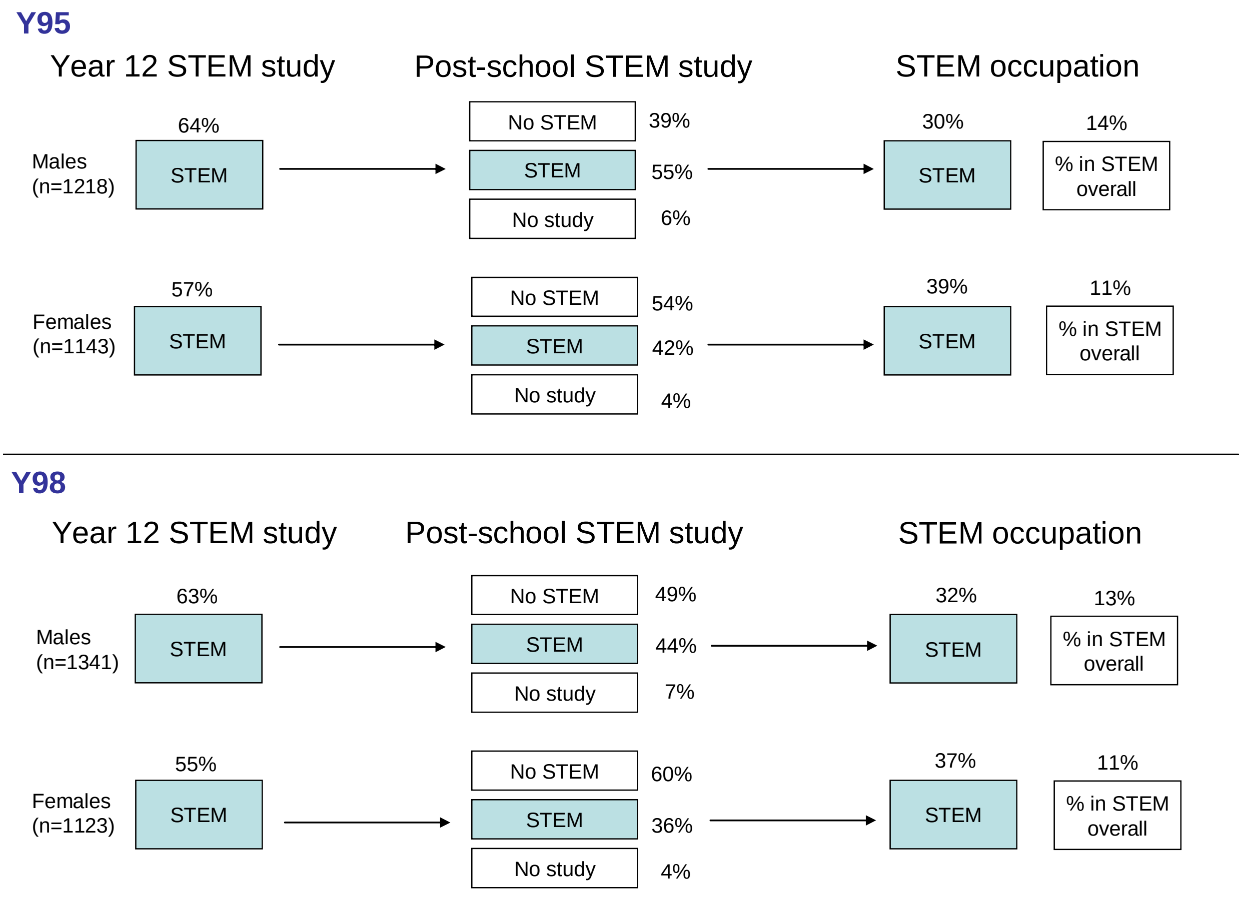
Where α_i is the intercept, $\boldsymbol{\beta}_\mathbf{i}$ is the vector of regression coefficients for explanatory variables, and $\boldsymbol{\varepsilon}$ is the vector of residuals. The reference category for all regressions is Y (STEM) and so a positive regression co-efficient indicates an increase in the chance of doing STEM, whereas a negative co-efficient indicates a smaller chance of doing STEM.

The significance of explanatory variables was tested using the Wald test, with a significance level of 90% ($\alpha = 0.1$). The results of the regression appear in appendix B, and the results presented are the regression co-efficient, standard error and p-value of the significant effects. A variable selection procedure using a stepwise selection method has been used to determine the significant effects. All regression procedures have been carried out using SAS v9.0.

Pathways from school into STEM occupations

In this section, we explore pathways from secondary school into commencing post-school study, and then on to STEM occupations, for those who studied STEM subjects in Year 12. Areas of leakage are identified where students do these subjects at school, but then do not work in careers in these areas. Data is used from the Y95 and Y98 cohorts, with separate analysis by gender. The population of interest is those who studied at least two STEM subjects in Year 12.

Figure 1 Pathways into commencing post-school study and STEM occupations of those who study STEM subjects at school



Source: LSAY Y95 and Y98 cohorts, those who study >=2 STEM subjects in Year 12.

Around 60% of all Year 12 students in the Y95 and Y98 cohorts undertook two or more STEM subjects. Slightly more males than females undertook two or more STEM subjects in Year 12 and this pattern was found in both the Y95 and the Y98 cohort (figure 1).

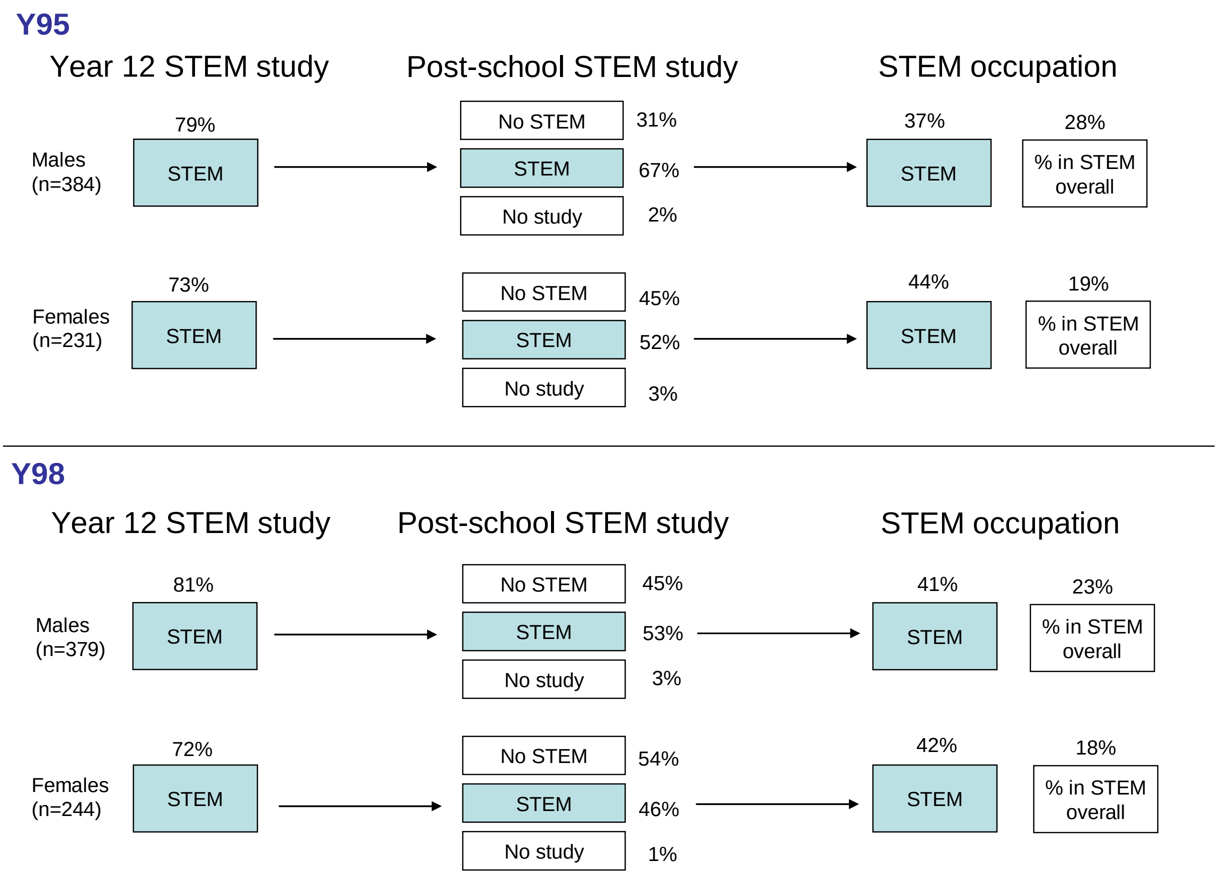
Of those students who undertook two or more STEM subjects in Year 12 in the 1995 cohort, 55% of males and 42% of females continued on to commence post-school STEM study. The proportion of students who undertook two or more STEM subjects in Year 12 and then went on to post-school STEM is smaller in the 1998 cohort, but a similar pattern is seen with more males than females continuing on with post-school STEM (44% and 36% respectively).

Overall, 14% of males and 11% of females from the Y95 cohort go on to work in a STEM career in their mid-twenties. These proportions were slightly smaller in the Y98 cohort (13% of males and 11% of females, refer to figure 2). In comparison, around a third of those who undertake STEM study in school and post-school in both the Y95 and Y98 cohort go on to work in a career in STEM. Despite a higher proportion of males than females going on to study post-school STEM subjects, a slightly higher proportion of the females who undertake post-school STEM proceed into a STEM career by their mid-twenties. Overall, it can be seen that there is substantial leakage out of STEM by individuals who have undertaken post-secondary studies in STEM but then do not work in a STEM occupation. The leakage which occurs at the transition from post-school STEM study to a STEM career may warrant further investigation using either the LSAY data-sets or Graduate Destination Surveys.

Pathways of those most likely to work in STEM careers

It would be expected that the most likely supply of labour for STEM occupations is the group of students who demonstrate the most academic ability. For this reason, it is worth looking at a sub-population of the LSAY cohort to examine the extent to which high achieving students are the most likely supply of labour for STEM occupations. Figure 2 presents the pathways as for figure 1, but provides information for a sub-group of the LSAY cohort who when tested in Year 9 were in the highest achievement quartile for mathematics.

Figure 2 Pathways into commencing post-school study and STEM occupations of high maths achievers who study STEM subjects at school



Source: LSAY Y95 and Y98 cohorts, those who study >=2 STEM subjects in Year 12, and are in highest maths achievement quartile.

The results from figure 2 show that there is a greater percentage of high achievers undertaking Year 12 STEM compared with the total population. For the 1995 cohort, 80% of high achievers undertake Year 12 STEM, as opposed to 63% of the general 1995 population. The same trend is evident for those who undertake post-school STEM studies, with 66% of the higher achievers (who did STEM at Year 12), and only 50% of the general LSAY population, undertaking post-school STEM.

There is no real difference in the undertaking of STEM at Year 12 between the 1995 and 1998 cohorts in this sub-population of students. In both the 1995 and the 1998 cohorts, 80% of high achieving males undertook STEM at Year 12. There has been an increase in the leakage of high achieving males going on from school STEM subjects to commencing post-school study, with two-thirds of the 1995 cohort taking this path, compared with just over half of those in the 1998 cohort taking this pathway.

Even in this high achieving group, we see that males are more likely to undertake Year 12 and post-school studies in STEM than females.

Figure 2 shows that overall, a larger proportion of high achieving students are more likely to work in a STEM career. Around one in five of the total number of high achievers pursues a STEM career in their mid-twenties in both the Y95 and Y98 cohorts. Additionally, high achievers who undertake STEM subjects in school and post-school are more likely to then pursue a STEM career. Interestingly, even with more high achieving students undertaking post-school STEM, the percentage of these continuing on to STEM occupations is only slightly higher than those of other students who did STEM school subjects in Year 12. In fact, 37% (cf 32%—all) of males and 44% (cf 39% —all) of females pursued a STEM career.

As for the general population, the biggest area of leakage for the high achieving group is the transition from post-school STEM study into STEM occupations.

What influences young people to undertake STEM in Year 12?

Logistic regressions were undertaken using the following demographic variables to determine which factors have an influence in differentiating between those who do and do not undertake STEM in Year 12:

- state/territory in which school attended in 1995 (Y95) or 1998 (Y98) is located
- gender
- respondent's country of birth (coded as Australia, overseas English speaking, overseas non-English speaking)
- geographic location (metropolitan, regional, rural/remote)
- school type (government, catholic, independent)
- mother's and father's educational background and occupation
- achievement quartiles (maths and reading assessed at Year 9)
- student's self-concept of ability (English, maths, studies of society and environment [SOSE], business, science, arts, languages other than English [LOTE], computing and technology, and health and physical education)
- school environment (quality of teachers, discipline, student learning, school spirit)
- career aspirations (STEM/not STEM—asked in Year 9)
- whether undertaken work experience.

The logistic regressions were undertaken for the cohort overall and separately for males, females and those in the highest maths achievement quartiles. Regressions were undertaken for each of the Y95 and Y98 cohorts. Further technical detail on the regression analysis is contained in appendix B.

The results of the regressions for all respondents for Y95 and Y98 separately show that there are common factors influencing an individual's decision to undertake STEM in Year 12. These include the state/territory in which the school is located, and a student's future career aspiration and the self-concept of their ability in maths, science, arts, computing and technology.

In the Y95 cohort there is a significant difference between males and females, with important factors including the educational level reached by fathers, and whether students undertook work experience. Gender is not a significant factor for the Y98 cohort, however, mother's educational background, the quality of their teachers and the student's desire to continue on to Year 12 became important. Surprisingly, the maths achievement quartiles were not a significant indicator as to whether STEM was studied in Year 12 for the Y98 cohort but it was for the Y95 cohort.

For males in the Y95 cohort, the influencing variables were their father's educational level, their future career aspirations, whether students undertook work experience and students' self-concept of ability in science and technology subjects. For males in the Y98 cohort, students' career aspirations and self-concept of their ability in science, computing and technology were also identified as important factors. State/territory in which they were studying, the geographic location of the school they attended (metropolitan, regional, rural/remote), their mother's educational level, the quality of their teachers and their plans for continuing to Year 12 were also identified as key indicators for STEM study.

For female respondents in Y95, important factors included the state/territory in which they were studying, the geographic location of the school they attended (metropolitan, regional, rural/remote), and both the father's and mother's educational background. Other important factors included students' maths achievement quartiles and their self-concept of their ability in English, maths, humanities, science and technology, as well as their career aspirations and whether students undertook work experience.. For the Y98 cohort, students' career aspirations and students' self-concept of their ability in science were also important predictors in studying STEM at Year 12.

For those respondents who were in the highest maths achievement quartiles, the key indicators for undertaking STEM in Year 12 were mother's educational background, future career aspirations, and self-concept of their ability in science. For high achieving maths students in Y95, other important factors included father's educational background, students' self-concept of ability in technology and schools' attitudes to learning. For the Y98 cohort, further important factors included the state/territory in which the student was studying, the geographic location of the school attended (metropolitan, regional, rural/remote), teacher quality, self-concept of ability in computing, and intentions to complete Year 12.

The results highlight the key variable in determining a student's decision to undertake STEM at Year 12 as being future career aspiration. Furthermore, if a student perceives they have ability in key STEM areas, then they are more likely to undertake STEM in Year 12.

Career aspirations of STEM and non-STEM school students

The career aspirations of students studying STEM subjects at school were analysed for the Y98 cohort. In 1999, when most were aged 15.5 years, these students were asked what type of career they intended to work in. These have been classified into STEM and non-STEM careers as per our definition throughout this report.

Those who did two or more STEM subjects in Year 12 were more likely to have demonstrated the intention to work in a STEM career when asked in Year 10, than students who did not undertake any STEM study in Year 12. The desire for a STEM career was stronger for males than females who undertook Year 12 STEM subjects. While 28% of those who did Year 12 STEM subjects had indicated the intention to aim for a STEM career, only around a third of this group actually achieved this goal.

Table 1 Career aspirations of STEM and non-STEM school students by gender, Y98 in 2000 (%)

Y98	STEM in Year 12 Males %	STEM in Year 12 Females %	STEM in Year 12 Total %	Did not do STEM in Year 12 Males %	Did not do STEM in Year 12 Females %	Did not do STEM in Year 12 Total %
STEM career	29	27	28	10	6	7
Non-STEM career	38	46	42	60	64	63
Don't know	30	22	26	27	24	25
Missing	3	4	4	3	6	5
All (%)	**100**	**100**	**100**	**100**	**100**	**100**
Total (N)	**283**	**244**	**527**	**330**	**609**	**938**

Source: LSAY Y98 cohort, those who studied Year 12, percentages may not sum to 100 due to rounding.

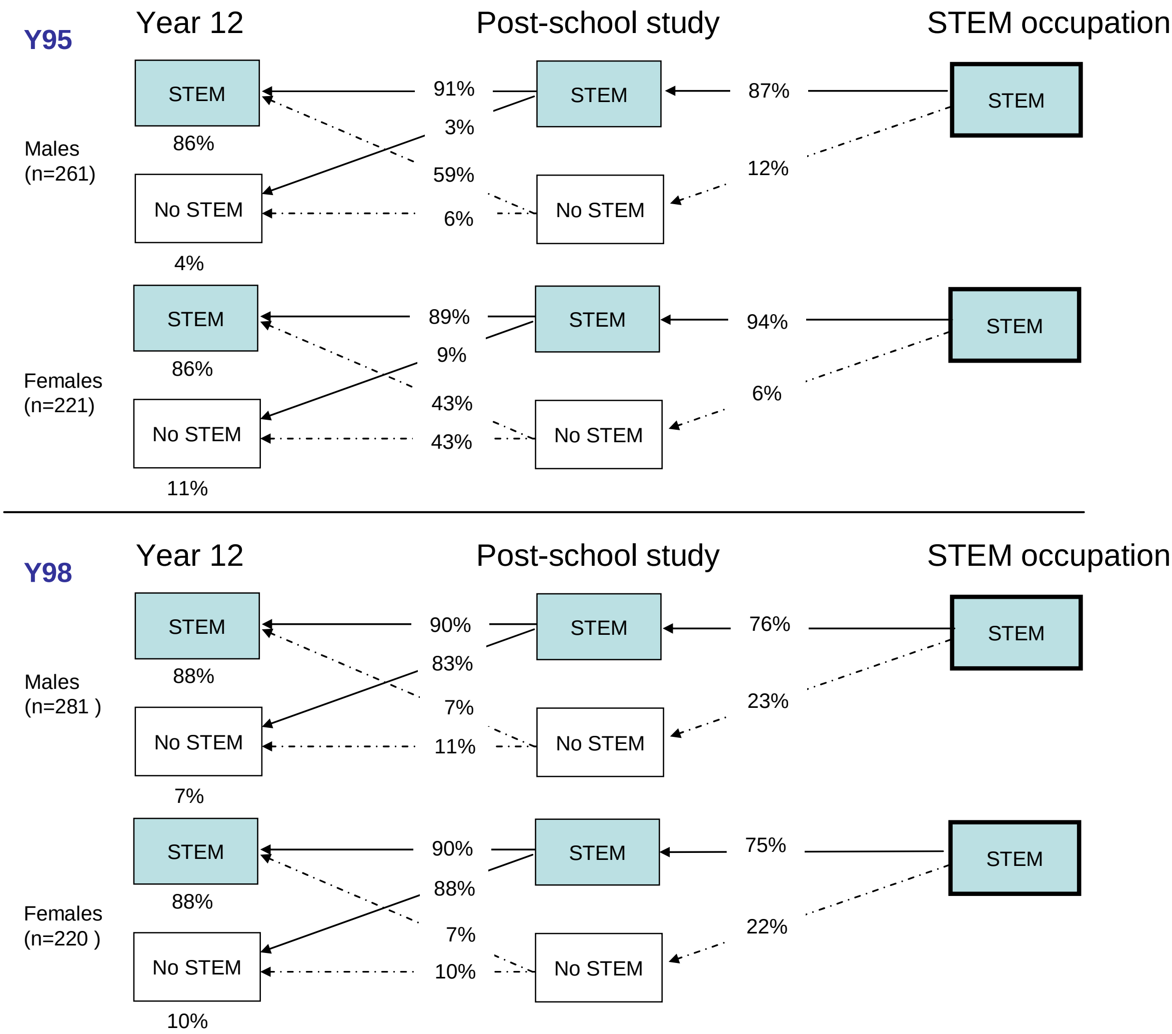
Of those who did not select at least two STEM subjects in Year 12, some 7% nevertheless had indicated an intention to work in a STEM career when they were asked in Year 10.

Interestingly, 26% of those who undertook STEM in Year 12 did not know what sort of career they wanted. In efforts to increase the numbers of skilled STEM workers in Australia, it is probably worth targeting this particular group of students by providing them with further information about STEM career opportunities.

Pathways taken by those in STEM occupations

In this section, we explore pathways from school into commencing post-school study for those who work in a STEM occupation. We also examine the extent of movement into STEM careers by those who have not undertaken post-school study in a STEM field. Data is used from the Y95 and Y98 cohorts, with separate analysis by gender. The population of interest is those who work in a STEM career at age 25 for the Y95 cohort, and at age 24 for the Y98 cohort.

Figure 3 Pathways into STEM occupations for the general Y95 and Y98 cohorts



Source: LSAY Y95 and Y98 cohorts, those who work in a STEM career.
NB: Percentages do not add up to 100% in some cases as percentages include 'unknown' which is not represented in the figure.

Figure 3 shows four pathways undertaken by those in both the Y95 and Y98 cohorts who work in a STEM career. The percentages shown indicate the size of the proportions undertaking the following pathways:

- those studying STEM in school and post-school
- those studying STEM in school but not in post-school
- those not studying STEM in school but undertake STEM post-school
- those with no previous STEM study prior to pursuing a STEM career.

As would be expected, the main pathway into a STEM occupation is a linear one, through studying STEM subjects in Year 12 and then commencing a STEM course post-school. In the Y95 cohort, 88% of males and 94% of females who work in a STEM career undertook post-school STEM. Of these students, almost all undertook two or more STEM subjects in Year 12 prior to undertaking post-school STEM (91% males; 97% females). The same pattern in seen in the Y98 cohort, but the proportions are slightly lower (figure 3). Very few people who work in STEM occupations have not undertaken any prior STEM study in Year 12 or post-school.

The difference between the Y95 and Y98 cohorts is interesting. The patterns are generally the same—those who study STEM subjects in Year 12 and post-school largely account for those who work in a STEM occupation. However, the Y98 cohort shows an even larger proportion of people taking a 'non-STEM' pathway towards their STEM occupation.

More females (94%) than males (87%) in the Y95 cohort undertake a linear path towards working in a STEM career; that is, undertaking STEM subjects in Year 12 and then post-school STEM study. In the Y98 cohort, where a larger proportion of people pursuing a STEM career do not start off studying STEM subjects in either Year 12 or post-school, there is no real difference between males and females in taking a linear route towards working in a STEM career.

An area for further investigation would be to examine the educational backgrounds (i.e. field of study) for those individuals entering a STEM occupation through the non-traditional route. It would also be interesting to examine the types of STEM occupations these individuals are entering, since the definition of a STEM occupation we have used generally requires individuals to have a diploma or higher-level qualification in a STEM field of study.

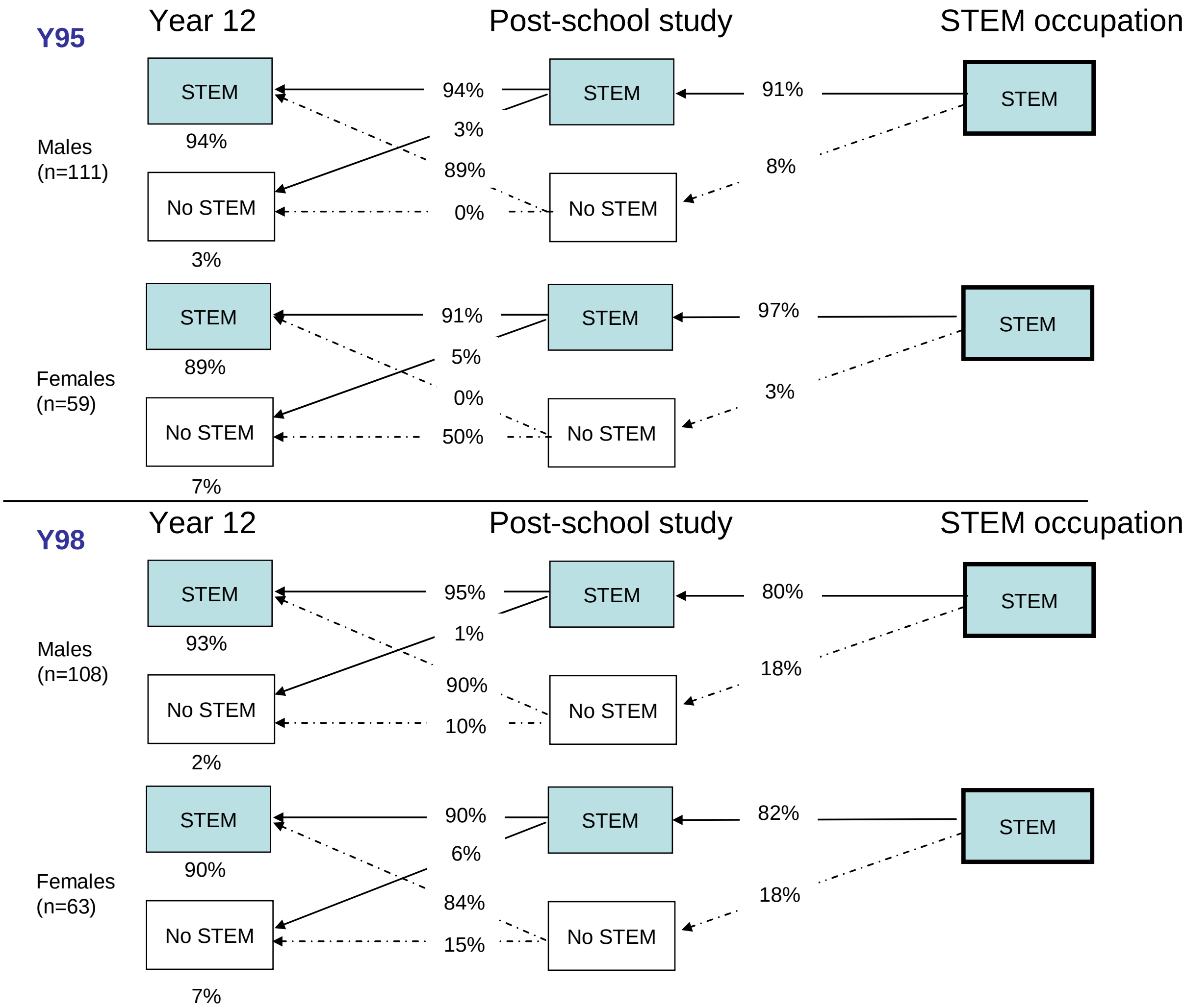
The phenomenon of entering a STEM occupation without post-school STEM qualifications is more prevalent in the 1998 cohort. This could be related to a shortage of skilled labour, with employers more prepared to employ individuals in a STEM career with non-STEM qualifications. Another area for further investigation would be to look into whether these individuals are undertaking part-time study to retrain for their STEM career.

Pathways of those most likely to work in STEM careers

Figure 4 shows the pathways of a sub-group of those who work in STEM careers, defined as students who when tested in Year 9 were in the highest achievement quartile for mathematics. The people in this sub-population are more likely to have undertaken some form of STEM study prior to pursuing a STEM career. Very few did not undertake any previous STEM study and are excluded in the figure below (base too small). Therefore, figure 4 shows only three pathways to a STEM career rather than four as shown in figure 3. The percentages again indicate the size of the proportions undertaking each pathway to a STEM career.

As for the general population, the majority of 'high achievers' who work in a STEM career undertake a STEM pathway through studying STEM subjects in Year 12 and post-school, although it can be seen that the proportion taking this path is larger amongst the high achieving students.

Figure 4 **Pathways into STEM occupations for high maths achievers**



Source: LSAY Y95 and Y98 cohorts, those who work in a STEM career and are in the highest maths achievement quartile.
NB: Percentages do not add up to 100% in some cases as percentages include 'unknown' which is not represented in the figure.

Characteristics of those who do and do not work in a STEM career

In describing the characteristics of those who do and do not work in a STEM career, data from the Y98 cohort is used[7]. Comparable results were seen when analysed for the Y95 cohort and these are not presented.

Some 14% of the Y98 cohort in 2007 were working in a STEM career. The characteristics which distinguished them from their non-STEM counterparts are outlined in the following tables.

[7] Y98 data has more consistent coding of occupational classifications, and there is a more recent (2007) wave of data.

Table 2 Demographic characteristics of STEM and non-STEM occupations (%)

Demographic	NON-STEM	STEM
	%	%
Gender		
Male	52	56
Female	48	44
Aboriginal and Torres Strait Islander		
0 No	94	98
1 Yes	2	1
8 Invalid response/Missing	4	1
Respondent's country of birth		
1 Born in Australia	88	85
2 Born overseas Eng speaking country	2	2
3 Born overseas non-Eng speaking country	6	10
4 Missing	3	2
Size of residential location in 1998		
10 Metropolitan area (over 100 000)	53	58
20 Regional area (1000 to 99 999)	25	20
30 Rural or remote (fewer than 1000)	20	21
Missing	2	2
School type in 1998		
1 Government	68	63
2 Catholic	21	22
3 Independent	11	15
All (%)	**100**	**100**
Total (N)	**3176**	**501**

Source: LSAY Y98 cohort, occupations defined in 2007 at average age of 24 years, excludes those whose occupations were undefined, those who were studying, and those who were unemployed.

Table 2 highlights that females, Indigenous students, those born in Australia, and those living in regional locations, and those attending government schools are less likely to work in a STEM career. Conversely, males, those born overseas in a non-English speaking country, those who went to school in metropolitan areas, and those who attended independent schools are more likely to work in a STEM career.

Table 3 Highest educational attainment and achievement of STEM and non-STEM occupations (%)

Total respondents (in final wave)	NON-STEM %	STEM %
Highest educational attainment		
Postgraduate degree (PhD/Masters)	1	2
Bachelor degree	26	62
Advanced diploma/diploma (incl. associate degree)	8	9
Graduate diploma/graduate certificate	2	3
Apprenticeship	11	1
Traineeship	9	2
Certificate IV	3	2
Certificate III	4	0
Certificate II	2	0
Certificate I	1	-
Certificate—level unknown	1	-
Short course	0	-
Other	1	1
No post-school study	31	16
Maths Achievement Quartiles		
1 Lowest Quartile	27	17
2 Second Quartile	31	20
3 Third Quartile	25	29
4 Highest Quartile	17	34
Total (%)	**100**	**100**
Total (N)	**3176**	**501**

Source: LSAY Y98 cohort, occupations defined in 2007 at average age of 24 years, excludes those whose occupations were undefined, those who were studying, and those who were unemployed.

In looking at the highest level of educational attainment for those working in STEM and non-STEM occupations, those in STEM occupations are substantially more likely to have a university degree or higher. Of those in STEM occupations, 62% have a university degree or higher, compared with 26% of those in non-STEM occupations.

Logistic regressions were again undertaken to determine those characteristics which might influence an individual to work in a STEM career. The results were similar to the characteristics of those likely to pursue STEM subjects in Year 12.

For the Y95 cohort, the variables which influence the decision whether or not to work in a STEM career were whether individual's undertook STEM at school or post-school and their ability in the arts and languages other than English. For example, those who perform well in arts at school are less likely to undertake a career in STEM, and those who perform well in languages other than English are more likely to undertake a career in STEM.

Considering the Y98 cohort, important variables influencing whether or not an individual is working in a STEM career were also whether a respondent undertook STEM at Year 12 and/or commenced post-school STEM study. Other important factors included the type of school which an individual attended, their father's educational level, respondent's future career aspirations, the school's student learning experience and school environment.

Table 4 presents the median gross weekly income of respondents in a STEM career versus those not in a STEM career. We can see that there are clear financial benefits from working in STEM, with STEM occupations earning $125 more per week. This may be due to the higher-level qualifications required to work in a STEM career.

Table 4 Median gross weekly income of STEM and non-STEM occupations

	NON-STEM		STEM		Total	
Y98	*n*	*$*	*n*	*$*	*n*	*$*
Median gross weekly income	1971	$825	449	$950	2420	$850

Source: LSAY Y98 cohort, occupations defined in 2007 at average age of 24 years.

Table 5 presents the same information but now includes the gross weekly earnings only for those in both STEM and non-STEM occupations who have a qualification level of diploma or higher. Here we see an increase in non-STEM median income, but no further increase for those in STEM occupations. This is because higher level qualifications are required for most STEM occupations.

Table 5 Median gross weekly income of STEM and non-STEM occupations with diploma or higher-level qualifications

	NON-STEM		STEM		Total	
Y98	*n*	*$*	*n*	*$*	*n*	*$*
Median gross weekly income	876	$850	370	$950	1246	$900

Source: LSAY Y98 cohort, occupations defined in 2007 at average age of 24 years.

Table 6 compares the employment outcomes of those who undertook STEM study post-school with those who did no post-school STEM study. Overall, those who pursue a STEM career are more likely to be working full-time than those working in a non-STEM career. The majority of those working in a STEM career are professionals and interestingly, the proportions are similar for those who undertook STEM post-school and those who did not. The main difference is that almost half of those who did not study STEM post-school, work in design, engineering, science and transport. In contrast, a larger proportion of those who undertook STEM post-school study work in health related areas.

Table 6 Comparison of employment outcomes between those who undertook STEM study post-school and those who did not (%)

	Post-school STEM study			
	Did STEM course		Did not do STEM course	
STEM Occupation	Not in STEM career	In STEM career	Not in STEM career	In STEM career
Total respondents (in final wave)	%	%	%	%
Labour Force Status				
Employed Full-Time	68	82	76	87
Employed Part-Time	31	18	22	12
Occupation at ANZSCO major group				
1 Mangers	7	-	8	-
2 Professionals	13	72	21	73
3 Technicians and trades workers	19	28	15	27
4 Community and professional service workers	18	-	13	-
5 Clerical and administrative workers	14	-	18	-
6 Sales workers	14	-	14	-
7 Machinery operators and drivers	4	-	4	-
8 Labourers	9	-	6	-
9 Not classifiable	2	-	1	-
Total (%)	**100**	**100**	**100**	**100**
Total (N)	**810**	**379**	**2083**	**113**
Median gross weekly income (full-time employed)				
Median gross weekly income ($)	$811	$975	$833	$900
Total (N)	**470**	**335**	**1359**	**106**

Source: LSAY Y98 cohort, occupations defined in 2007 at average age of 24 years, excludes those whose occupations were undefined, those who were studying, and those who were unemployed. Median gross weekly income is for full-time employed persons only and is unweighted.

Working in a STEM career also has a financial benefit but there is a better pay-off when undertaking post-school STEM courses. For those who are working in a STEM career, studying a STEM course post-school leads to higher weekly earnings than not studying STEM post-school. However, the financial benefit of studying STEM post-school appears to only pay-off when that pathway leads to a STEM career. For those not in a STEM career, those who undertook STEM study post-school earn less per week than those who did not study STEM post-school.

Career aspirations of individuals who do and do not work in a STEM career

Students were asked about future career aspirations when they were in Year 10, when most were aged 15.5 years. The results for the Y98[8] cohort are outlined below, aggregated by whether or not they work in a STEM career at age 24 years.

[8] Y98 was analysed rather than Y95, as there were fewer missing values in the Y98 cohort, although similar trends were evident in the Y95 analysis.

Table 7 Career aspirations of STEM and non-STEM occupations, Y98 wave 2 (%)

Career in 2007	STEM occupation			Non-STEM occupation		
	Males	Females	Total	Males	Females	Total
Career aspirations in Year 10	%	%	%	%	%	%
STEM career	45	46	45	17	14	16
Non-STEM career	29	31	30	46	57	51
Don't know	25	21	23	34	24	29
Missing	0	3	1	3	5	4
All (%)	**100**	**100**	**100**	**100**	**100**	**100**
Total (N)	**281**	**220**	**501**	**1663**	**1513**	**3176**

Source: LSAY Y98 cohort, occupations defined in 2007 at average age of 24 years, percentages may not sum to 100 due to rounding.

At age 15.5 years, around a quarter of students did not know what career they intended to work in when they left school. Just under half of students who wished to work in a STEM career did so. Interestingly, 16% of students who did not aspire to a STEM career in Year 10 were working in a STEM career at age 24 (table 7).

Those working in a non-STEM career were more decided on their occupation at age 15.5 than those whose final career was in a STEM occupation. Females working in a non-STEM career were more decided on this pathway at age 15.5 than males working in a non-STEM career or those working in a STEM career. Males working in non-STEM related areas were less likely to know what career they wanted to work in at age 15.5 years than their STEM counterparts (25% of males working in a STEM career stating 'don't know' compared with 34% of males not working in a STEM career stating 'don't know').

Factors which influence decisions to study STEM subjects

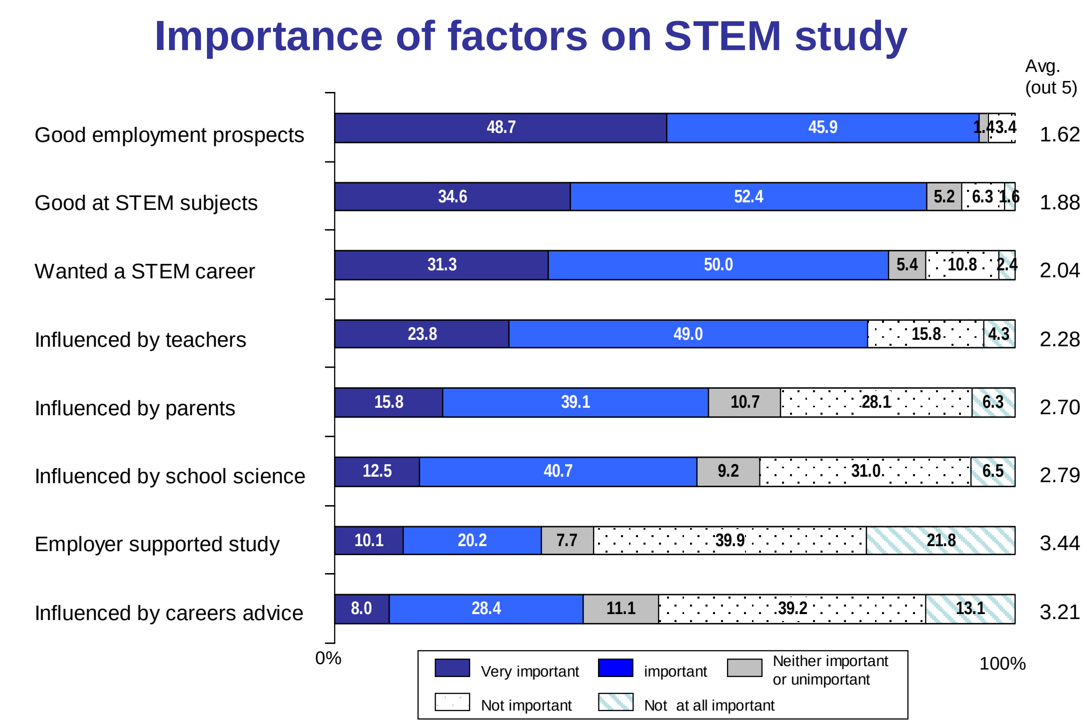
In this section, we use data from the Y03 cohort which contained an additional series of questions asked in 2007 at age 19 years, about factors which influence decisions whether or not to study STEM subjects post-school.

Factors which influence decisions about post-school STEM study

Of the 6657 young Australians who were in the Y03 LSAY cohort in 2007, a third indicated they studied STEM subjects in Year 12 and had gone on to post-school study. Of this group, just over half (55%) indicated that they were studying a science, engineering, mathematics or IT- related post-school course. Most of this self-identified post-school STEM study was in natural and physical sciences and health related courses.

Students studying these post-school STEM courses were asked about the importance of a range of factors on their decision to study science, engineering, maths or IT, the results of which are contained in the figure below.

Figure 5 Factors influencing decisions to study post-school STEM courses



Source: LSAY Y03, 2007 interviews, those who self-identified studying a STEM-related qualification post-school in 2007 n=1221.
*excludes don't know responses, 1 = very important, 5 = not at all important

The most important factors for young people in their decision to study STEM post-school were the employment prospects offered by STEM careers, a personal motivation to work in a career in this field, and school performance in STEM subjects. The influence of others was seen as being of relatively lesser importance, but having good science or maths teachers in high school was seen as influential for almost two-thirds of those who went on to post-school STEM study. Teachers were perceived as being more influential than parents, and more important as an influencing element than science-related experiences at high school. The influence of careers advice was seen as relatively unimportant.

There are, however, some differences by gender, as highlighted in table 8.

Table 8 Factors which influenced decisions about post-school STEM study by gender

Factor	% who rated it important or very important	
	Males (n=631)	Females (n=590)
Good employment prospects in liked areas	94.9	94.1
Wanted a STEM career	93.2	79.2
Good at STEM subjects	88.9	84.9
Influenced by good science and maths teachers	72.9	72.7
Influenced by parents	56.1	53.6
Influenced by school science experiences	52.9	53.4
Influenced by careers advise at school	34.2	38.8
Employer supported STEM study	26.7	34.1

Source: Y03 students studying in a STEM study area in 2007.

For males, performance in school STEM subjects and a personal drive to work in a STEM career appear to be the most important influences in their decision to seek work in a STEM occupation. For females, while these factors are also important, their personal desire for a STEM career is less important. However, the influence of others (namely employer support and school careers advice) is slightly more important than for males.

These findings are consistent with the regressions analysis in the earlier section on STEM subjects in Year 12, which highlighted that self-motivation (careers aspirations) and ability (performance in science) and the school learning environment are characteristics which differentiate those who study post-school STEM from those who do not. This suggests that factors which influence choices for post-school STEM study are well developed before students leave school.

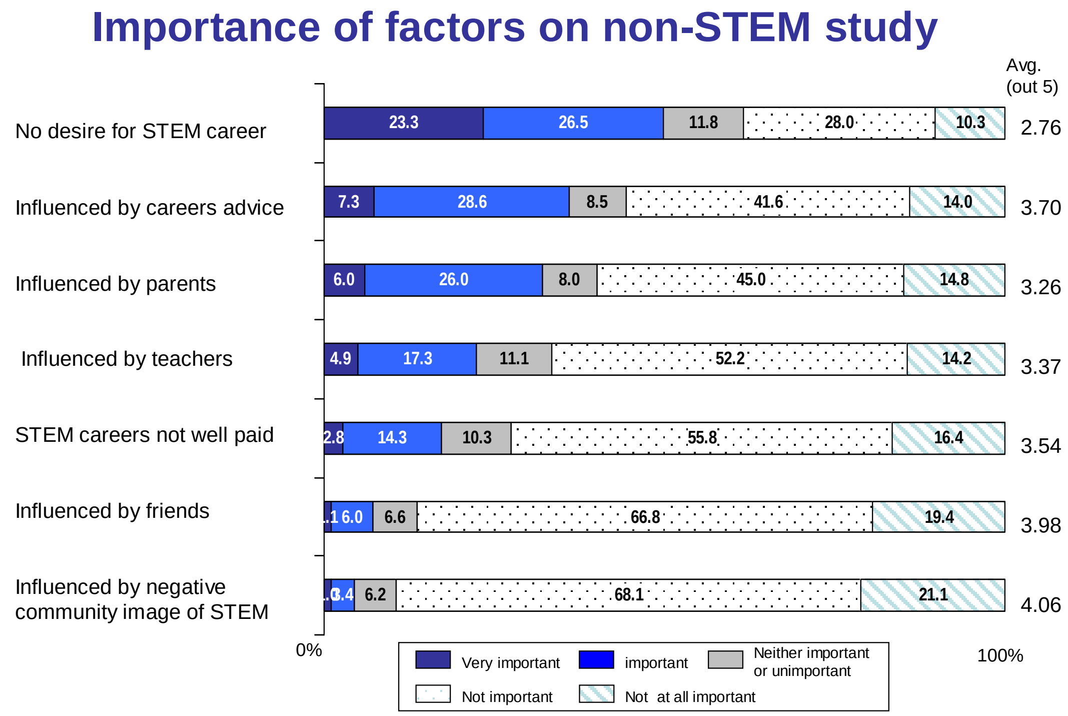
Factors which influence decisions about post-school study in areas other than STEM

Some 45% of 19 year olds in the Y03 cohort who had studied STEM subjects in Year 12 indicated that, although they were currently studying, it was in a non-STEM related field.

A third of this non-STEM study was in the field of management and commerce and a further 28% in society and culture fields. For females studying non-STEM courses, these two fields were equally popular; however, for males, there was a preference for management and commerce, accounting for 35% of their non-STEM study.

These students were asked about the importance of a range of factors on their decision to study in a non-STEM related field, the results of which are contained in figure 6.

Figure 6 Factors influencing decisions to study non-STEM post-school courses



Source: LSAY Y03, 2007 interviews, those who were studying, but not in a STEM-related qualification post-school in 2007 n=1013.
*excludes don't know responses, 1 = very important, 5 = not at all important

Similar to the analysis of factors which influence decisions about post-school STEM study, it is lack of personal motivation which drives the desire not to work in a STEM career. However, unlike motivators of post-school STEM study, the influence of others appears stronger in influencing non-STEM study, particularly from careers advisors. Negative community perceptions and the influence of friends have a negligible influence on choices not to study STEM subjects, with these factors having less impact on females than males, as demonstrated in table 9.

Table 9 Factors which influenced decisions for non-post-school STEM study by gender

Factor	% who rated it important or very important	
	Males (n=395)	Females (n=618)
No desire for STEM career	48.1	50.8
Influenced by advice from teacher or careers advisor	36.2	35.8
Influenced by parents	36.2	29.3
Would not be well paid	22.3	13.8
Science and maths teachers were uninspiring	22.3	22.1
Influenced by friends	8.4	6.3
Influenced by negative community perception of STEM	5.6	3.6

Source: Y03 students studying in 2007, but in non-STEM study areas.

For both males and females, the personal desire for a non-STEM career was the most important influence on their post-school study choices. The influence of parents and, to a lesser extent, their peers, was stronger for males than for females. The perception that STEM careers are not well paid is a more influential factor in the choice of non-STEM subjects for females, perhaps related more to the nature of STEM careers entered by females which tend to be in the health sciences, rather than the generally more highly paid male-dominated engineering occupations.

Factors which would need to be changed to consider studying post-school STEM

The majority (60%) of those who were studying non-STEM courses indicated that nothing could have influenced them to study science, engineering, or maths. Of those who indicated that they might have been influenced to study STEM, factors cited as potentially influential included better performance in STEM subjects at school, more STEM careers information, financial incentives to study STEM or higher perceived future remuneration, a more positive image for STEM careers, and better STEM teachers and teaching methods in school.

Table 10 Factors which would need to change to consider STEM study by gender

Factor	% who mentioned (verbatim)	
	Males (n=631)	Females (n=590)
Nothing	60.8	60.3
Better marks	9.1	10.3
More STEM careers information	8.6	6.8
Financial study incentives or future remuneration	4.8	3.4
Improved image of STEM career	2.8	3.2
Better teachers or teaching methods	1.5	2.8

* Source: Y03 students studying in 2007, but in non-STEM study areas, who suggested other factors.

In summary, this section has demonstrated that self-motivation in pursuing a career that has good employment prospects and a desire to study in an area of strong academic ability appear to be key motivators in post-school STEM study. The school environment also has a role to play in engaging students with science and other STEM subjects.

Self-motivation was slightly stronger for males than females, and males were less likely to be influenced by others. Having good science teachers in high school is seen as an important motivator for pursuing post-school STEM study for almost three-quarters of young people. Teachers are more influential on young people's decisions to undertake post-school STEM study than their actual science experiences in high school, and more influential than advice given by parents and careers advisors.

By comparing the importance given to careers advisors on decisions to study and not to study STEM subjects, we conclude that careers advisors are perceived to be more influential in steering young people away from, rather than into, STEM careers.

Of those students who studied STEM subjects in Year 12 but were undertaking post-school study in a non-STEM field, most indicated that nothing could have persuaded them to choose a STEM course. Of those who indicated that they may have been influenced to undertake a STEM course, better marks in STEM subjects in school and more STEM careers information were suggested as the most likely positive influences.

A key message from this section for those interested in encouraging young people to undertake post-school STEM study and work in a STEM career is the vital importance of effective and inspiring STEM teachers in secondary school, and good careers advice on the opportunities provided by STEM careers.

STEM changes over time

The following table compares the proportion of school STEM and post-school STEM students using data from the Y03, Y98 and Y95 cohorts at comparable ages[9]. The data on school STEM is taken from Year 12 study[10] and the post-school STEM is based on any study undertaken after leaving school. STEM occupations are measured in 2007 (Y98, Y03) and 2006 (Y95). All proportions are measured as the proportion of all students, irrespective of whether the study type or final occupation was known or unknown.

Table 11 Proportions in school STEM, post-school STEM, STEM careers (%)

	Year 12 STEM			Post-school STEM			STEM career		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
	%	%	%	%	%	%	%	%	%
Y03 (n = 6657)	59	51	55	-	-	-	-	-	-
Y98 (n = 4210)	63	55	59	38	27	32	13	11	12
Y95 (n = 3914)	64	57	60	46	32	39	14	11	12

Source: LSAY Y95, Y98, Y03 cohorts, proportions are of all respondents.

The proportion of students studying STEM subjects at school has decreased over time by an equivalent amount for males and females, with the percentage of males undertaking STEM in Year 12 declining from 68% in 1998 (Y95 cohort) to 59% in 2006 (Y03 cohort), and females declining from 60% in 1998 (Y95 cohort) to 51% in 2006 (Y03 cohort). The proportion of students studying post-school STEM also declined between the Y95 and Y98 cohorts, with a larger decrease in post-school STEM study by males, but from a larger base.

Interestingly, the proportion of students working in a STEM career changed little between the Y98 and Y95 cohorts, despite decreases in the proportion of students undertaking post-school STEM study. This data supports indications from the pathway analysis that there is movement into STEM occupations by those who are not studying school or post-school STEM subjects and courses.

Table 12 Proportions of high achievers in school STEM, post-school STEM, STEM careers (%)

	Year 12 STEM			Post-school STEM			STEM career		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
	%	%	%	%	%	%	%	%	%
Y98 (n = 1179)	81	72	77	48	37	43	23	18	21
Y95 (n = 1033)	79	73	77	58	43	53	23	19	21

Source: LSAY Y95 and Y98 cohorts, proportions are of all high achieving respondents.

Table 12 shows similar results for high achieving students as for other students. While greater proportions of students from the higher achieving quartiles study STEM in Year 12, study post-school STEM courses and work in STEM careers, the proportions have fallen for post-school STEM study, not for those going into a STEM career. Students from the higher achievement quartiles are twice as likely to end up working in a STEM career (21%) as all other students (12%).

[9] Data for the Y03 is unweighted; the Y98 and Y95 data is weighted to the wave 1 population.
[10] The Y03 cohort was mostly in Year 12 in 2006, the Y98 cohort was in Year 12 in 2001, and the Y95 cohort was in Year 12 in 1998.

Conclusion

The four sections in this report have provided an insight into where Australian STEM students are heading in terms of study and career choices. Between 2003 and 2007, there has been a clear decrease in the uptake of STEM subjects at school, and in students undertaking post-school STEM study. However, the proportion moving into a STEM career is holding steady at 12% of all students.

Of the two-thirds of Year 12 students who undertake STEM subjects at school, around half go on to post-school STEM study, and a third commence post-school STEM study and then go on to work in a STEM career.

Motivators for post-school STEM study are related strongly to academic ability in STEM subjects at school, the desire for a STEM career, and the perception that STEM careers have good employment prospects. The influence of others, aside from maths and science teachers, is not strong, but these teachers are perhaps the critical element in the decision about whether or not to work in a STEM career. The lesser role of careers advisors could be strengthened, as could information for parents and school students about career choices for young people. Factors which influenced decisions to study in non-STEM areas appear to be similar to those which influenced students to undertake STEM study; that is, knowledge of careers, ability and interest in the subject area.

These finding are consistent with other research (Adamuti-Trache 2006), which finds that teachers, parents and students themselves all have roles to play in encouraging science careers. However, the main determinants in the pursuit of STEM-related careers are students' attitudes towards school, decisions about post-secondary education, satisfaction with school results in science, and interest in working in the STEM area.

By comparing the importance given to careers advisors on decisions whether or not to study STEM subjects, it can be concluded that careers advisors are perceived as more influential in steering young people away from, rather than into, STEM careers.

This analysis has highlighted that one of the key motivators for people undertaking STEM studies, and working in a STEM career, is simply a desire to work in a career in STEM, followed by ability in science, mathematics and technology subjects. High achievers (those in the upper maths quartile) have a slightly greater propensity to undertake STEM post-school than the general population, and while one in five of these high achievers are going into a STEM career, we would expect this proportion to be larger. Therefore, in order to attract these students into STEM careers, there could be value in promoting the benefits of working in these occupations. Given that the LSAY analysis also shows there is a financial gain in working in a STEM career, this might provide careers advisors with information to encourage those who have the ability—but might otherwise head towards non-STEM careers—to consider undertaking a career in one of these many occupational areas. A further motivator is the influence of STEM teachers. The analysis clearly shows the importance of science and maths teachers motivating students to enjoy STEM and do well in STEM subjects, if we want them to work in STEM occupations and develop a long-term career in these areas.

References

Adamuti-Trache, M, 2006, *Who likes science and why? Individual, family and teacher effects*, University of British Columbia, Canada.

Ashby, C 2005, *Higher education: Federal science, technology, engineering, and mathematics programs and related trends*, United States Government Accountability Office, viewed June 2008, <http://www.gao.gov/new.items/d06114.pdf>.

ABS (Australian Bureau of Statistics) 1997, *Australian Standard Classification of Occupations*, Second Edition, cat.no.1220.0, ABS, Canberra.

—— 2001, *Australian Standard Classification of Education*, cat.no.1272.0, ABS, Canberra.

Department for Education and Skills 2004, *Report on the science, technology, engineering and maths (STEM) Mapping Review*, Department for Education and Skills, UK.

Department of Employment and Workplace Relations, *Australian Jobs 2007*, DEWR, Canberra.

Gillard, J 2008, *Budget: Education revolution 2008–2009*, Commonwealth of Australia, Canberra, viewed June 2008, <http://www.aph.gov.au/budget/2008-09/content/ministerial_statements/download/Education.pdf>.

Kuenzi, J, Matthews, C, Mangan, B 2006, *Science, Technology, Engineering, and Mathematics (STEM) education issues and legislative options*, CRS Report for Congress, US.

Lyon, T 2006, *The puzzle of falling enrolments in physics and chemistry courses: Putting some pieces together*, Research in Science Education, vol.36, no.3, pp.285–311.

Langen A & Dekkers, H 2005, 'Cross-national differences in participating in tertiary science, technology, engineering and mathematics education', *Comparative Education*, vol.41, no.3, pp.329–350, Radbound University, Netherlands.

NCVER 2008, *Australian vocational education and training statistics: Students and courses 2007*, NCVER, Adelaide.

Queensland Government, Department of Education, Training and the Arts, 2007, *Towards a 10 year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland—Discussion paper*, viewed June 2008, <http://education.qld.gov.au/projects/stemplan/docs/stem-discussion-paper.pdf>.

Tyson, W, Borman, K, Hanson, M & Lee R, 2006, *Growing STEM students: High school pathways and STEM degree attainment*, paper presented at the annual meeting of the American Sociological Association, Montreal Convention Center, Montreal, Quebec, Canada, Aug 11, 2006, viewed June 2007, <http://www.allacademic.com/meta/p104344_index.html>.

Tytler, R 2007, *Re-imagining science education: Engaging students in science for Australia's future*, Australian Council for Educational Research, Melbourne.

Appendix A: STEM classifications

STEM post-school study

The Australian Standard Classification for Education (ASCED) (ABS 2001) was used for the classification of the post-school qualifications. Whilst not able to explicitly differentiate between qualification levels, it does provide a description of the nature of the course. ASCED is generally hierarchical, with the lower numbered codes within a category classification requiring higher levels of study. In our definitions we have tried to align the commencing post-school STEM study with the types of occupations which are in the STEM field (i.e. aligning ASCO and ASCED).

The following categories were included in our definition of commencing post-school STEM study:

ASCED 01 Natural and physical sciences

- All included

ASCED 02 Information technology

- All included

ASCED 03 Engineering and related technologies

- 030101 Manufacturing engineering included only with 0301
- 0303 process and resource engineering—all included
- 03050501 Automotive engineering only included in 0305
- 030701 Mechanical engineering and industrial engineering only included in 0307
- All 0309 civil engineering included
- All 0311 geomatic engineering included
- 031301 electrical engineering, 031303 electronic engineering and 031305 computer engineering included within 0313
- 031501 aerospace engineering, 031505 aircraft operation and 031507 air traffic control included in 0315
- 031701 maritime engineering, 031705 marine craft operation included from 0317
- 039901 environmental engineering and 039903 biomedical engineering included within 0399

ASCED 04 Architecture and building

- 040101 architecture and 040103 urban design and regional planning included from 0401
- 040301 building science and technology and 040305 building surveying included in 0403

ASCED 05 Natural and physical sciences

- 050101 agriculture science and 050103 wool science included from 0502
- All 0503 horticulture and viticulture included
- Excluded 0505 forestry studies, 0507 fisheries studies, 0509 environmental studies and 0599 other agriculture, environment and related studies

ASCED 06 Health

- 0601 medical studies, 0603 nursing and 0605 pharmacy all included
- 060701 dentistry included but not dental assisting, etc.

- 0609 optical science all included
- 061101 veterinary science included, but not veterinary assisting, etc.
- Only 061311 epidemiology included from public health (0613)
- All 0615 radiology included
- Included from rehabilitation therapies only 061701 physiotherapy, 061703 occupational therapy, 061705 chiropractic and osteopathy, 061707 speech pathology, 061709 audiology and 061713 podiatry included. Excluded were 061711 massage therapy and 061799 rehabilitation therapies, n.e.c
- 0619 complementary therapies excluded
- 0699 other health, included 069901 nutrition and dietics, 069903 human movement, 069905 paramedical studies, excluded 069907 first aid and other non-defined (069999).

The following ASCED classifications were excluded:

- 07 Education—not able to define specifically whether maths, science, technology or engineering teachers
- 08 Management and commerce—in keeping with not including business and information professionals in the ASCO classifications
- 09 Society and culture—predominantly arts
- 10 Creative arts
- 11 Food, hospitality and personal services
- 12 Mixed field programs.

STEM occupation

The ABS standards for classifying occupations was used to define STEM occupations within the relevant year. Each LSAY cohort was asked about their occupational aspirations and destinations. These include the Australian Standard Classification of Occupations (ASCO first edition), Australian Standard Classification of Occupations (ASCO second edition), and the Australian and New Zealand Standard Classification of Occupations (ANZSCO first edition). The focus was on occupations requiring higher skill levels above certificate III level. As an example, the following categories were included in our definition of STEM occupations using the ASCO second edition:

ASCO 1 Manager and Administrator

- Excluded managers and administrators (e.g. ASCO 1) because although most occupations in this grouping have a high skill level, it is not possible to determine whether a title such as ‘general manager’ relates to STEM specific occupations. The nature of their work is more strategic than technically focused.

ASCO 2 Professionals

- Included all science, building and engineering professional (e.g. ASCO 21)
- Excluded business and information specialists (e.g. ASCO 22) with the exception of 223 computer professionals and 2293 mathematicians, statisticians and actuaries because most of these are accountancy type professions.
- Included all health professionals (e.g. ASCO 23)
- Excluded all teachers (e.g. ASCO 24) because in ASCO we are not able to differentiate between maths and science teachers and other teachers.
- Included urban and regional planners (e.g. ASCO 2523)
- Included pilots and sea captains (e.g. ASCO 2541, 2542).

ASCO 3 Associate professionals

- Included all science, engineering and related associate professionals (e.g. ASCO 31) only from this category.

Exclusions

All the following ASCO occupational categories were excluded, as these occupations relate more to skill levels at certificate III level or lower. Similar occupations, requiring higher-level qualifications are included in the Professionals (e.g. ASCO 2) and Associate professionals (e.g. ASCO 3) classifications:

- ASCO 4 Tradespersons and related workers
- ASCO 5 Advanced clerical and service workers
- ASCO 6 Intermediate clerical, sales and service workers
- ASCO 7 Intermediate production and transport workers
- ASCO 8 Elementary clerical, sales and service workers
- ASCO 9 Labourers and related workers.

Appendix B

The results of the regression analysis are contained in the following tables.

Table B1 Regression results: Yr 12 STEM—all respondents, Y95 cohort

Variable	Level	Estimate	StdErr	ProbChiSq	Label
Intercept		0.203	0.736	0.783	Intercept: Stem_Sub=N
STATE	1 ACT	0.099	0.581	0.864	State of school attended In 1995 1 ACT
STATE	2 NSW	0.389	0.505	0.441	State of school attended In 1995 2 NSW
STATE	3 VIC	-0.030	0.505	0.953	State of school attended In 1995 3 VIC
STATE	4 QLD	1.135	0.516	0.028	State of school attended In 1995 4 QLD
STATE	5 SA	-0.105	0.520	0.841	State of school attended In 1995 5 SA
STATE	6 WA	1.092	0.526	0.038	State of school attended In 1995 6 WA
STATE	7 TAS	-0.998	0.560	0.075	State of school attended In 1995 7 TAS
SEX	1 Male	0.623	0.097	0.000	Sex 1 Male
M_ACHQ	1 Lowest Quartile	0.410	0.408	0.315	Maths achievement quartiles 1 Lowest Quartile
M_ACHQ	2 Second Quartile	0.424	0.404	0.294	Maths achievement quartiles 2 Second Quartile
M_ACHQ	3 Third Quartile	0.700	0.404	0.083	Maths achievement quartiles 3 Third Quartile
M_ACHQ	4 Highest Quartile	1.095	0.412	0.008	Maths achievement quartiles 4 Highest Quartile
EDUC_F5	1 Didn't complete Sec school	-0.026	0.128	0.841	Father's Education: 5 Categories 1 Didn't complete Sec school
EDUC_F5	2 Completed Sec school	-0.555	0.145	0.000	Father's Education: 5 Categories 2 Completed Sec school
EDUC_F5	3 TAFE/Apprenticeship	-0.093	0.140	0.507	Father's Education: 5 Categories 3 TAFE/Apprenticeship
EDUC_F5	4 University Qualification	-0.187	0.134	0.163	Father's Education: 5 Categories 4 University Qualification
Carasp		-0.092	0.169	0.586	
Carasp	1	-1.126	0.289	0.000	Carasp 1
Carasp	2	-0.093	0.151	0.539	Carasp 2
Carasp	3	0.449	0.237	0.058	Carasp 3
Carasp	4	-0.300	0.220	0.173	Carasp 4
Carasp	5	-1.035	0.324	0.001	Carasp 5
Carasp	6	-0.053	0.237	0.823	Carasp 6
Carasp	7	-2.791	0.880	0.002	Carasp 7
Carasp	8	1.436	0.699	0.040	Carasp 8
AA005	1 Average or above	0.431	0.303	0.156	Self-concept of Ability: Maths 1 Average or above
AA005	2 Below average	-0.046	0.323	0.887	Self-concept of Ability: Maths 2 Below average
BA004B	1 Average or above	-0.126	0.383	0.742	A4b How well in subject: Mathematics 1 Average or above
BA004B	2 Below average	-0.630	0.398	0.113	A4b How well in subject: Mathematics 2 Below average
BA004E	1 Average or above	-0.189	0.299	0.528	A4e How well in subject: Science 1 Average or above
BA004E	2 Below average	-1.172	0.329	0.000	A4e How well in subject: Science 2 Below average
BA004F	1 Average or above	-0.251	0.105	0.017	A4f How well in subject: Arts 1 Average or above
BA004F	2 Below average	0.479	0.307	0.119	A4f How well in subject: Arts 2 Below average
BA004H	1 Average or above	0.432	0.104	0.000	A4h How well in subject: Technology 1 Average or above
BA004H	2 Below average	0.055	0.258	0.830	A4h How well in subject: Technology 2 Below average
BA012	.	-0.825	0.319	0.010	A12 Did you take part in work experience in 1996.
BA012	2 No	-0.370	0.110	0.001	A12 Did you take part in work experience in 1996 2

Table B2 Regression results: Yr 12 STEM—male respondents, Y95 cohort

Variable	Level	Estimate	StdErr	ProbChiSq	Label
Intercept		3.020	1.454	0.038	Intercept: Stem_Sub=N
EDUC_F5	1 Didn't complete Sec school	-0.122	0.427	0.774	Father's Education: 5 Categories 1 Didn't complete Sec school
EDUC_F5	2 Completed Sec school	-0.467	0.446	0.295	Father's Education: 5 Categories 2 Completed Sec school
EDUC_F5	3 TAFE/Apprenticeship	1.917	0.641	0.003	Father's Education: 5 Categories 3 TAFE/Apprenticeship
Carasp	1	-2.720	0.834	0.001	Carasp 1
Carasp	2	-0.261	0.489	0.594	Carasp 2
Carasp	3	0.199	0.737	0.788	Carasp 3
Carasp	4	-0.412	0.624	0.509	Carasp 4
Carasp	6	-2.379	1.144	0.038	Carasp 6
Carasp	7	-3.288	1.114	0.003	Carasp 7
Carasp	8	-0.450	1.517	0.767	Carasp 8
BA004E	1 Average or above	-2.061	1.419	0.146	A4e How well in subject: Science 1 Average or above
BA004E	2 Below average	-3.951	1.460	0.007	A4e How well in subject: Science 2 Below average
BA004H	1 Average or above	1.215	0.393	0.002	A4h How well in subject: Technology 1 Average or above
BA004H	2 Below average	0.435	0.797	0.585	A4h How well in subject: Technology 2 Below average
BA012	2 No	0.898	0.380	0.018	A12 Did you take part in work experience in 1996 2

Table B3 Regression results: Yr 12 STEM—female respondents, Y95 cohort

Variable	Level	Estimate	StdErr	ProbChiSq	Label
Intercept		2.320	2.024	0.252	Intercept: Stem_Sub=N
STATE	1 ACT	-0.983	1.378	0.476	State of school attended In 1995 1 ACT
STATE	2 NSW	0.101	1.190	0.933	State of school attended In 1995 2 NSW
STATE	3 VIC	-0.454	1.190	0.703	State of school attended In 1995 3 VIC
STATE	4 QLD	1.114	1.222	0.362	State of school attended In 1995 4 QLD
STATE	5 SA	-0.274	1.239	0.825	State of school attended In 1995 5 SA
STATE	6 WA	1.009	1.256	0.422	State of school attended In 1995 6 WA
STATE	7 TAS	-1.483	1.412	0.294	State of school attended In 1995 7 TAS
M_ACHQ	1 Lowest Quartile	-1.097	0.413	0.008	Maths achievement quartiles 1 Lowest Quartile
M_ACHQ	2 Second Quartile	-0.721	0.321	0.025	Maths achievement quartiles 2 Second Quartile
M_ACHQ	3 Third Quartile	-0.223	0.326	0.494	Maths achievement quartiles 3 Third Quartile
SIZE	10 Metropolitan area (over 100,000)	-0.046	0.321	0.885	Size of place of residence 10 Metropolitan area (over 100,000)
SIZE	20 Regional area (1,000 to 99,999)	-0.759	0.361	0.036	Size of place of residence 20 Regional area (1,000 to 99,999)
EDUC_M5	1 Didn't complete Sec school	-0.705	0.303	0.020	Mother's Education: 5 Categories 1 Didn't complete Sec school
EDUC_M5	2 Completed Sec school	-0.301	0.361	0.404	Mother's Education: 5 Categories 2 Completed Sec school
EDUC_M5	3 TAFE/Apprenticeship	-1.340	0.476	0.005	Mother's Education: 5 Categories 3 TAFE/Apprenticeship
EDUC_F5	1 Didn't complete Sec school	0.837	0.361	0.021	Father's Education: 5 Categories 1 Didn't complete Sec school
EDUC_F5	2 Completed Sec school	-0.041	0.377	0.913	Father's Education: 5 Categories 2 Completed Sec school
EDUC_F5	3 TAFE/Apprenticeship	0.649	0.339	0.056	Father's Education: 5 Categories 3 TAFE/Apprenticeship
HEL	1 University Degree or Higher	0.313	0.505	0.535	Highest Educational Attainment 1 University Degree or Higher
HEL	2 Advanced Diploma/Diploma	1.067	0.638	0.094	Highest Educational Attainment 2 Advanced Diploma/Diploma
HEL	3 Traineeship	-0.661	0.605	0.275	Highest Educational Attainment 3 Traineeship
HEL	4 Certificate III & IV	-0.958	0.616	0.120	Highest Educational Attainment 4 Certificate III & IV
HEL	5 Certificate I & II	0.081	0.810	0.921	Highest Educational Attainment 5 Certificate I & II
HEL	6 Certificate n.f.d	-1.226	1.961	0.532	Highest Educational Attainment 6 Certificate

Variable	Level	Estimate	StdErr	ProbChiSq	Label
					n.f.d
HEL	No Post School	-0.217	0.495	0.662	Highest Educational Attainment No Post School
HEL	Other Post School	14.429	1132.627	0.990	Highest Educational Attainment Other Post School
Carasp	1	-1.314	0.659	0.046	Carasp 1
Carasp	2	-0.431	0.350	0.217	Carasp 2
Carasp	3	-0.711	0.527	0.178	Carasp 3
Carasp	4	-1.330	0.591	0.024	Carasp 4
Carasp	5	-2.141	0.715	0.003	Carasp 5
Carasp	6	-0.051	0.528	0.923	Carasp 6
Carasp	8	15.072	1218.470	0.990	Carasp 8
BA004A	1 Average or above	-1.716	0.971	0.077	A4a How well in subject: English 1 Average or above
BA004B	1 Average or above	1.107	0.937	0.237	A4b How well in subject: Mathematics 1 Average or above
BA004B	2 Below average	-0.114	0.983	0.908	A4b How well in subject: Mathematics 2 Below average
BA004C	1 Average or above	-0.479	0.332	0.149	A4c How well in subject: Humanities and Social Sciences 1 Average or above
BA004C	2 Below average	-3.577	1.203	0.003	A4c How well in subject: Humanities and Social Sciences 2 Below average
BA004E	1 Average or above	0.749	0.582	0.198	A4e How well in subject: Science 1 Average or above
BA004E	2 Below average	-0.142	0.709	0.841	A4e How well in subject: Science 2 Below average
BA004H	1 Average or above	0.381	0.246	0.121	A4h How well in subject: Technology 1 Average or above
BA004H	2 Below average	-1.307	0.804	0.104	A4h How well in subject: Technology 2 Below average
BA012	2 No	-0.901	0.268	0.001	A12 Did you take part in work experience in 1996 2
CA020	0 No	0.511	0.258	0.048	A20 Work experience at school 0 No

Table B4 Regression results: Yr 12 STEM—maths achievers, Y95 cohort

Variable	Level	Estimate	StdErr	ProbChiSq	Label
Intercept		-3.682	3.172	0.246	Intercept: Stem_Sub=N
EDUC_M5	1 Didn't complete Sec school	-1.953	0.597	0.001	Mother's Education: 5 Categories 1 Didn't complete Sec school
EDUC_M5	2 Completed Sec school	-0.077	0.716	0.915	Mother's Education: 5 Categories 2 Completed Sec school
EDUC_M5	3 TAFE/Apprenticeship	-0.910	0.781	0.244	Mother's Education: 5 Categories 3 TAFE/Apprenticeship
EDUC_F5	1 Didn't complete Sec school	1.506	0.764	0.049	Father's Education: 5 Categories 1 Didn't complete Sec school
EDUC_F5	2 Completed Sec school	0.412	0.637	0.518	Father's Education: 5 Categories 2 Completed Sec school
EDUC_F5	3 TAFE/Apprenticeship	1.660	0.682	0.015	Father's Education: 5 Categories 3 TAFE/Apprenticeship
Carasp	1	-4.391	1.326	0.001	Carasp 1
Carasp	2	-0.220	0.633	0.729	Carasp 2
Carasp	3	1.309	1.393	0.347	Carasp 3
Carasp	4	-1.006	1.174	0.392	Carasp 4
Carasp	6	-1.475	1.158	0.203	Carasp 6
Carasp	8	12.837	1724.415	0.994	Carasp 8
BA004B	1 Average or above	3.103	0.883	0.000	A4b How well in subject: Mathematics 1 Average or above
BA004E	1 Average or above	-0.232	1.811	0.898	A4e How well in subject: Science 1 Average or above
BA004E	2 Below average	-3.354	1.984	0.091	A4e How well in subject: Science 2 Below average
BA004H	1 Average or above	0.902	0.448	0.044	A4h How well in subject: Technology 1 Average or above
BA004H	2 Below average	-1.545	1.410	0.273	A4h How well in subject: Technology 2 Below average
BA011C	1 Average or above	2.659	2.390	0.266	A11c School Overall: Student learning 1 Average or above

Variable	Level	Estimate	StdErr	ProbChiSq	Label
BA011C	2 Below average	-0.991	2.663	0.710	A11c School Overall: Student learning 2 Below average

Table B5 Regression results: STEM occupations—all respondents, Y95 cohort

Variable	Level	Estimate	StdErr	ProbChiSq	Label
Intercept		-1.243	0.605	0.040	Intercept: STEM_Oc2=N
HEL	1 University Degree or Higher	0.897	0.469	0.056	Highest Educational Attainment 1 University Degree or Higher
HEL	2 Advanced Diploma/Diploma	-1.251	0.910	0.169	Highest Educational Attainment 2 Advanced Diploma/Diploma
HEL	3 Apprenticeship	-1.052	1.243	0.398	Highest Educational Attainment 3 Apprenticeship
HEL	3 Traineeship	-0.635	0.795	0.424	Highest Educational Attainment 3 Traineeship
HEL	4 Certificate III & IV	-0.170	0.761	0.823	Highest Educational Attainment 4 Certificate III & IV
HEL	5 Certificate I & II	-1.417	1.269	0.264	Highest Educational Attainment 5 Certificate I & II
HEL	6 Certificate n.f.d	0.422	1.320	0.749	Highest Educational Attainment 6 Certificate n.f.d
HEL	No Post School	0.570	0.460	0.215	Highest Educational Attainment No Post School
HEL	Other Post School	1.366	1.479	0.356	Highest Educational Attainment Other Post School
JobAsCareer	0 No	-0.317	0.488	0.516	Job want as a final career 0 No
JobAsCareer	1 Yes	0.617	0.446	0.166	Job want as a final career 1 Yes
BA004F	1 Average or above	-0.540	0.210	0.010	A4f How well in subject: Arts 1 Average or above
BA004F	2 Below average	-0.917	0.674	0.174	A4f How well in subject: Arts 2 Below average
BA004G	1 Average or above	0.522	0.217	0.016	A4g How well in subject: LOTE 1 Average or above
BA004G	2 Below average	0.701	0.500	0.161	A4g How well in subject: LOTE 2 Below average
Stem_Sub	N	-0.736	0.342	0.031	Undertook more than 2 STEM subjects in Year 12 N
Stem_Sub	NA	0.307	0.502	0.541	Undertook more than 2 STEM subjects in Year 12 NA
STEM_Stu	N	-3.025	0.311	0.000	Undertook STEM Course in post-school studies N
STEM_Stu	NA	-2.659	0.778	0.001	Undertook STEM Course in post-school studies NA

Table B6 Regression results: STEM occupations—male respondents, Y95 cohort

Variable	Level	Estimate	StdErr	ProbChiSq	Label
Intercept		-0.285	0.591	0.630	Intercept: STEM_Oc2=N
COB_S3	1 Born in Australia	-1.411	0.455	0.002	Respondent's Country of Birth: 3 Categories 1 Born in Australia
COB_S3	2 Born overseas Eng Speaking country	-1.519	0.830	0.067	Respondent's Country of Birth: 3 Categories 2 Born overseas Eng Speaking country
JobAsCareer	0 No	-0.530	0.599	0.377	Job want as a final career 0 No
JobAsCareer	1 Yes	0.634	0.553	0.251	Job want as a final career 1 Yes
Stem_Sub	N	-2.498	0.784	0.001	Undertook more than 2 STEM subjects in Year 12 N
Stem_Sub	NA	-0.181	0.469	0.699	Undertook more than 2 STEM subjects in Year 12 NA

Table B7 Regression results: STEM occupations—female respondents, Y95 cohort

Variable	Level	Estimate	StdErr	ProbChiSq	Label
Intercept		0.937	0.813	0.249	Intercept: STEM_Oc2=N
M_ACHQ	1 Lowest Quartile	-0.626	0.506	0.216	Maths achievement quartiles 1 Lowest Quartile
M_ACHQ	2 Second Quartile	-1.204	0.440	0.006	Maths achievement quartiles 2 Second Quartile
M_ACHQ	3 Third Quartile	-0.479	0.377	0.204	Maths achievement quartiles 3 Third Quartile
JobAsCareer	0 No	-0.494	0.829	0.551	Job want as a final career 0 No

Variable	Level	Estimate	StdErr	ProbChiSq	Label
JobAsCareer	1 Yes	0.586	0.765	0.444	Job want as a final career 1 Yes
BA004F	1 Average or above	-1.199	0.339	0.000	A4f How well in subject: Arts 1 Average or above
BA004F	2 Below average	-16.484	1684.918	0.992	A4f How well in subject: Arts 2 Below average
BA012	2 No	-0.741	0.335	0.027	A12 Did you take part in work experience in 1996 2
STEM_Stu	N	-4.331	0.567	0.000	Undertook STEM Course in post-school studies N
STEM_Stu	NA	-17.560	1695.864	0.992	Undertook STEM Course in post-school studies NA

Table B8 Regression results: STEM occupations—maths achievers, Y95 cohort

Variable	Level	Estimate	StdErr	ProbChiSq	Label
Intercept		1.269	0.910	0.163	Intercept: STEM_Oc2=N
JobAsCareer	0 No	-1.303	0.785	0.097	Job want as a final career 0 No
JobAsCareer	1 Yes	-0.396	0.709	0.577	Job want as a final career 1 Yes
BA004B		-0.474	0.222	0.033	A4b How well in subject: Mathematics
BA004C	1 Average or above	0.355	0.516	0.492	A4c How well in subject: Humanities and Social Sciences 1 Average or above
BA004C	2 Below average	3.534	1.154	0.002	A4c How well in subject: Humanities and Social Sciences 2 Below average
BA012	2 No	-0.930	0.380	0.014	A12 Did you take part in work experience in 1996 2
STEM_Stu	N	-3.560	0.590	0.000	Undertook STEM Course in post-school studies N
STEM_Stu	NA	-1.832	1.477	0.215	Undertook STEM Course in post-school studies NA