National Institute of Labour Studies
Flinders University, Adelaide, Australia

Do STEM graduates command a premium?

Tom Karmel and David Carroll

Table of Contents

.... i

Executive Summary v

1 Introduction 1

2. Some context 2

3. Outcomes for STEM graduates 4

4. Proportion of STEM graduates going to STEM jobs 8

5. Is there a premium for STEM graduates? 12

6. Discussion 17

References 18

APPENDIX 1: FIELD OF EDUCATION 20

Tables

Table 1: Percentage of new graduate being in full-time work or full-time study, by field of study, 2008-2015 . 5

Table 2: Percentage of graduates in full-time work, 2008 and 2015, by field of study.................................... 6

Table 3: Estimate of the percentage of graduates in full-time employment after completing a contiguous period of study (one or more awards), 2008-2015, by field of study 8

Table 4: Definition of STEM occupations, by STEM field of study 9

Table 5: Percentage of STEM graduates (under graduate awards) in matched occupation, full-time employed, average 2008-2015 10

Table 6: Quality of jobs by whether graduate is in a matched occupation or not, full-time employed, pooled data over 2008-2015.. 11

Table 7: Job outcomes for STEM and non-STEM graduates by major occupational groups 13

Table 8: Distribution of graduates in full-time employment across ANZSCO major groups 14

Table 9: ABS skill level, starting annual salaries and average occupational annual salaries of STEM and non-STEM graduates.. 15

Table 10: Decomposition of the premium of STEM graduates in average starting salaries 16

Table 11: Decomposition of the premium of STEM graduates in occupational average annual salaries....... 16

Figures

Figure 1: Domestic undergraduate completions, by field of study, 2001-2015 3

Figure 2: Domestic undergraduate completions, shares by field of study, 2001-15 4

Figure 3: Proportion of STEM graduates in a STEM occupation, by field of study, 2008-2015..................... 10

Executive Summary

Governments tend to have a very positive perspective on the benefits of study in STEM fields, in contrast with some commentators who observe that the labour market is not particularly good for STEM graduates. Our focus is which of these two perspectives is supported by data from the Graduate Destination Survey. Relevant questions are whether the employment prospects for STEM graduates are good, whether the labour market is valuing the vocational skills of STEM graduates (that is, salaries in matched STEM jobs) and whether the labour market is valuing the general skills of STEM graduates (which we would observe by a premium to STEM graduates in non-matched jobs).

On balance, we find that STEM graduates have reasonably positive outcomes in the labour market, and therefore it does little harm to encourage prospective student to study in STEM fields relative to other fields. On the other hand, there is nothing to suggest that non-STEM graduates are missing out on huge opportunities by not studying in STEM fields, and there is no evidence for an undersupply of STEM graduates overall.

Science, mathematics, and engineering and technology graduates have quite good transitions with relatively small numbers being in neither full-time work nor study four months after graduation. However, the other STEM fields have poorer outcomes with the life sciences, agriculture and environment, and information technology graduates having quite poor average outcomes.

Of those in full-time work, STEM graduates do pretty well:

- Overall, they are a little more likely to be in a managerial, professional or technical/trade job compared to non-STEM graduates.
- Their STEM skills are valued in the labour in respect of both vocational and general skills.

We see that STEM graduates do much better if they can find a STEM job compared to a job in a non-STEM field. At the same time we see that quite a small proportion of STEM graduates transition to a STEM job.

It is interesting to note that, graduates in mathematics and information technology and agriculture and environment get better paid jobs if they get a STEM job *other than one in a matched field*. For example, mathematical science graduates get paid more if they get a STEM job not as a mathematician. This suggests that the demand for mathematicians and agricultural/environmental scientists is limited, but the skills obtained in those fields are valued in other STEM jobs.

Also, STEM graduates get better jobs than non-STEM graduates if they obtain a job in any occupational group except community and personal service and sales. If we look at the quality of jobs STEM graduates obtain overall (of those in full-time employment), on two measures (starting salary and average occupational salary) STEM graduates do attract a premium compared to non-STEM graduates. Most of this premium is explained by the quality of the jobs that STEM graduates obtain in the ‘professional’ occupational group.

These general positive findings are consistent with experience overseas which shows that on the whole STEM graduates do well.

On the basis of these results, one would not be overly concerned about the numbers of STEM graduates. On one hand, the STEM graduates are doing reasonably well in the labour market, but on the other hand there is nothing to suggest that the labour market is screaming out for more STEM graduates.

1 Introduction

STEM – science, technology, engineering and mathematics - has received considerable policy attention in recent years, being seen as critical for Australia's future. For example, in 2015-16 the Australian Government committed an extra $12 million to 'restore the focus, and increase student uptake of, science, technology, engineering and mathematics (STEM) subjects in primary and secondary schools across the country.' [2]

'Restoring the focus on STEM subjects is about ensuring Australia's young adults are equipped with the necessary skills for the economy of the future.

Encouraging school students to study STEM subjects and showing them some of the great careers built on science, engineering, maths and technology will also help secure the nation's future. Starting this interest at the school level will help increase the number of students taking up STEM subjects in higher education and in their careers and help keep Australia competitive internationally in these important fields.'

On the other hand, commentators such as Andrew Norton (2016) point out that many recent science and information technology graduates are failing to find full-time work despite STEM education being a priority for government and industry.

He comments 'Prospective students thinking about studying science need to know that a bachelor science degree is high risk for finding a job.'

This ambivalence is consistent with experience elsewhere, especially in the United States, where we see papers such as 'The STEM crisis: Reality or Myth' (Anft 2013) and 'The STEM crisis is a myth' (Charette 2013) which contrast government rhetoric extolling the need for more STEM graduates with the realities of the labour market (see also Stevenson 2014; Craig *et al*. 2011; Langdon *et al.* 2011, Xue and Larson 2015). We see similar discussion in the United Kingdom (Smith and Gorard 2011).

The aim of this paper is to drill deeper into the destinations of STEM graduates, based on Graduate Destination Survey (GDS) data for 2008 to 2015, to see how new STEM graduates are faring in the labour market.

Ideally, we would compare the outcomes of those choosing STEM fields with those with the same characteristics who chose other fields. However, this is not possible from the GDS data because the range of background characteristics is very poor, and the likelihood that those choosing STEM fields are different in some unmeasurable way. However, what we can do is to look in some detail about the jobs that STEM graduates do get, and the extent to which STEM graduates are getting jobs in STEM occupations. Further, we can look at the extent to which STEM graduates are valued relative to other graduates by looking at the salary of STEM graduates relative to other graduates in both STEM jobs and non-STEM jobs. Essentially, we can look at whether STEM graduates command some sort of premium in the job market.

Before we start we need to define what we mean by STEM. The definition used by the Australian Bureau of Statistics (2014) is that STEM comprises:

- Natural and Physical Sciences (NPS)
- Information Technology (IT)
- Engineering and Related Technologies (ERT)
- Agriculture, Environmental and Related Studies (AERS)

[2] https://www.studentsfirst.gov.au/restoring-focus-stem-schools-initiative, accessed 21 June 2017

While this definition is arguable – for example, fields such as architecture and building, health and economics have very strong science or mathematics components - it is the one used by the Australian Bureau of Statistics, and the one we adopt for this paper.

We start with some simple context by looking at numbers of enrolments in STEM and non-STEM fields over time (Section 2). Section 3 looks at outcomes for those in STEM fields, using a three way split: full-time employment, full-time study, and those neither in full-time employment nor full-time study. The fourth section considers the match of study and jobs, in particular how many STEM graduates go into STEM jobs. We then look at the job quality for those gaining full-time employment in Section 5. We consider a number of aspects:

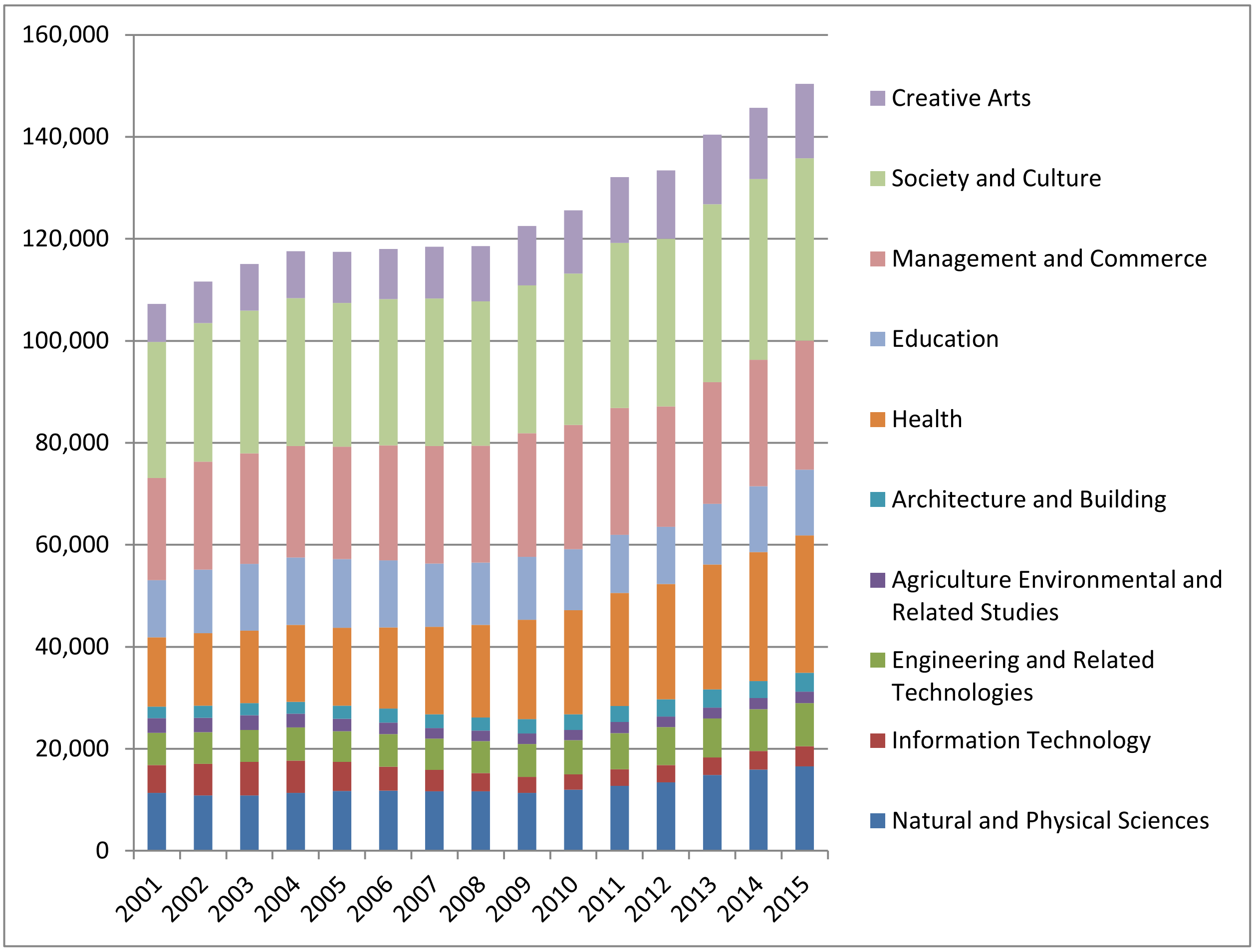
- How does the average job quality for STEM graduates compare to non-STEM graduates?
- What proportion of STEM graduates is going on to STEM occupations?
- To what extent do non-STEM graduates go to STEM occupations?
- Do STEM graduates command a premium in non-STEM occupations? (premium in this case would be in terms of starting salary). Do they command a premium in STEM occupations?

The paper ends with a brief discussion,

2. Some context

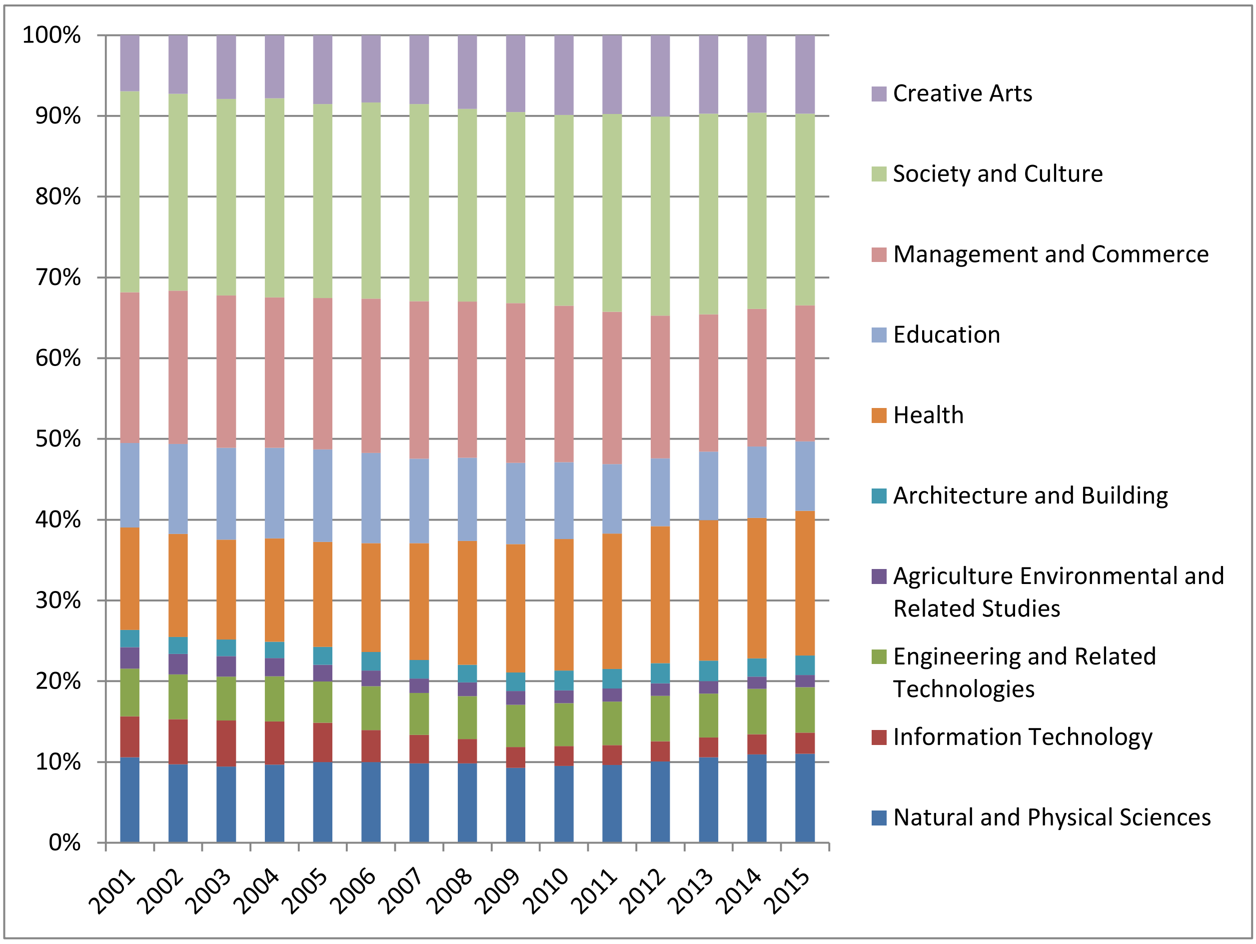
Figure 1 shows the number of completions by field of study for the period 2001-2015. The STEM fields are at the bottom of the stacked bar charts, and we see that STEM graduates have grown from around 25,000 in 2001 to over 30,000 in 2015. We also see that in recent years the number of science graduates has increased but the number of Information technology graduates decreased from the early 2000s.

Figure 1: Domestic undergraduate completions, by field of study, 2001-2015



To get a better picture of shares, Figure 2 presents the data in Figure 1 as a proportional stacked bar chart, where the percentages sum to 100%.

Figure 2: Domestic undergraduate completions, shares by field of study, 2001-15



We see that the share of graduations in STEM fields declined from 2001 through to 2009 but has subsequently recovered somewhat, to reach around 20 per cent in 2015.

3. Outcomes for STEM graduates

Following Karmel and Carroll (2016) we look at three mutually exclusive but comprehensive outcomes as at the time of the GDS, some four months after completing a degree: in full-time employment, in full-time study and ‘other’ – neither in full-time employment nor full-time study.

The proportions in each category the period 2008-2015 are presented in Table 1 according to a 22 level field of study classification. We have bolded STEM fields of study. We have also ordered the fields by the proportion of graduates being in neither full-time work nor full-time study, which we take as an indicator of the ease of transition – a small proportion reflects an easy transition on average for that field.[3]

[3] The precise scope for the analysis based on GDS data is: Australian citizens, aged < 25, graduated from bachelor degree, and in Australia at the time of the GDS.

Table 1: Percentage of new graduate being in full-time work or full-time study, by field of study, 2008-2015

	FT employment	FT study	Neither
Medicine	69.6	19.7	10.7
Rehabilitation therapies	67.0	11.8	21.2
Engineering and technology	69.2	9.6	21.3
Other health	48.9	28.6	22.5
Other sciences	29.8	47.7	22.5
Economics	49.6	26.1	24.3
Mathematics	32.5	42.4	25.1
Law and justice studies	56.6	18.1	25.4
Accounting	66.2	7.5	26.3
Nursing	71.0	2.6	26.4
Architecture and building	49.0	23.1	27.9
Life sciences	22.1	47.9	30.0
Psychology and behavioural sciences	25.1	42.4	32.5
Agriculture and environment	45.1	22.3	32.6
Language and literature	28.5	38.8	32.7
Business and management	56.0	11.1	32.8
Information technology	55.5	11.2	33.2
Social work and human welfare	55.0	11.2	33.8
Studies in human society	27.8	38.0	34.2
Education	57.9	6.6	35.4
Other humanities	32.6	31.9	35.5
Visual and performing arts	24.0	29.2	46.8

We see that STEM fields are scattered across the table with engineering and technology having a particularly low proportion graduates neither in full-time employment non full-time study (21.3%). Three STEM fields – life sciences, agriculture and environment, and information technology - have more than 30% of their graduates in neither full-time employment nor full-time study. There is no reason to argue that STEM graduates face particularly easy or hard transitions.

The above table averages data between 1983 and 2014. As such the table masks a great deal of change over time. This is seen in Table 2 where we present proportions of graduates in full-time work for 2008 (representing a high point in employment rates) and 2015.

Table 2: Percentage of graduates in full-time work, 2008 and 2015, by field of study

	2008	2015	Decrease between 2008 and 2015
Nursing	85.5	52.4	33.1
Engineering and technology	81.0	57.9	23.1
Accounting	77.3	62.0	15.3
Medicine	74.9	63.5	11.5
Rehabilitation therapies	73.5	62.5	11.1
Law and justice studies	69.1	50.9	18.2
Education	68.5	53.9	14.5
Business and management	67.5	52.7	14.8
Architecture and building	66.8	44.9	21.9
Social work and human welfare	65.8	48.6	17.3
Information technology	64.6	50.2	14.3
Agriculture and environment	62.6	38.0	24.6
Economics	61.7	49.3	12.4
Other health	59.5	42.7	16.8
Mathematics	45.7	34.0	11.8
Other humanities	42.1	28.2	13.9
Studies in human society	37.3	24.5	12.8
Language and literature	35.8	24.5	11.3
Other sciences	34.6	21.3	13.3
Psychology and behavioural sciences	32.6	20.1	12.5
Life sciences	32.6	17.7	14.9
Visual and performing arts	32.1	20.3	11.8

In this table we have ordered the fields of study by the proportion of graduates in full-time employment in 2008. Again the STEM fields are bolded. We see again that STEM fields are spread across the rows of the table. All fields were affected by the downturn following the global financial crisis, with engineering and technology being affected particularly badly (noting, though, that employment rates in this field were very high before the crisis). This field tends to be affected by the state of the economy more so that other STEM fields.

The interpretation of relatively low full-time employment outcomes for a number of the STEM fields – notably, other science, life science, and mathematics- is made difficult by the high proportion of graduates going onto further full-time study. In each of these fields over 50% are predicted to go onto full-time study. This suggests that the employment outcomes from an undergraduate degree are an incomplete measure of employment outcomes from these fields over all. To make better sense of the full picture we ideally need to look at outcomes from post-graduate degrees as well.

While we do not have a longitudinal data set which traces the activities of individual graduates, we do have data on transitions for those who complete post-graduate awards.[4] By making a number of 'stylised' assumptions we can combine these transitions with those of the undergraduate completers. We assume that those going on to further full-time study do so in the same field, and that they ultimately complete the post-graduate award. A further complication is that a proportion of those graduating with a post-graduate award go on to further post-graduate study. We treat these

[4] While the GDS can be combined with the Beyond Graduation Survey conducted three years later, the sample size is not sufficiently large to be useful here.

as having the same outcomes (after their next award) as those we observe. While these assumptions may be heroic they do enable us to combine data from undergraduates and postgraduates in a coherent manner, and the relativities between fields of study should be robust even if the point estimates are ‘notional’.

The precise way we combine the data is as follows:

Let p_{FTE} be the probability that an undergraduate is in full-time employment at the time of the survey, and p_{FTS} be the corresponding probability of being in full-time study.

Similarly let π_{FTE} be the probability that a postgraduate is in full-time employment at the time of the survey, and π_{FTS} be the corresponding probability of being in full-time study.

Then the notional probability that a graduate is in full-time employment four months after completion of their complete period of (successful) study is

$$\hat{p}_{FTE} = p_{FTE} + p_{FTS} * \pi_{FTE} + p_{FTS} * \pi_{FTS} * \pi_{FTE} + p_{FTS} * \pi_{FTS}^2 * \pi_{FTE} + \cdots \ldots \ldots$$

where $\hat{p}_{FTE}$ represents the notional probability of being in full-time employment four months after the completion of the whole period of study (consisting of one or more awards).

This can be simplified to

$$\hat{p}_{FTE} = p_{FTE} + p_{FTS} * \frac{\pi_{FTE}}{1 - \pi_{FTS}}$$

One way of thinking about this formula is that it is the proportion of graduates in full-time employment after adjusting for the outcomes of those going on to full-time study.

In Table 3 we present these notional proportions. We present the average for the period 2008-2015 (postgraduate sample sizes are too small to present annual data). We order the fields of study by the average proportion in full-time employment.

Table 3: Estimate of the percentage of graduates in full-time employment after completing a contiguous period of study (one or more awards), 2008-2015, by field of study

Medicine	85.2
Rehabilitation therapies	75.4
Engineering and technology	75.3
Nursing	72.9
Law and justice studies	70.6
Accounting	70.2
Other health	69.6
Economics	66.8
Architecture and building	64.3
Business and management	63.0
Information technology	62.2
Social work and human welfare	62.0
Education	61.7
Mathematics	59.6
Agriculture and environment	57.2
Other sciences	55.6
Other humanities	49.5
Language and literature	47.9
Psychology and behavioural sciences	47.2
Studies in human society	46.9
Life sciences	46.8
Visual and performing arts	34.7

We see that of the STEM fields of study only engineering and technology features at the top of the table. Information technology is in the middle and mathematics and agriculture and environment are a little lower in the rankings. The life sciences have a relatively low proportion of graduates in full-time employment, similar to a number of humanities or social science fields. Graduates from visual and performing arts come a clear last. We conclude that adjusting for the proportions of graduates going on to further full-time study does not make much difference to our estimates of the relative ease of finding a full-time job after graduation for those undertaking a STEM degree.

4. Proportion of STEM graduates going to STEM jobs

As the definition of STEM fields of study is somewhat arbitrary, so is the definition of a STEM job. We took the ANZSCO job classification and used our judgment in defining STEM occupations. While most of the assignments are obvious we have also made a judgment in declaring ‘education professional’ a STEM occupation, along with certain technical occupations (311 Agricultural, medical and science technicians, and 2254 Technical sales representatives for example) and certain lower-level jobs (such as farm, forestry and garden workers as being as being a matched job for graduates from 05 Agriculture and environmental studies). The definitions we have used are in Table 4.

Table 4: Definition of STEM occupations, by STEM field of study

Field of study	ANZSCO	Occupational description
01 Natural and Physical Sciences, excluding mathematics		
	1325	Research and development manager
	2254	Technical sales representatives
	234	Natural and physical science professionals
	24	Education professionals
	311	Agricultural, medical and science technicians
0101 Mathematical Sciences		
	1325	Research and development manager
	2241	Actuaries, mathematicians and statisticians
	2254	Technical sales representatives
	24	Education professionals
02 Information technology		
	1325	Research and development manager
	135	ICT managers
	2232	ICT trainers
	2252	ICT professionals
	2254	Technical sales representatives
	26	ICT professionals
	24	Education professionals
	313	ICT and telecommunications technicians
03 Engineering and technology		
	1325	Research and development manager
	133	Construction, distribution and production managers
	2254	Technical sales representatives
	233	Engineering professionals
	24	Education professionals
	312	building and engineering technicians
05 Agriculture, environmental and related studies		
	121	Farmers and farm managers
	1325	Research and development manager
	2341	Agricultural and forestry scientists
	2342	Chemists, and food and wine scientists
	2343	Environmental scientists
	24	Educational professionals
	2254	Technical sales representatives
	311	Agricultural, medical and science technicians
	36	Skilled animal and horticultural workers
	7211	Agricultural, forestry and horticultural plant operators
	84	Farm, forestry and garden workers

In Table 5 we present statistics on the occupations into which STEM graduates go (of those in full-time work), classified as matched occupations, occupations which do not match the STEM discipline but are regarded as a STEM occupation, and other occupations.

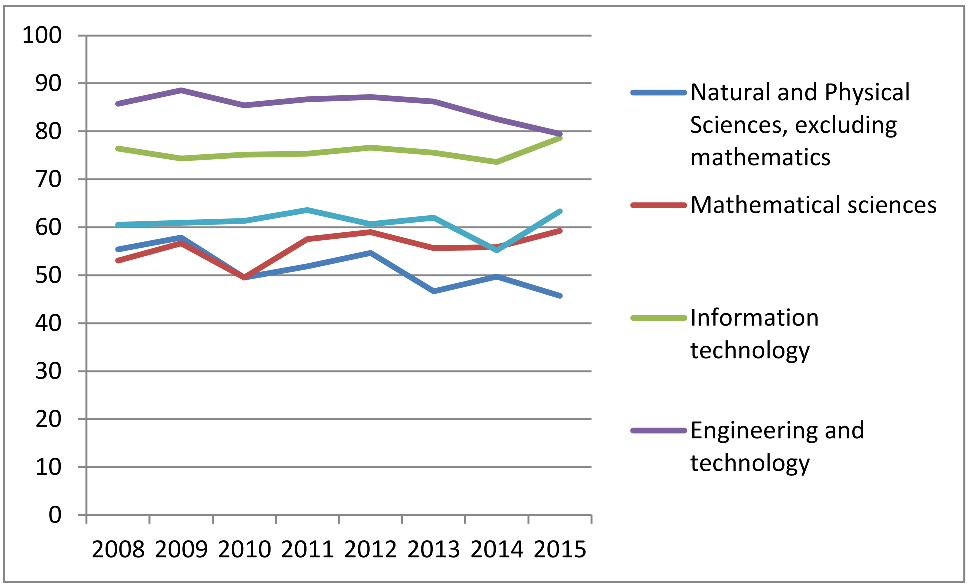
Table 5: Percentage of STEM graduates (under graduate awards) in matched occupation, full-time employed, average 2008-2015

	Matched occupation	Other STEM occupation	Non-STEM occupation	Total
Natural and Physical Sciences, excluding mathematics	45.2	6.8	48.1	100
Mathematical sciences	29.8	26.0	44.2	100
Information technology	73.4	2.3	24.3	100
Engineering and technology	75.4	10.0	14.6	100
Agriculture, environmental and related studies	55.1	5.9	39.0	100

We see that STEM covers both vocational disciplines where there is a high match between the discipline and the occupation – information technology and engineering and technology - and disciplines which are less vocational – science and mathematics. Mathematics has the lowest proportion going into strictly mathematical occupation, but about a quarter of mathematics graduates (of an undergraduate award) go into other STEM occupations.

Table 5 aggregates over 2008 to 2015. In Figure 3 we plot the proportion matching for each year separately, to see if the extent of matching has changed over this period. To keep it simple we plot the proportion of STEM graduates (by field of study) in a STEM occupation, and restrict ourselves to undergraduate degrees.

Figure 3: Proportion of STEM graduates in a STEM occupation, by field of study, 2008-2015



We see that the proportions of graduates in science and engineering and technology in STEM jobs have declined somewhat, but the proportion of information technology graduates has stayed at a high level. The number of mathematics graduates is lower and the numbers jump around a bit, but there is no obvious trend in the proportion going to a STEM job.

We know that the proportion of STEM graduates going to a STEM job is variable, but we don't know whether that is because STEM graduates are having trouble getting a matched job or whether they are choosing an occupation other than a STEM job. While we cannot really separate out supply and demand issues we can look at the quality of jobs that STEM graduates are getting. If, by way of argument, the STEM jobs are of 'better quality' than the non-STEM jobs then we could infer that it is labour demand that is dominating the story. On the other hand, if the non-STEM jobs are of 'better quality' then it would seem to be more a matter that STEM graduates are choosing to take non-STEM jobs to optimise their earnings.

This begs the question of how to measure the quality of a job. We employ four measures of quality:

- The graduates starting salary (for full-time employed)[5]
- The mean annual salary of the occupation (derived from 2011 Census data for all full-time employed)
- The percentage of graduates reporting that the qualification is important in their job
- The ABS occupational skill level (1 being the highest and 5 the lowest).

In Table 6 we present the quality of jobs for STEM fields, by whether the job is a matched one or not.

Table 6: Quality of jobs by whether graduate is in a matched occupation or not, full-time employed, pooled data over 2008-2015

Natural and Physical Sciences, excluding mathematics	**Matched occupation**	**Other STEM occupation**	**Non-matched occupation**
Full-time annual bachelor starting salary	59381	57812	51270
Mean annual salary of occupation	77111	77472	64600
Per cent who say qual. is important to job	86.5	57.6	43.8
ABS skill level (1 highest)	1.2	2.0	2.8
Mathematical sciences			
Full-time annual bachelor starting salary	60167	62403	56543
Mean annual salary of occupation	83343	87143	75019
Per cent who say qual. is important to job	92.7	77.9	57.4
ABS skill level (1 highest)	1.0	1.2	2.1
Information technology			
Full-time annual bachelor starting salary	57272	62913	55266
Mean annual salary of occupation	84498	86136	71589
Per cent who say qual. is important to job	75.5	65.1	58.1
ABS skill level (1 highest)	1.1	1.3	2.3
Engineering and technology			
Full-time annual bachelor starting salary	67837	63425	60078
Mean annual salary of occupation	97219	84182	75766
Per cent who say qual. is important to job	91.7	77.8	62.4
ABS skill level (1 highest)	1.1	1.2	2.1
Agriculture, environmental and related studies			
Full-time annual bachelor starting salary	52282	54997	52430
Mean annual salary of occupation	64391	82642	67742
Per cent who say qual. is important to job	70.2	82.6	51.3
ABS skill level (1 highest)	1.9	1.1	2.8

We see that there are both supply and demand factors at work. In each of the STEM fields it is the case that those who end up with a non-STEM job are in a poorer quality job than if they had managed to get a STEM job. This suggests that the demand for STEM graduates in STEM fields is less than the supply of graduates. For each STEM field of study, the non-matched non-STEM jobs have lower starting salaries, lower average occupational salaries, a lower proportion of graduates reporting that the qualification is important for the job, and lower skill levels according to the ABS

[5] Outliers have been removed.

measure. The last of these is rather interesting. The difference between the skill levels of STEM jobs and non-STEM jobs is more than a whole point for science, information technology and engineering. This suggests that that the non-STEM jobs are considerably lower in the pecking order than the jobs for which these graduates are being trained. It is not the case that, on average, they are getting good jobs but not in STEM occupations. It seems that the occupational choice is being dominated by demand factors – lack of jobs in STEM.

On the other hand, it is a different story for those who get a STEM job but not one matched to their field of study. For engineering and technology graduates, the STEM non-engineering jobs are inferior on every measure, but this is not the case for the other fields. While graduates getting a non-matched STEM job report a lower proportion saying that the qualification is important for their job, the results on other measures are quite varied. In fact, science graduates in non-matched STEM jobs have better jobs on all the other measures – higher starting salaries, in better paying occupations, and in more skilled jobs on the ABS measure. Those trained in mathematics in non-matched STEM jobs report higher starting salaries and better paid occupations, as do those trained in information technology. Thus it appears that some STEM graduates are choosing STEM occupations not directly related to their field of study because the jobs are better than what is on offer in their field.

5. Is there a premium for STEM graduates?

Finally, we consider the question as to whether STEM graduates do better than other graduates, once in a full-time job. In Table 7 we show outcomes for both STEM and non-STEM graduates by the major occupational group in which the graduates have obtained full-time employment. For ANZCO 2 (professionals) and ANZSCO 3 (technicians and trades) we split occupations by whether they are a STEM occupation or not. We calculate a 'STEM premium' which measures in percentage terms the advantage that STEM graduates enjoy.

We should point out that the measures we use have their limitations. In particular, the average occupational salary is a measure of how well paid the (four digit) occupation is – the same value is assigned to all graduates in that occupation. It does not enable us to observe whether STEM graduates get paid more or less than non-STEM graduates within a (four digit) occupation. Similarly, the difference in starting salaries of STEM and non-STEM graduates within a broad occupational group will reflect the differences in the disaggregated occupational distributions within those broad groups, as well as differences in salaries for a given detailed level occupation. Nevertheless a comparison of outcomes at the broad occupational group level does provide insights into the quality of the jobs that STEM graduates get in relation to non-STEM graduates.

Table 7: Job outcomes for STEM and non-STEM graduates by major occupational groups

		STEM	Non-STEM	STEM premium (%)
ANZSCO 1, managers	ABS skill level	1.2	1.4	16.2
	Full-time annual bachelor salary	59072	53341	10.7
	Average annual occupational salary	88563	80590	9.9
	Qualification important to job	59.6	50.6	17.7
ANZSCO 2, professionals - STEM	ABS skill level	1.0	1.0	0.0
	Full-time annual bachelor salary	64742	57788	12.0
	Average annual occupational salary	92095	76344	20.6
	Qualification important to job	88.5	93.3	-5.1
ANZSCO 2, professionals - Non-STEM	ABS skill level	1.0	1.0	-1.0
	Full-time annual bachelor salary	58586	55041	6.4
	Average annual occupational salary	85076	80825	5.3
	Qualification important to job	76.5	89.3	-14.3
ANZSCO 3, technicians and trades - STEM	ABS skill level	2.1	2.1	-1.0
	Full-time annual bachelor salary	54243	48079	12.8
	Average annual occupational salary	63460	62675	1.3
	Qualification important to job	68.9	73.7	-6.6
ANZSCO 3, technicians and trades - Non-STEM	ABS skill level	2.9	2.9	-1.0
	Full-time annual bachelor salary	52643	49251	6.9
	Average annual occupational salary	62291	54919	13.4
	Qualification important to job	45.5	36.4	24.7
ANZSCO 4, community and personal services	ABS skill level	3.6	3.1	-16.0
	Full-time annual bachelor salary	47994	52514	-8.6
	Average annual occupational salary	51050	54385	-6.1
	Qualification important to job	34.5	50.3	-31.5
ANZSCO 5, clerical and administrative	ABS skill level	3.5	3.5	2.0
	Full-time annual bachelor salary	52107	50797	2.6
	Average annual occupational salary	59895	57358	4.4
	Qualification important to job	42.3	49.2	-14.2
ANZSCO 6, sales	ABS skill level	4.7	4.6	-4.2
	Full-time annual bachelor salary	45390	46039	-1.4
	Average annual occupational salary	46687	49628	-5.9
	Qualification important to job	16.0	24.8	-35.6
ANZSCO 7 & 8, machinery operators and drivers, and labourers	ABS skill level	4.7	4.7	-0.4
	Full-time annual bachelor salary	51936	49234	5.5
	Average annual occupational salary	49878	48005	3.9
	Qualification important to job	29.2	13.0	124.4

We note that the ABS Skill level is not a particularly useful measure in this exercise, for the simple reason that virtually all occupations in the professional group are assigned a value of 1, and this is the occupational group in which graduates are concentrated. Similarly, all STEM jobs in ANZSCO 3 are assigned a skill level of 2.

However, the other measures show that STEM graduates tend to command higher starting salaries, and are in better paying occupations, if they obtain a job in ANZSCO 1 (managers), ANZSCO 2 (professionals) or ANZSCO 3 (technicians and trades).

Not surprisingly the highest premium is obtained by STEM graduates if they obtain a STEM professional job – one would not expect non-STEM graduates to be very competitive in STEM jobs. In the lower level occupational groups, STEM graduates get a small premium in ANZSCO 5 (clerical and administrative) and ANZSCO 7&8 (machinery operators, drivers, labourers)but receive lower salaries in ANZSCO 4 (community and personal services) and ANZSCO 6 (sales). Why this is the case is not obvious although we can speculate that STEM generic skills are more likely to be stronger in quantitative and analytical aspects but weaker on inter personal skills, on average, relative to the skills of non-STEM graduates. It will also be the case that a number of non-STEM fields of study relate directly to community and personal service occupations, and thus it is not surprising that STEM graduates are at some disadvantage in this occupational group. We can also speculate that STEM graduates on average are 'more practical' than non-STEM graduates and perhaps this explains why STEM graduates end up with better jobs than non-STEM graduates if they end up in the two lowest occupational groups – machine operators and labourers.[6]

We should not, however, over emphasize the differences in the lower-skill occupational groups because the proportion of graduates in full-time employment in these groups is relatively small. On the other hand, these occupational groups should not be ignored either, with around 18% of STEM graduates and 21% of non-STEM graduates in ANZSCO major groups 4 to 8. Of some interest is the fact that STEM graduates are much more lightly represented among the three lowest ANZSCO groups (sales, machinery operators and drivers and labourers) - 8.9% compared to 18.6% for non-STEM graduates.

Table 8: Distribution of graduates in full-time employment across ANZSCO major groups

	STEM	Non-STEM
ANZSCO 1, managers	4.7	5.1
ANZSCO 2, professionals	68.7	71.2
ANZSCO 3,trades and technicians	8.8	2.6
ANZSCO 4, community and personal service	8.1	2.1
ANZSCO 5, clerical and administrative	0.8	0.5
ANZSCO 6, sales	3.0	5.0
ANZSCO 7 & 8, machinery operators and drivers, labourers	5.9	13.6
	100	100

We now explore the differences between STEM and non-STEM graduates a little more closely. Our starting point is that, overall, STEM graduates have higher starting salaries, and are in occupations with higher average salaries than non-STEM graduates (and higher skill levels according to the ABS skill level measure), as shown in Table 9.

[6] Another factor is that the STEM graduates are more likely to be male (and being male is probably an advantage in these two occupational groups).

Table 9: ABS skill level, starting annual salaries and average occupational annual salaries of STEM and non-STEM graduates

	STEM	Non-STEM	STEM premium (%)
ABS Skill level (1 highest, 5 lowest)	1.5	1.7	7.3
Annual starting salary	61154	54249	12.7
Annual occupational average salary	82910	73607	12.6
Percentage reporting that qual is important to job	75.8	77.0	-1.6

The fourth outcome measure – the percentage reporting that their qualification is important to their job - is the odd man out. While the differences between STEM and non-STEM graduates is very small, STEM graduates have a lower percentage reporting that their qualification is important to their job.

We can decompose these differences in order to establish whether the differences within occupations dominate or whether the distribution of STEM and non-STEM graduates across occupations is what drives the overall difference.

We define w_s as the average wage (starting salary or average occupational salary) for STEM graduates and w_{ns} as the corresponding average wage for non-STEM graduates. Then we can write

$$\boldsymbol{w_s - w_{ns} = \sum_i v_{si} w_{si} - \sum_i v_{nsi} w_{nsi}} \qquad \textbf{(1)}$$

where v_{si} and v_{nsi} are the weights reflecting the distribution of STEM and non-STEM graduates across occupations, respectively. Then we can rewrite (1) as

$$\boldsymbol{w_s - w_{ns} = \sum_i v_{si}(w_{si} - w_{nsi}) + \sum_i (v_{si} - v_{nsi}) w_{nsi}} \qquad \textbf{(2)}$$

The first term on the RHS shows the contribution to the overall wage difference of the differences within occupations. The second term captures the contribution of the differences in the distribution of STEM and non-STEM graduates across occupations.

We present the results of this decomposition for the average starting salaries and the average annual occupational salary in Table 10 and Table 11.

Table 10: Decomposition of the premium of STEM graduates in average starting salaries

	Percent of STEM graduates in occupational group	Premium	Contribution of premium
ANZSCO 1, managers	4.9	5731	282
ANZSCO 2, professionals - STEM	63.7	6955	4430
ANZSCO 2, professionals - Non-STEM	10.9	3545	386
ANZSCO 3, trades and technicians - STEM	8.0	6164	493
ANZSCO 3,trades and technicians - Non-STEM	0.7	3392	24
ANZSCO 4, community and personal service	2.2	-4520	-101
ANZSCO 5, clerical and administrative	5.7	1310	75
ANZSCO 6, sales	1.9	-649	-12
ANZSCO 7 & 8, machinery operators and drivers, labourers	1.9	2702	52
Total contribution of premium effect			5628
Total contribution of distributional effect			1277
Total premium			6905

We see that the overall difference is largely driven by the premium STEM graduates get in STEM professional occupations, but with contributions from the premium they get in managerial positions, professional (but non-STEM) occupations and STEM technical occupations. The differences in salaries in other occupations play no significant role, with pluses and minuses virtually cancelling each other out. The overall distribution of STEM graduates also plays a role.

Table 11: Decomposition of the premium of STEM graduates in occupational average annual salaries

	Percent of STEM graduates in occupational group	Premium	Contribution of premium
ANZSCO 1, managers	4.9	7974	393
ANZSCO 2, professionals - STEM	60.6	15750	9547
ANZSCO 2, professionals - Non-STEM	10.6	4250	452
ANZSCO 3, trades and technicians - STEM	8.4	785	66
ANZSCO 3,trades and technicians - Non-STEM	0.8	7372	58
ANZSCO 4, community and personal service	3.1	-3335	-104
ANZSCO 5, clerical and administrative	6.1	2537	155
ANZSCO 6, sales	2.9	-2941	-85
ANZSCO 7 & 8, machinery operators and drivers, labourers	2.6	1874	48
Total contribution of premium effect			10531
Total contribution of distributional effect			-1227
Total premium			9303

The results are similar for the average annual occupational salary variable, although the distribution of STEM graduates across occupations detracts somewhat from the overall wage premium.

What should be remembered is that the average occupational salary measure relates to occupations rather than pay within a particular job; so any premium held by STEM graduates relates to the occupations in which they find full-time employment, not the pay they receive in a particular job. The fact that the results are similar for both measures suggests that the premium observed for STEM graduates in starting salaries relates to the types of jobs obtained, rather than any wage premium as such.

6. Discussion

We began this paper contrasting a very positive governmental perspective on the benefits of study in STEM fields with a view that the labour market was not particularly good for STEM graduates. Our focus is on which of these two perspectives is supported by data from the Graduate Destination Survey. Relevant questions are whether the employment prospects for STEM graduates are good, whether the labour market is valuing the vocational skills of STEM graduates (that is, salaries in matched STEM jobs) and whether the labour market is valuing the general skills of STEM graduates (which we would observe by a premium to STEM graduates in non-matched jobs).

On balance, we find that STEM graduates have reasonably positive outcomes in the labour market, and therefore it does little harm to encourage prospective student to study in STEM fields relative to other fields. On the other hand, there is nothing to suggest that non-STEM graduates are missing out on huge opportunities by not studying in STEM fields, and there is no evidence for an undersupply of STEM graduates overall.

Science, mathematics, engineering and technology graduates have quite good transitions with relatively small numbers being neither in full-time work nor study four months after course completion. However, the other STEM fields have poorer outcomes with the life sciences, agriculture and environment, and information technology graduates having quite poor average outcomes.

Of those in full-time work, STEM graduates do pretty well:

- Overall, they are a little more likely to be in a managerial, professional or technical/trade job compared to non-STEM graduates.
- Their STEM skills are valued in the labour in respect of both vocational and general STEM skills.

We see that STEM graduates do much better if they can find a STEM job compared to a job in a non-STEM field. This echoes US experience (see Meluizo and Wolniak 2012). And the numbers in non-STEM jobs are large, ranging from 14.6 per cent (of our respondents over the period 2008-2015) for engineering and technology, 24.3% for information technology, 39% for agriculture and environment, 44.2 per cent for mathematical sciences and 48.1 per cent for natural and physical sciences (excluding mathematics). When we take the relatively low proportion of graduates in full-time employment (around 30 per cent for sciences and mathematics) we see that quite a small proportion of STEM graduates transition to a STEM job at least in the short term as measured by the GDS.

It is interesting to note that, graduates in mathematics and information technology and agriculture and environment get better paid jobs if they get a STEM job *other than one in a matched field*. For example, mathematical science graduates get paid more if they get a STEM job not as a mathematician. This suggests that the demand for mathematicians and agricultural/environmental sciences is limited, but the skills obtained in those fields are valued in other STEM jobs.

Also, STEM graduates get better jobs than non-STEM graduates if they obtain a job in any occupational group except community and personal service workers and sales. That is, it seems that general STEM skills are valued widely, but less so in community and personal service and sales jobs (despite almost 9% of STEM graduates working in community and personal service jobs). If we look at the quality of jobs STEM graduates obtain overall (of those in full-time employment), on two measures (starting salary and average occupational salary) STEM graduates do attract a premium compared to non-STEM graduates. Most of this premium is explained by the quality of the jobs that STEM graduates obtain in the professional occupational group.

These general positive findings are consistent with experience overseas which shows that on the whole STEM graduates do well. For example, Carnevale *et al*. (2011) find that in the US STEM occupations pay well at all education levels – although non-STEM managerial and healthcare professional occupations have more substantial wage premiums. On the other hand Walker and Zhu (2011) found that, for graduates in England and Wales, returns were larger for law, economics and management than for other subjects

On the basis of these results, one would not be overly concerned about the numbers of STEM graduates. On one hand, the STEM graduates are doing reasonably well in the labour market, but on the other hand there is nothing to suggest that the labour market is screaming out for more STEM graduates. This is consistent with Xue and Larson's (2015) nuanced argument that in the US there is no overall STEM shortage although there may be shortages in niche areas.

Andrew Norton's comment that 'Prospective students thinking about studying science need to know that a bachelor science degree is high risk for finding a job' is perhaps a little alarmist, but it is clear that graduates do face risks in finding a good job, and STEM graduates are not immune to these risks. Thus there appears to be no pressing need to expand the number of STEM graduates. A more pressing worry is the overall deterioration in the graduate labour market since 2008 in virtually all fields (with medicine being the best insulated from this decline in graduate opportunities).

References

Anft, M., 2013. The STEM crisis: Reality or myth. *The Chronicle of Higher Education*, *58*(12), pp.1-14.

Australian Bureau of Statistics, 2014, cat.no. 4250.0.55.005 - Perspectives on Education and Training: Australians with qualifications in science, technology, engineering and mathematics (STEM), 2010–11

Carnevale, A., Smith, N., Melton, M., 2011, STEM: Science, Technology, Engineering, Mathematics, Centre of education and the Workforce, Georgetown University

Charette, R.N., 2013. The STEM crisis is a myth. *IEEE Spectrum*, *50*(9), pp.44-59.

Craig, E., Thomas, R., Hou, C. and Mathur, S., 2011. No shortage of talent: How the global market is producing the STEM skills needed for growth. *Accenture Institute for High Performance (October, 2011). www. accenture. com/institute*.

Karmel, T. and Carroll, D., 2016. Has the graduate job market been swamped?, NILS working paper.

Langdon, D., McKittrick, G., Beede, D., Khan, B. and Doms, M., 2011. STEM: Good Jobs Now and for the Future. ESA Issue Brief# 03-11. *US Department of Commerce*.

Melguizo, T. and Wolniak, G.C., 2012. The earnings benefits of majoring in STEM fields among high achieving minority students. *Research in Higher Education*, *53*(4), pp.383-405.

Norton, A 2016, Mapping Australian Higher Education 2016, Grattan Institute

Smith, E. and Gorard, S., 2011. Is there a shortage of scientists? A re-analysis of supply for the UK. *British Journal of Educational Studies*, *59*(2), pp.159-177.

Stevenson, H.J., 2014. Myths and motives behind STEM (science, technology, engineering, and mathematics) education and the STEM-worker shortage narrartive. *Issues in Teacher Education*, *23*(1), p.133.

Walker, I. and Zhu, Y., 2011. Differences by degree: Evidence of the net financial rates of return to undergraduate study for England and Wales. *Economics of Education Review*, *30*(6), pp.1177-1186.

Xue, Y. and Larson, R.C., 2015. STEM crisis or STEM surplus: Yes and yes. *Monthly Lab. Rev.*, *138*, p.1.

APPENDIX 1: FIELD OF EDUCATION

01 NATURAL AND PHYSICAL SCIENCES

0101 MATHEMATICAL SCIENCES
- 010101 Mathematics
- 010103 Statistics
- 010199 Mathematical Sciences, n.e.c.

0103 PHYSICS AND ASTRONOMY
- 010301 Physics
- 010303 Astronomy

0105 CHEMICAL SCIENCES
- 010501 Organic Chemistry
- 010503 Inorganic Chemistry
- 010599 Chemical Sciences, n.e.c.

0107 EARTH SCIENCES
- 010701 Atmospheric Sciences
- 010703 Geology
- 010705 Geophysics
- 010707 Geochemistry
- 010709 Soil Science
- 010711 Hydrology
- 010713 Oceanography
- 010799 Earth Sciences, n.e.c.

0109 BIOLOGICAL SCIENCES
- 010901 Biochemistry and Cell Biology
- 010903 Botany
- 010905 Ecology and Evolution
- 010907 Marine Science
- 010909 Genetics
- 010911 Microbiology
- 010913 Human Biology
- 010915 Zoology
- 010999 Biological Sciences, n.e.c.

0199 OTHER NATURAL AND PHYSICAL SCIENCES
- 019901 Medical Science
- 019903 Forensic Science
- 019905 Food Science and Biotechnology
- 019907 Pharmacology
- 019909 Laboratory Technology
- 019999 Natural and Physical Sciences, n.e.c.

02 INFORMATION TECHNOLOGY

0201 COMPUTER SCIENCE
- 020101 Formal Language Theory
- 020103 Programming
- 020105 Computational Theory
- 020107 Compiler Construction
- 020109 Algorithms
- 020111 Data Structures
- 020113 Networks and Communications

020115 Computer Graphics

020117 Operating Systems

020119 Artificial Intelligence

020199 Computer Science, n.e.c.

0203 INFORMATION SYSTEMS

020301 Conceptual Modelling

020303 Database Management

020305 Systems Analysis and Design

020307 Decision Support Systems

020399 Information Systems, n.e.c.

0299 OTHER INFORMATION TECHNOLOGY

029901 Security Science

029999 Information Technology, n.e.c.

03 ENGINEERING AND RELATED TECHNOLOGIES

0301 MANUFACTURING ENGINEERING AND TECHNOLOGY

030101 Manufacturing Engineering

030103 Printing

030105 Textile Making

030107 Garment Making

030109 Footwear Making

030111 Wood Machining and Turning

030113 Cabinet Making

030115 Furniture Upholstery and Renovation

030117 Furniture Polishing

030199 Manufacturing Engineering and Technology, n.e.c.

0303 PROCESS AND RESOURCES ENGINEERING

030301 Chemical Engineering

030303 Mining Engineering

030305 Materials Engineering

030307 Food Processing Technology

030399 Process and Resources Engineering, n.e.c.

030399 Process and Resources Engineering, n.e.c.

0305 AUTOMOTIVE ENGINEERING AND TECHNOLOGY

030501 Automotive Engineering

030503 Vehicle Mechanics

030505 Automotive Electrics and Electronics

030507 Automotive Vehicle Refinishing

030509 Automotive Body Construction

030511 Panel Beating

030513 Upholstery and Vehicle Trimming

030515 Automotive Vehicle Operations

030599 Automotive Engineering and Technology, n.e.c.

0307 MECHANICAL AND INDUSTRIAL ENGINEERING AND TECHNOLOGY

030701 Mechanical Engineering

030703 Industrial Engineering

030705 Toolmaking

030707 Metal Fitting, Turning and Machining

030709 Sheetmetal Working

030711 Boilermaking and Welding

030713 Metal Casting and Patternmaking

030715 Precision Metalworking

030717 Plant and Machine Operations

030799 Mechanical and Industrial Engineering and Technology, n.e.c.

0309 CIVIL ENGINEERING

030901 Construction Engineering
030903 Structural Engineering
030905 Building Services Engineering
030907 Water and Sanitary Engineering
030909 Transport Engineering
030911 Geotechnical Engineering
030913 Ocean Engineering
030999 Civil Engineering, n.e.c.

0311 GEOMATIC ENGINEERING

031101 Surveying
031103 Mapping Science
031199 Geomatic Engineering, n.e.c.

0313 ELECTRICAL AND ELECTRONIC ENGINEERING AND TECHNOLOGY

031301 Electrical Engineering
031303 Electronic Engineering
031305 Computer Engineering
031307 Communications Technologies
031309 Communications Equipment Installation and Maintenance
031311 Powerline Installation and Maintenance
031313 Electrical Fitting, Electrical Mechanics
031315 Refrigeration and Air Conditioning Mechanics
031317 Electronic Equipment Servicing
031399 Electrical and Electronic Engineering and Technology, n.e.c.

0315 AEROSPACE ENGINEERING AND TECHNOLOGY

031501 Aerospace Engineering
031503 Aircraft Maintenance Engineering
031505 Aircraft Operation
031507 Air Traffic Control
031599 Aerospace Engineering and Technology, n.e.c.

0317 MARITIME ENGINEERING AND TECHNOLOGY

031701 Maritime Engineering
031703 Marine Construction
031705 Marine Craft Operation
031799 Maritime Engineering and Technology, n.e.c.

0399 OTHER ENGINEERING AND RELATED TECHNOLOGIES

039901 Environmental Engineering
039903 Biomedical Engineering
039905 Fire Technology
039907 Rail Operations
039909 Cleaning
039999 Engineering and Related Technologies, n.e.c.

04 ARCHITECTURE AND BUILDING

0401 ARCHITECTURE AND URBAN ENVIRONMENT

040101 Architecture
040103 Urban Design and Regional Planning
040105 Landscape Architecture
040107 Interior and Environmental Design
040199 Architecture and Urban Environment, n.e.c.

0403 BUILDING

040301 Building Science and Technology

040303 Building Construction Management
040305 Building Surveying
040307 Building Construction Economics
040309 Bricklaying and Stonemasonry
040311 Carpentry and Joinery
040313 Ceiling, Wall and Floor Fixing
040315 Roof Fixing
040317 Plastering
040319 Furnishing Installation
040321 Floor Coverings
040323 Glazing
040325 Painting, Decorating and Sign Writing
040327 Plumbing
040329 Scaffolding and Rigging
040399 Building, n.e.c.

05 AGRICULTURE, ENVIRONMENTAL AND RELATED STUDIES

0501 AGRICULTURE
050101 Agricultural Science
050103 Wool Science
050105 Animal Husbandry
050199 Agriculture, n.e.c.
0503 HORTICULTURE AND VITICULTURE
050301 Horticulture
050303 Viticulture
0505 FORESTRY STUDIES
050501 Forestry Studies
0507 FISHERIES STUDIES
050701 Aquaculture
050799 Fisheries Studies, n.e.c.
0509 ENVIRONMENTAL STUDIES
050901 Land, Parks and Wildlife Management
050999 Environmental Studies, n.e.c.
0599 OTHER AGRICULTURE, ENVIRONMENTAL AND RELATED STUDIES
059901 Pest and Weed Control
059999 Agriculture, Environmental and Related Studies, n.e.c.

06 HEALTH

0601 MEDICAL STUDIES
0603 NURSING
0605 PHARMACY
0607 DENTAL STUDIES
0609 OPTICAL SCIENCE
0611 VETERINARY STUDIES
0613 PUBLIC HEALTH
0615 RADIOGRAPHY
0617 REHABILITATION THERAPIES
0619 COMPLEMENTARY THERAPIES
0699 OTHER HEALTH

07 EDUCATION

0701 TEACHER EDUCATION
0703 CURRICULUM AND EDUCATION STUDIES
0799 OTHER EDUCATION

079999 Education, n.e.c.

08 MANAGEMENT AND COMMERCE

0801 ACCOUNTING
0803 BUSINESS AND MANAGEMENT
0805 SALES AND MARKETING
0807 TOURISM
0809 OFFICE STUDIES
0811 BANKING, FINANCE AND RELATED FIELDS
0899 OTHER MANAGEMENT AND COMMERCE

09 SOCIETY AND CULTURE

0901 POLITICAL SCIENCE AND POLICY STUDIES
0903 STUDIES IN HUMAN SOCIETY
0905 HUMAN WELFARE STUDIES AND SERVICES
0907 BEHAVIOURAL SCIENCE
0909 LAW
0911 JUSTICE AND LAW ENFORCEMENT
0913 LIBRARIANSHIP, INFORMATION MANAGEMENT AND CURATORIAL STUDIES
0915 LANGUAGE AND LITERATURE
0917 PHILOSOPHY AND RELIGIOUS STUDIES
091701 Philosophy
091703 Religious Studies
0919 ECONOMICS AND ECONOMETRICS
0921 SPORT AND RECREATION
0999 OTHER SOCIETY AND CULTURE

10 CREATIVE ARTS

1001 PERFORMING ARTS
1003 VISUAL ARTS AND CRAFTS
1005 GRAPHIC AND DESIGN STUDIES
1007 COMMUNICATION AND MEDIA STUDIES
1099 OTHER CREATIVE ARTS

11 FOOD, HOSPITALITY AND PERSONAL SERVICES

1101 FOOD AND HOSPITALITY
1103 PERSONAL SERVICES

12 MIXED FIELD PROGRAMMES

1201 GENERAL EDUCATION PROGRAMMES
1203 SOCIAL SKILLS PROGRAMMES
1205 EMPLOYMENT SKILLS PROGRAMMES
1299 OTHER MIXED FIELD PROGRAMMES