



# Measuring STEM in vocational education and training

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## INTRODUCTION

The concept of ‘STEM’ (science, technology, engineering and mathematics) has influenced many education and workforce strategies and policies with the intention of improving innovation, productivity and international competitiveness. Generally, the focus has been on how the school and university sectors can help equip the workforce with the STEM-related skills and knowledge considered necessary for the changing economy (see Siekmann and Korbel 2016).

This paper explores ways to measure how the vocational education and training (VET) sector is contributing to the development of STEM-related skills. Better measurement of STEM in VET can help to identify supply and demand for education and training, assess (and improve) outcomes and efficiency, direct funding and resources, and properly inform students’ choices.

For further information, see the accompanying paper *What is STEM? The need for unpacking its definitions and applications* and support documents *Defining ‘STEM’ skills: review and synthesis of the literature* and *Identifying STEM occupations: national and international approaches*, available at <<http://www.ncver.edu.au/publications/2888.html>>.

## HIGHLIGHTS

- STEM is a complex and multi-faceted concept encompassing a range of competencies; foundational, socio-emotional, advanced cognitive and technical skills. Nevertheless, it is important to find a way to measure the extent of VET’s contribution to the development of STEM skills and knowledge to properly represent VET and establish its place alongside school and university.
- Existing data can be used to measure STEM in VET by counting the number of enrolments in VET programs by field of education, intended occupation and relevant industry. These approaches are useful when comparing VET to other education sectors, analysing employment and labour force data and assessing industry skills needs, respectively.
- Other approaches to measuring STEM can be more comprehensive but rely on detailed data about the competencies required in various occupations. These are not easily collected or quantified; however, possible ways to achieve this include data linkage or conducting surveys.

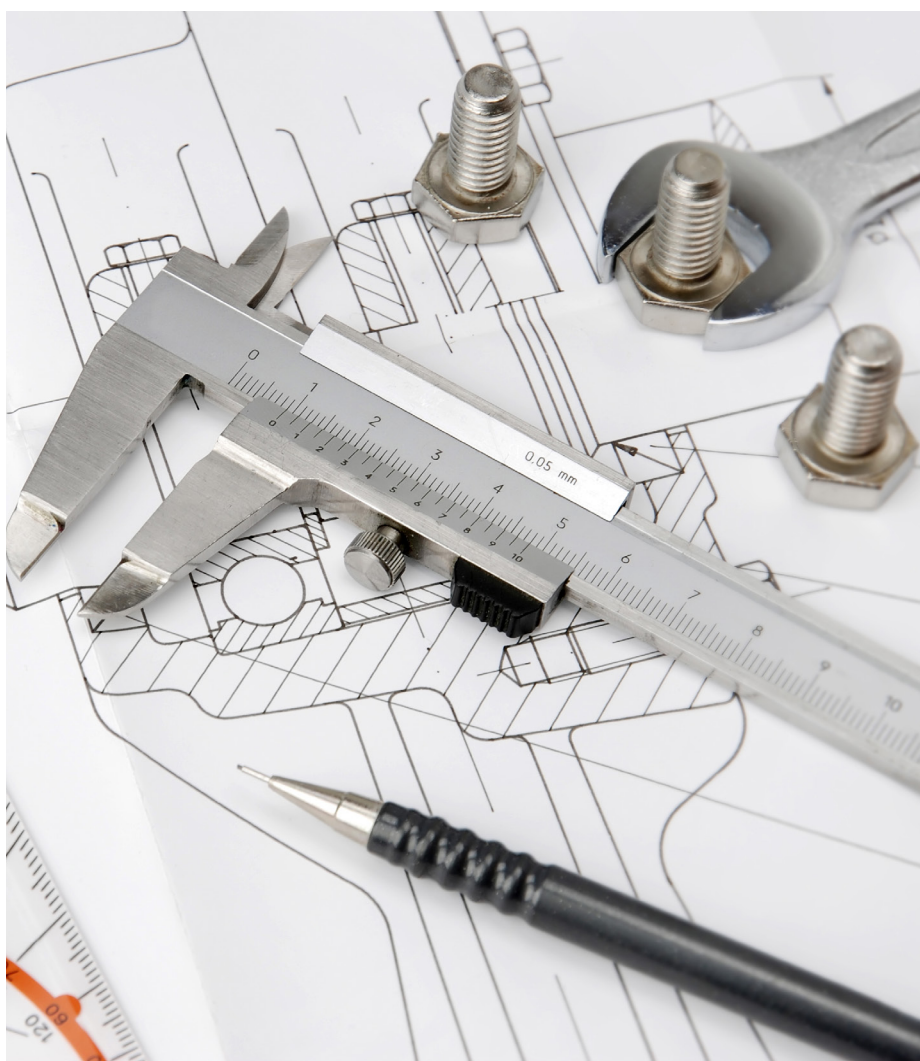
# BACKGROUND

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The overarching definition of STEM put forward by Siekmann and Korbel (2016) (based on one developed by the STEM Education Caucus [2016]) incorporates the four constituent disciplines of science, technology, engineering and mathematics and also encompasses other competencies such as scientific literacy, and critical and creative thinking skills. The definition also recognises that STEM is a combination of the four constituent disciplines, interconnected with other disciplines and integrated in other areas of education and work.

This definition recognises that the boundaries between STEM and non-STEM education and training are not as clear as rhetoric and statistics sometimes claim, and that STEM education and training occurs across all sectors and levels of education. While producing a single statistic to represent all STEM activity risks misrepresenting its multidisciplinary nature, it is still important to measure VET's contribution to STEM, as often the focus is just on STEM education in schools and universities. The following approaches are suggested ways of measuring STEM in VET, with an aim to help establish VET in the crowded STEM policy space.



# MEASURING STEM IN VET

The outputs of the VET sector can be measured in various ways, including enrolments, completions, employment outcomes and satisfaction. This paper looks at three different approaches to measuring STEM in VET and, as an example, uses them to determine the number of enrolments in VET programs that could be considered STEM.

The three approaches are based on:

- the educational field of the programs
- the intended occupations of the programs
- the industry area of the programs.

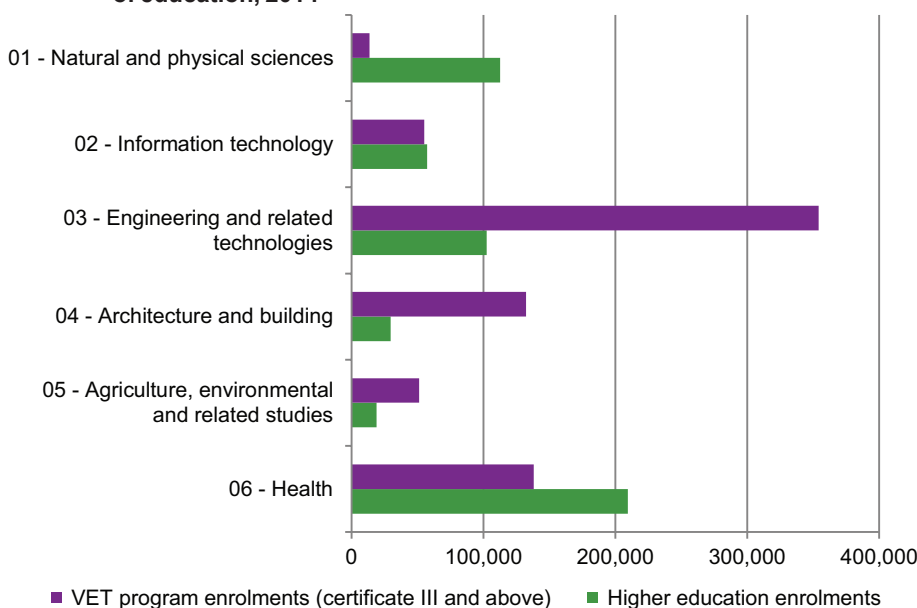
These approaches are not exhaustive or definitive, but are examples of how to measure STEM in VET. They use data that are collected on VET activity by the National Centre for Vocational Education and Research (NCVER).

## Measuring by fields of education

Identifying STEM education and qualifications by their field of education is common practice in Australia and internationally. In Australia, we use the Australian Standard Classification of Education (ASCED), as defined by the Australian Bureau of Statistics (ABS), which classifies field of education in 12 broad areas (ABS 2001). VET subjects and programs included in NCVER data collections are assigned to a matching field of education.

Figure 1 shows enrolments in the fields of education commonly selected as STEM fields across educational sectors. The selection of fields is contested; for example, some limit it to the first three fields (Healy et al. 2013) and others include sub-fields of '08 - Management and commerce' (Elgin Economics 2013).

**Figure 1 Enrolment in VET and higher education by selected STEM-related fields of education, 2014**



Source: NCVER (2014); Department of Education and Training (2016).

Enrolments in STEM-related VET programs can be measured by fields of education, occupations and qualifications.

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The benefits of using field of education are that such data are directly comparable with university data, ABS data on education and qualifications and many other Australian data collections that use ASCED (for example, the Longitudinal Survey of Australian Youth). A drawback is that this approach assumes a direct relationship between a person's qualification and occupation; that is, only STEM qualifications lead to STEM occupations. This is an issue if these statistics are used to identify and address skills and knowledge gaps in the workforce.

### **Measuring by occupations**

Another approach is to identify STEM education and qualifications by the intended occupation of that education and training. In NCVER collections, VET programs are assigned an occupation from the Australian and New Zealand Standard Classification of Occupations (ANZSCO) as defined by the ABS and Statistics New Zealand under eight major groups (ABS 2006). These are:

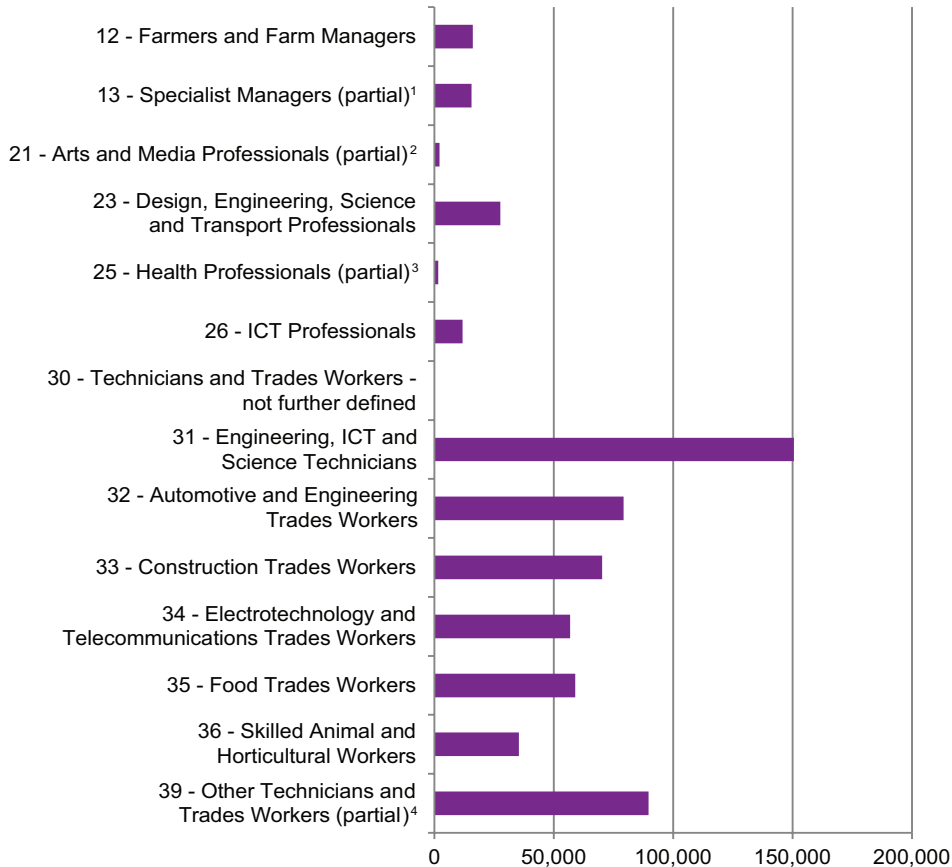
- 1 - Managers
- 2 - Professionals
- 3 - Technicians and Trades Workers
- 4 - Community and Personal Service Workers
- 5 - Clerical and Administrative Workers
- 6 - Sales Workers
- 7 - Machinery Operators and Drivers
- 8 - Labourers

Using occupation is another way of connecting education and training to workforce outcomes. Using ANZSCO is beneficial because such data is directly comparable with ABS data on employment and many other Australian data collections (for example, the Household, Income and Labour Dynamics in Australia Survey). However, it means that the data cannot be easily compared with university data because those qualifications are not assigned intended occupations. As with field of education, using occupation also assumes a direct relationship between qualification and occupation.

### **Measuring by qualifications**

Much of the education and training activity in the VET system occurs in units of competency, skill sets and qualifications defined in the training package system. Training packages define the competencies required by different occupations and industries. These competencies are packaged into nationally recognised qualifications. Industry groups are involved in creating and maintaining training packages.

**Figure 2 Enrolment in VET programs (certificate III and above) by selected STEM-related occupations, 2014**



Of the 57 groups of training packages offered by VET, 30 could be considered as being STEM-related.

Source: NCVET (2014).

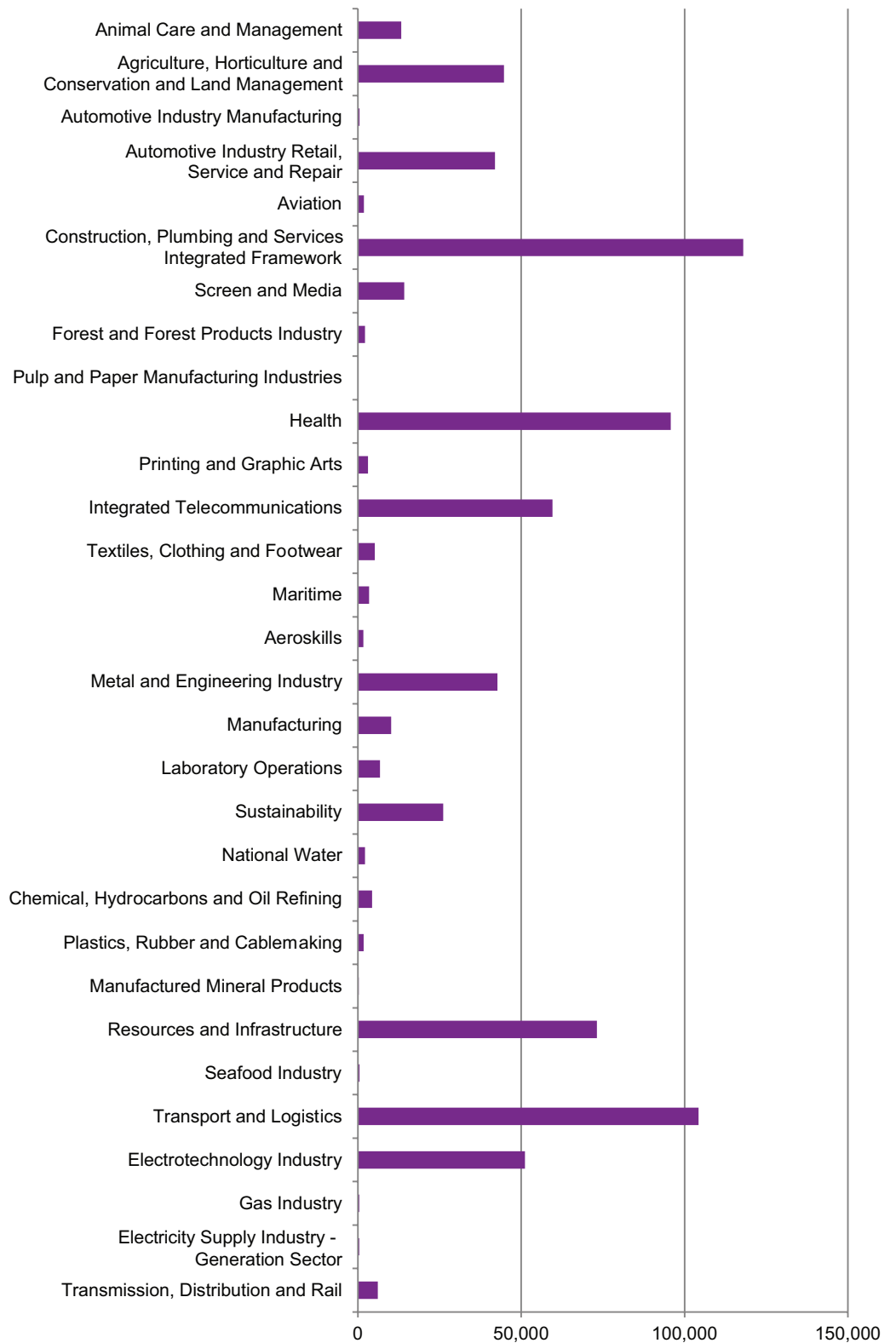
Note: partial groups include -

- 1 133 - Construction, Distribution and Production Managers and 135 - ICT Managers.
- 2 2113 - Photographers, 2123 - Film, Television, Radio and Stage Directors.
- 3 251 - Health Diagnostic and Promotion Professionals.
- 4 392 - Printing Trades Workers and 399 - Miscellaneous Technicians and Trades Workers.

NCVER reports 57 groups of training packages, of which 30 could be considered as STEM training packages (shown in figure 3). As with fields of education and occupations, the choice of STEM training packages is contestable.

As the training packages are created with industry consultation, they closely align with industry and skills needs. Using this as a basis for identifying STEM education and qualifications is valuable because it ensures that VET can match workforce needs. However, this classification is unique to the VET system so the data is not easily comparable with other sources of data such as ABS employment data.

**Figure 3 Enrolments in VET programs (certificate III and above) by selected STEM-related training package groups, 2014**



Source: NCVET (2014).



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## Benefits and limitations of these approaches

It is important to note that there is not one single way to measure VET's contribution to the development of STEM skills and knowledge. The three measures each give a different number of total STEM program enrolments in VET, and selecting different fields of education, occupations and training packages would also give different results. The choice of approach depends on the aim and purpose of the analysis and the other data available:

- fields of education are best used when comparing education sectors
- occupations are best used when analysing employment and labour force data
- training packages are best used when matching skills to industries.

The key benefit of all three approaches is that they can be applied using data that NCVER already collects on education and training. Field of education is a widely used measure in Australia and overseas, and ASCED and ANZSCO are common standards used in much research in Australia, allowing a high level of comparability. Following the selection of appropriate STEM fields, occupations and training packages, the data can easily be sourced and produced from existing NCVER products such as VOCSTATS.<sup>2</sup>

However, there are also limitations to using these classifications to measure STEM:

- At the level shown here, these are broad classifications that can miss or obscure differences within them. However, at narrow levels of these classifications, the selection of fields, occupations and training packages become difficult and time consuming.
- They do not recognise that skills can be transferable between different jobs. STEM skills can be useful in non-STEM work and non-STEM skills can be useful in STEM work. These classifications assume direct links between what a person studies and their eventual job, which may not always be correct.
- They tend to encourage a strict classification where some qualifications are STEM and the rest are non-STEM. It is more accurate to recognise that some qualifications have a closer link to STEM than other qualifications, rather than having to rule certain qualifications 'in' or 'out'.
- They do not recognise that some STEM education and training may be embedded in non-STEM qualifications or jobs. It is important to recognise that elements of STEM may be included in unexpected places, such as the way numeracy is the foundation for many other skills.

**There is no single way to measure VET's contribution to the development of STEM skills.**

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<sup>2</sup> A web interface for NCVER's statistical collections, available at <<http://www.ncver.edu.au/resources/vocstats.html>>.

# ALTERNATIVE APPROACHES TO MEASURING STEM

**ABS Census data has been used to measure actual and projected growth in occupations requiring science and maths skills.**

Other research on STEM education and training uses alternative approaches to measuring the STEM output of the VET sector. These approaches require data that is outside of the current scope of NCVER's collections, but they demonstrate what may be possible.

## Occupations and qualifications

Due to an interest in the importance of science and mathematics skills in the labour market, the Victorian Government commissioned a study to measure the actual and projected growth in occupations which require those skills (Elgin Economics 2013). Using data from the ABS Census, Elgin Economics calculated the percentage of workers in each (ANZSCO) occupation that had a qualification in scientific and mathematical (ASCED) fields of education determined by Elgin Economics.

The benefits to this approach are that it:

- is easily replicable with access to Census data
- provides a scale measure of STEM (rather than ruling occupations in or out)
- connects qualifications with occupations – providing a measure of how education and training relates to STEM in the workforce.

But there are also potential drawbacks:

- It is strongly dependent on the initial choice of fields of education (similar to approaches using existing data).
- The Census only records people's highest qualification, so it tends to miss lower level qualifications. As VET generally provides lower level qualifications, this means VET's contribution would be underreported.
- The results can be skewed because in some occupations certain qualifications are mandatory (particularly in health care occupations, such as chiropractors).

As NCVER collections include information on intended occupations (as outlined above), this data could be applied to training activity.

## Occupations, qualifications and skill needs

The UK Commission for Employment and Skills (UKCES) was interested in identifying STEM occupations, particularly in relation to higher apprenticeships; that is, apprenticeships leading to higher level qualifications (UKCES 2015). The approach was similar to that applied by Elgin Economics using the percentage of workers with STEM qualifications, but the data were also combined with information about the numeracy needs of each qualification.



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These numeracy needs were taken from the UK Skills and Employment Survey, a more comprehensive survey of workers and the characteristics of the occupations they held. The main benefits of this approach are that including the numeracy skills needs of the occupations, reduces the tendency for skewed results in which a mandatory qualification may mask the relatively low STEM skills requirements of the occupation (for example, chiropractors).

However, there are drawbacks to this approach:

- As with Elgin Economics' approach, it depends on which fields of education are chosen and, using Census data will underreport the importance of lower level qualifications.
- It requires additional data on skills needs in occupations (such as numeracy) that may not be readily available. One potential source is data from the Programme for the International Assessment of Adult Competencies run by the Organisation for Economic Co-operation and Development (OECD 2016).
- This approach classifies occupations as STEM or non-STEM without gradations between them. It does not differentiate between occupations that have a relatively strong or weak need for STEM skills and knowledge.

If there were similar data on skills needs for Australian occupations, this could be applied to NCVER collections in a similar way to the Elgin Economics approach.

## Occupations and competencies

In the United States, the O\*NET database <<http://www.onetonline.org>> provides comprehensive data on competencies required for occupations. This information is based on extensive surveys of workers in each of those occupations. The Brookings Institution used this data to calculate the STEM knowledge required for each occupation (Rothwell 2013). They based their calculations on the reported knowledge of biology, chemistry and physics (science), computers and electronics (technology), engineering and mathematics.

Based on this data, the Brookings Institution proposed two measures to determine whether an occupation could be called STEM. One measure included any occupations that had a high knowledge requirement in any one of the four disciplines of STEM – occupations that required education in at least one discipline. The other measure included any occupations that had a high knowledge requirement across all four disciplines combined – occupations that required education across the disciplines. Other measures could be calculated, such as occupations that require education in STEM and non-STEM disciplines.

**Including the numeracy skill needs of occupations helps avoid over-stating actual STEM skills within them.**

**Knowing what competencies are required for occupations leads to better data but it's not easily collected or quantified.**

There are many benefits to this approach:

- It is based on the actual requirements of occupations and is not based on broader fields of education.
- It takes into account the transferability of skills and knowledge between education and occupations that may not appear to match. It may pick up where STEM skills and knowledge are needed in apparently non-STEM occupations.
- While the Brookings Institute created a measure that ruled occupations in or out, it is also possible to create a scale measure or ranking of occupations.

A significant drawback to this approach is that it requires a comprehensive database similar to O\*NET. Such a database does not currently exist for Australian occupations and would be difficult and expensive to collect. However, the Commonwealth Scientific and Industrial Research Organisation have linked O\*NET data to (ANZSCO) occupations in Australia (Reeson et al. 2016) and there are other researchers working on this linkage. This would make the O\*NET data usable here, though it would not be based on Australia's particular skills and knowledge requirements.

Using the already established link between VET programs and occupations, similar data could be used to see which programs were linked to occupations that required high levels of STEM skills and knowledge.

### **What can we learn from these approaches?**

All three approaches offer a different way of analysing the contribution of VET to the STEM workforce. The Elgin Economics approach is the easiest to implement, but also has fewer benefits compared to the other approaches. The UK Commission for Employment and Skills and Brookings Institution approaches rely on extra data that may not be readily available in Australia.

There are a few general points we can learn from these approaches:

- Knowing the intended or actual occupation of students is very useful, but relies on the assumption that the benefits of education and training follow directly into certain occupations.
- We get a much richer picture if we know what competencies (skills, knowledge, etc.) are required for occupations, but this is not easily collected or quantified.

These points are also reflected in Siekmann's (2016) concept of 'the House of STEM' in which STEM includes foundational literacies, socio-emotional skills and advanced cognitive skills in addition to the technical skills that are usually in focus. Measuring STEM using fields of education, occupations

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and training packages provides a good coverage of technical skills, but these alternative approaches that can include actual usage of skills provide a more comprehensive picture of STEM.

There are some potential ways of collecting data on skills that could be linked to NCVER's data and improve the way STEM is measured in VET. For example:

- using the existing Programme for the International Assessment of Adult Competencies data or O\*NET data, through a linkage with (ANZSCO) occupations
- conducting a survey to measure the knowledge and skills requirements of employed VET graduates (or workers more generally) or incorporating items into an existing survey
- working with stakeholders to identify STEM components of training (for example skill sets) in the VET system.

These are potential options if stakeholders require better and more comprehensive information on VET's contribution to the STEM skills and knowledge of the workforce.



# CONCLUSION

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**Better data on STEM helps support planning and key decision making for a range of stakeholders, including the students themselves.**

Many stakeholders and those who fund the system, such as industry groups, governments and employers, value STEM-related skills and knowledge and want them and other specific skills like digital literacy or entrepreneurship, to be a focus of the education system. For this to happen effectively, we must be able to measure the outputs of the system (for example, attained competencies, qualification-employment match, satisfaction, completion).

More comprehensive data and information allows more precise measurement of outcomes, more efficient structuring of the system, improved targeting of funding and resources and a better match of education and training to the skills and knowledge that is required by students, employers and industry.

It is important to note that relevant and accessible data also helps students make informed choices, separate to any rhetoric surrounding STEM. Students should be able to see what STEM competencies are, what occupations require those competencies, what courses will deliver those competencies and potential outcomes they can achieve. A better match of students, education and training and skills and knowledge requirements will benefit the whole system.

Field of education, occupation and training package STEM classifications are possible to implement with the data that NCVER already collects. However, they can only cover STEM education and training in a fairly basic way because these classifications were designed for other purposes.

There are other approaches already in use and similar approaches that could be developed, but these rely on much more extensive and fit-for-purpose data. New data collections or systems must be put in place if we are to gather better information about the how the VET system runs and properly meet skills and knowledge demands.

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