



# Identifying STEM occupations: national and international approaches

Support document 2

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# What is a STEM occupation?

## National and international approaches

In the following sections we explore the definition and selection of science and technology-related jobs in more depth. Examples from the US, UK and Australia will be described, with similarities and differences highlighted.

### Case 1: US think tank 'Brookings Institute'

Jonathon Rothwell (2013) from the Brookings Institute released a report, *The hidden STEM economy*, which argues that a large number of STEM jobs go unnoticed due to the attention that researchers and the media pay to occupations requiring a bachelor's degree or higher. The author suggests that a variety of jobs may require some degree of STEM knowledge and skills.

In response, a new method for classifying what constitutes a STEM job was proposed. As part of occupational data base, O\*NET (Occupational Information Network Data Collection Program) (Rothwell 2013, p.4), workers in each occupation complete a self-report survey about training, education, experience and skill use. The report used the knowledge survey portion of the data to grade occupations according to their STEM skill requirements.

Using O\*NET knowledge scores in biology, chemistry, physics, computers and electronics, engineering and technology, and mathematics, Rothwell (2013) calculated gradations of STEM knowledge in occupations, and subsequently classified STEM occupations as;

- *High STEM* - If an occupation has one domain score at least 1.5 standard deviations above the average then it is classed as a 'high-STEM' occupation
- *Super STEM* - If an occupation has a combined knowledge score at least 1.5 standard deviations above the average combined score then it is classed as a 'super-STEM' occupation

The report justifies the use of both classifications by saying that education and training usually focus on one specific domain (hence the applicability of high-STEM) and workers with abilities in more than one field tend to receive higher pay (hence the relevance of super-STEM).

The premise is that workers can apply STEM skills in apparently non-STEM areas (for example, applying scientific reasoning and knowledge to improve agriculture, horticulture or aquaculture) and, conversely, might not apply STEM skills in apparently STEM areas (for example, corporate management of an engineering firm).

Table 1 provides a summary of occupations with a high degree of knowledge and skills in the scientific and technology-related occupations, based on all disciplinary STEM knowledge scores in descending order.

**Table 1 Summary of occupations with a high degree of knowledge and skills in the scientific and technology related occupations in descending order (Rothwell 2013)**

Major group occupational category
Architecture and engineering
Life, physical and social science
Healthcare practitioner and technical
Computer and mathematical science
Installation, maintenance and repair
-Management
Construction and extraction

## Occupational rankings

There is a high concentration of super-STEM jobs in architecture and engineering and sciences occupations - these are usually jobs that are associated with STEM in other reports like the UKCES report below. The table also reveals the specificity of some groups of occupations - like computer and mathematical science occupations which have a 100% share of high-STEM jobs, but only a 30% share of super-STEM jobs which suggests highly specific and narrow activities.

**Table 2 Ranking of major occupation groups according to various measures of STEM occupational parameters**

	First	Second	Third	Fourth	Fifth
STEM score	Architecture and engineering	Life, physical and social science	Healthcare practitioner and technical	Computer and mathematical science	Installation, maintenance and repair
High-STEM job share	Architecture and engineering and computer and mathematical science		Life, physical and social science	Healthcare practitioner and technical	Installation, maintenance and repair
Super-STEM job share	Architecture and engineering	Life, physical and social science	Installation, maintenance and repair	Computer and mathematical science	Healthcare practitioner and technical
High- to super-STEM ratio	Architecture and engineering	Life, physical and social science	Education, training and library	Installation, maintenance and repair	Management
Share of all high-STEM jobs	Healthcare practitioner and technical	Computer and mathematical science	Business and financial operations and installation, maintenance and repair		Architecture and engineering
Share of all super-STEM jobs	Architecture and engineering and healthcare practitioner and technical		Installation, maintenance and repair	Computer and mathematical science	Life, physical and social science and management

Source: Rothwell 2013, p.10

Note: high- to super-STEM ratio is based on the authors' calculation of the ratio between high-STEM job share and super-STEM job share.

## Geographical application

The Brookings report also conducted a geographic analysis of the occupation data. Looking at the 100 largest metropolitan areas, it noted that the range of STEM job share for jobs that required less than a bachelor's degree was narrower than those required a bachelor's degree or higher. The share of non-bachelor's degree jobs in metropolitan areas ranged from 7% to 13%, whereas the share of bachelor's degree jobs ranged from 4% to 24%.

The report explained this by suggesting that "mechanics and nurses" are needed wherever there is a large concentration of people, but "scientists, engineers and computer workers" tend to be servicing export markets and clustered in certain locations (Rothwell 2013, p.14). For example, people need

access to healthcare near where they live, but technology focused enterprises often cluster together in places like Silicon Valley.

## Case 2: UK Commission for Employment and Skills

A similar but more comprehensive approach was used by the UK Commission for Employment and Skills (UKCES) 2015), which recently produced a report titled *Reviewing the requirement for high level STEM skills* (table 3).

**Table 3: Definition of STEM disciplines in the UKCES report**

STEM disciplines	Non-STEM disciplines
Medicine and dentistry	Social studies
Subjects allied to medicine	Law
Biological sciences	Business and administrative studies
Veterinary science, agriculture and related subjects	Mass communication and documentation
Physical sciences	Linguistics, classics and related subjects
Mathematical and computer sciences	European language, literature and related subjects
Engineering	East, Asiatic, African, American and Australian languages, literature
Technologies	Historical and philosophical studies
Architecture, building and planning	Creative arts and design

Note: Subject area of qualification is based on that used by the Office for National Statistics in the Labour Force Survey. Source: UK Commission on Skills and Employment (2015).

The Commission for Employment and Skills report recognised that the level of STEM-qualified people in an occupation is not necessarily directly linked to the specific STEM skills requirements of that occupation. In particular, it noted that if there are relatively high wages on offer capable workers who incidentally have STEM qualifications may be attracted (UK Commission for Employment and Skills 2015).

The report identified STEM occupations by using data in two dimensions. One dimension was the proportion of workers in each occupation who had a STEM qualification (according to the list in table 2). The other dimension was an index for 'Numeracy and problem-solving' based on data from the UK Skills and Employment Survey to provide a measure of the use of additional STEM base skills in each occupation (UK Commission for Employment and Skills 2015).

Using a cluster analysis, STEM and non-STEM clusters were identified and narrowed down by logic based filtering approach.

The issues with this approach are firstly the assumption that people are in particular jobs because of their (highest) qualification, secondly the selection of occupations based on a dichotomous (STEM/non STEM) rather than continuous index (degree of STEM skills) and thirdly the initial pre-selection of the fields of education for investigation.

The cluster analysis produces a binary classification of STEM and non-STEM occupations, which has the potential to create artificial boundaries between occupations and obscure the relative differences between occupations within those groups. The fields covering health, architecture and building, management and business and economics were not considered to be STEM fields so occupations in these areas are largely absent from the final list (table 4).

**Table 4 Top 15 ranked STEM occupations (out of 38 total)**

<b>Ranking SOC unit groups (4-digit level)</b>	<b>Composite score</b>
Programmers and software development	1.63
Production managers and directors in manufacturing	1.40
Information technology specialist managers	1.30
Information technology and telecommunications professionals nec	0.99
Engineering professionals nec	0.71
Mechanical engineers	0.71
Information technology business analysts, architects and systems designers	0.54
Design and development engineers	0.51
Civil engineers	0.49
Information technology project and programme managers	0.46
Electrical engineers	0.43
Production and process engineers	0.31
Electronics engineers	0.25
Information technology and telecommunications directors	0.21
Quality assurance and regulatory professionals	0.05

Most of the occupations listed as STEM occupations in the Commission for Employment and Skills report usually require a degree-level qualification.

### Case 3: Elgin Economics (for the Government of Victoria)

Research commissioned by the Higher Education and Skills Group of the Victorian Department of Education and Early Childhood Development (Elgin Economics 2014) adopts a broader approach to the coverage of fields of study that constitute science and mathematics (SM) capabilities. The traditional approach of focusing on STEM fields of study (science, technology, engineering and mathematics qualifications) has been found to be too narrow to capture the full extent of SM capabilities in the workforce.

The authors included a wide range of broad and narrow fields of education (ASCED) as science and mathematics fields. The report selected 4-digit fields of education based on those used by the ABS, with the addition of fields to include areas such as commerce, business and economics. The justification for the additional fields was that they require an advanced level of numeracy and mathematics skills.

Using Victorian data derived from the 2011 Census of Population and Housing, the authors ranked all 475 4-digit unit groups by their 'SM intensity'. The intensity index for each unit group was calculated using the following formula:

$$\text{SM intensity of unit group} = (\text{number of employed people with an SM qualification} / \text{number of employed people}) * 100$$

(Elgin Economics 2014, p.15)

Unit groups which had a higher proportion of employed people with a qualification in a STEM field had a higher level of STEM intensity. In this way, occupations have been linked to field of education.

The advantage of this approach is that calculating the intensity index is relatively straightforward and it only requires data on the qualifications and occupations of the population. While the report itself

only used 4-digit occupation and field of education classifications, it could be extended to 6-digit classifications. This approach naturally lends itself to ranking the occupations and provides a continuous index, rather than a binary STEM or non-STEM classification. The index can be recalculated when new data become available and reproduced in new contexts (as long as some equivalence between fields of education can be assigned).

It is startling however to see midwifery and nursing professionals as the top science and mathematical occupation and a science technician at position 113 in the list (table 5). There are a number caveats involved with this method, for example, recording highest level of qualification only, assuming that people are in a particular job because of their highest qualification and choosing very broad levels of occupational categories.

**Table 5 Top 15 ranked occupation groupings according to the SM intensity index**

Ranking	ANZSCO occupational unit group (4-digit level)	SM intensity
1.	Midwifery and nursing professionals nfd	100.00
2.	Anaesthetists	99.15
3.	Specialist physicians	99.09
4.	Surgeons	98.65
5.	Chiropractors and osteopaths	97.91
6.	Podiatrists	97.67
7.	Medical practitioners nfd	97.66
8.	Generalist medical practitioners	97.49
9.	Optometrists and orthoptists	97.38
10.	Physiotherapists	97.37
11.	Veterinarians	97.30
12.	Psychiatrists	97.22
13.	Dental practitioners	97.18
14.	Midwives	96.19
15.	Geologists and geophysicists	95.9
::		
113.	Science Technicians	64.5
::		
130.	Agricultural Technicians	61.4

Source: Elgin Economics (2014, p.37).

## Case 4: SA Department of State Development

The methodology employed by the South Australian Department of State Development (DSD) resulted in a list of 58 STEM occupational unit groups (4-digit ANZSCO), which were published on the department's website as of 2014–15 (<http://www.skills.sa.gov.au/careers-jobs>). The list mainly includes

- Design, engineering, science and transport professionals,
- ICT professionals,
- Health professionals
- Technicians and Trades workers.

The methodology is based on a cross-reference of each ANZSCO occupation title with a person's highest achieved qualification, classified by field of education. The data are derived from the ABS 2011 Census of Population and Housing.

The following fields of education were selected as STEM:

- Natural and physical sciences
- Information technology
- Engineering and related technologies
- Architecture and building
- Agriculture, environmental and related studies
- Health.

The cross-referencing enabled each ANZSCO occupation to be ranked according to the proportion of individuals possessing a qualification within one of the selected six fields of education at certificate IV level or above for Professionals, and certificate III and higher for Technicians and trade workers.

Only those occupational groups with 50% or more individuals in that occupation with a STEM qualification were retained. Subsequent filters removed groupings based on a low skill level.

This list will be used in South Australia for reporting, statistical analysis and assisting with the determination of the public value of courses for the SA Funded Training List.

## Case 5: Australian Bureau of Statistics

The ABS (2013) preselected the following ASCED fields of education for further analysis:

- 01 Natural sciences
- 02 Information technology
- 03 Engineering
- 05 Agriculture, environmental studies

STEM occupation groups were defined by the concentration of STEM-qualified people (based on field of education) per ANZSCO occupation group. This yielded 23 sub-major occupation groups (2-digit level) with at least 25 000 STEM-qualified people in each category. An intensity score based on the percentage of people with a STEM qualification working in a STEM-relevant job was identified. The following summary accounts for 64% of all working people with a STEM qualification (Table 6).

**Table 6 People with STEM qualifications by common STEM occupation groups**

<b>Occupational category</b>	<b>% working in job relevant to STEM qualification</b>	<b>% STEM-qualified of total employed</b>	<b>% of all STEM-qualified workers</b>
Design, engineering, science and transport professionals	97.0	58.6	10.4
ICT professionals	95.7	64.4	6.9
Automotive and engineering trades workers	95.6	62.8	9.2
Electro technology and telecommunications trades workers	94.4	62.7	8.1
Education professionals	93.2	14.1	3.6
Engineering, ICT and science technicians	88.6	54.4	6.4
Specialist managers	81.3	28.1	9.8
Business, human resource and marketing professionals	66.2	13.9	4.3
Hospitality, retail and service managers	63.7	12.3	2.8
Road & rail drivers	35.7	17.5	2.6

The work on identifying occupations in the STEM disciplines demonstrates that jobs can come from a variety of educational pathways and education sectors and are not the exclusive property of university education.

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