Deloitte Access Economics

Australia's STEM workforce: a survey of employers

Office of the Chief Scientist

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AAUW	American Association of University Women
ACER	Australian Council for Educational Research
ACOLA	Australian Council of Learned Academies
AIG	Australian Industry Group
APS	Australian Public Service
ASX	Australian Stock Exchange
ATSE	Academy of Technological Science and Engineering
CBI	Confederation of British Industry
CEO	Chief Executive Officer
CTI	Commission for Technology and Innovation
DAE	Deloitte Access Economics
EU	European Union
GBAORD	Government Budget Appropriations or Outlays for Research and Development
GDP	Gross Domestic Product
GII	Global Innovation Index
GNI	Gross National Income
INSEAD	Institut Europeen d'Administration des Affaires (European Institute of Business Administration)
IT	Information Technology
KPI	Key Performance Indicator
OCS	Office of the Chief Scientist
OECD	Organisation for Economic Co-operation and Development
PhD	Doctor of Philosophy
PISA	Programme for International Student Assessment
PPP	Purchasing Power Parity
R&D	Research and Development
SERI	State Secretariat for Education, Research and Innovation
SNA	System of National Accounts
STEM	Science, Technology, Engineering and Mathematics
STELR	Science and Technology Education Leveraging Relevance
UCES	UK Commission for Employment and Skills

UK	United Kingdom
US	United States
VET	Vocational Education and Training
WIPO	World Intellectual Property Organisation

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Finally, Deloitte Access Economics would also like to acknowledge the contribution of all those who participated in the consultation process and/or provided information via the online survey conducted as part of this project. A full list of organisations that participated in the consultations is included in Appendix A of this report.

Executive summary

Science, Technology, Engineering and Mathematics (STEM) play a critical role in Australia's ability to innovate, expand, and remain a competitive force globally.

In early 2013, Australia's Chief Scientist, Professor Ian Chubb, proposed the development of a long-term and cohesive national strategy for developing and building Australia's capabilities across STEM. As noted by the Chief Scientist at the time, "several countries have developed strategies to ensure that their STEM enterprise is coordinated to ensure they build the capacity they need to support their communities – or develop their capacity to minimise the risk of falling behind" (OCS, 2013).

This sentiment was echoed in a recent report from the Australian Industry Group (Ai Group), in which its Chief Executive, Innes Willox, noted that "STEM skills are essential for the future economic and social well-being of the nation with an estimated 75% of the fastest growing occupations requiring STEM skills and knowledge. Despite this, enrolments and the number of graduates with STEM qualifications continue to decline. This is a major concern for industry" (Ai Group, 2013).

Ensuring that the workforce has the relevant skills in sufficient quantities requires an understanding of how these skills are used within Australian businesses and skill needs into the future. **Efficient and effective investment to ensure sufficient supply of individuals with skills in STEM disciplines requires understanding the use of these skills in the workplace, including how this may change in the future**. Despite the importance of this information, limited research has been conducted into the demand for these skills in Australian workplaces.

Successfully delivering the skills for a knowledge economy will depend not only on producing the right number of graduates, but also on the education system supplying these graduates with the **right knowledge, competencies, and qualities**. Education not only meets demand from the economy, it also **drives the economy by supporting innovation**.

As well as being important from an economic viewpoint, the innovation which comes from **having a highly skilled STEM workforce can also deliver improved living standards**, in areas such as medicine, environmental science and engineering.

An Australian Council of Learned Academies (ACOLA) report, released in May 2013, stated **that there is a lack of knowledge about the way that STEM skills are used by employers**. This report also identified that most nations are closely focused on advancing STEM, and proposed that although Australia is currently well positioned , it lacks the national urgency seen in the United States, East Asia and much of Western Europe.

In order to fill this gap, the Office of the Chief Scientist commissioned Deloitte Access Economics to conduct research into the demand for STEM skills within the Australian workplace. An extensive research project was developed, including a literature scan, consultations, focus groups and an employer survey. The research conducted contributes to knowledge regarding demand and views around the STEM workforce by Australian industry.

STEM graduate demand

The employer survey conducted for this project confirms that STEM graduates are in demand in Australian workplaces. **Over 82% of respondents to the employer survey agreed that people with STEM qualifications are valuable to the workplace**, even when their qualification is not a prerequisite for the role.

Not only did the majority of respondents recognise the innovative talents that many STEM-qualified staff bring to their workplaces – **with 71% nominating their STEM staff as among their most innovative, but almost half (45%) expect their requirements for STEM to increase** over the next five years.

Along with the ability to innovate, flexibility to work with and implement those innovations will also be crucial for business success. People with STEM qualifications also appear to fit this profile, with **71% of employers agreeing that people with STEM qualifications are able to adapt to changes in business.** Against this backdrop of the need for innovation and the increasing demand for STEM skills, some employers noted that they were already, having **difficulty in filling Technician and Trades Worker roles (40%);** as well as other roles for STEM graduates (32%)[1].

STEM graduates and skills they bring to the workplace

The demand for people with STEM qualifications is closely linked to the skills that they bring to the workplace. The results from the survey show that employers are particularly looking for capabilities in (1) active learning, (2) critical thinking, (3) complex problem-solving and (4) creative problem-solving, all of which correlate closely with STEM qualification based skills. STEM qualified individuals tend to excel in these areas, particularly in comparison with their non-STEM qualified counterparts. For example, respondents rated the average skill level of people with STEM qualifications as higher across a range of skills and attributes, with the biggest differences seen between STEM and non-STEM qualified employees for the four most important skills to employers as listed above.

Employers – on average – rated interpersonal skills as the most important candidate attribute that they look for during recruitment. In the interpersonal skills category, employers reported that STEM qualified employees displayed slightly lower levels on average than their non-STEM counterparts.

STEM workforce recruitment

Some of the issues encountered by respondents during recent recruitment exercises included a **lack of business understanding and the content of qualifications not being relevant to the business**. For recruitment processes that targeted inexperienced hires, other issues encountered included a lack of general workplace experience and a lack of practical experience – issues that could be probably be seen amongst any recently qualified cohort. The critical role of complementary employability skills – particularly the ability to communicate, collaborate and operate effectively within an industry environment – were also strongly emphasised throughout the consultation contribution to this research.

[1] Includes professional or manager roles.

Of more immediate concern, perhaps, should be the finding that over one-fifth (21%) of employers looking to hire inexperienced STEM staff (i.e. those with less than five years' experience) felt that there was a **shortage of STEM graduates**. Along similar lines, over one-fifth of employers looking to hire more experienced STEM staff (i.e. those with more than five years' experience) noted that they had **a lack of applications received for advertised positions.**

Collaboration between educational institutions and Australian workplaces

Shortages can arise where the supply of available skills does not meet demand. As indicated through the survey, many Australian workplaces are looking to increase their number of STEM qualified staff. Throughout the consultations, the need was identified for collaboration between industry and education providers to ensure that the right number of appropriately qualified candidates is available.

An important factor highlighted throughout the research was the fast pace of change of many STEM-related industries. This lends itself to **re-evaluate whether the demands of Australian businesses operating in these sectors are being adequately met in relation to skill needs**. This is of particular importance if Australia wants to keep pace with innovation levels of other countries, with many nations implementing policies and programs which boost the supply and use of STEM skills in their workforces.

Meeting this demand will also require initiatives that provide students with the skills and attributes that are most important to employers. Overall, the current level of engagement with education providers remains relatively low. Respondents to the survey recorded a particularly **low level of satisfaction with their engagement with educational institutions to develop business-relevant STEM content**.

The survey results highlights that STEM qualified individuals bring important skills to the workplace, and in some instances they are hard to recruit. These recruitment difficulties in most part are attributed to the quality of non-STEM-related skills and attributes of the applicant.

Work experience is valuable

Although the importance of work experience is well established, there was a clear distinction from survey respondents between the value placed on short or unpaid work experience, compared with paid or longer (i.e. more than 12 weeks duration) work experience. For example, when asked to assess the importance of various candidate attributes **almost one third (31%) said that work experience of short duration (i.e. less than 12 weeks) was not important.** In contrast, work experience in the relevant industry was more highly valued, with 30% seeing this as very important.

As noted above, many respondents also noted a lack of general workplace experience as an issue encountered during recent recruitment processes, particularly when recruiting people who had recently gained their qualifications. Coupled with this, **work placements and work experience were also highlighted as one of the most effective teaching methods for helping students acquire the skills they need in the workplace.**

Together, these findings highlight the importance of long-term work placements for assisting students in preparing for their work lives. Despite the importance and value of these learning experiences, most respondents (62%) indicated that they did not currently offer structured work placements.

The survey explored whether employers would offer more work experience opportunities if government grants were provided, and although further research and exploration would be required, the majority of respondents (62%) indicated that they would increase placements with a government grant.

The provision of meaningful work placements for people gaining STEM qualifications appears to be a particular area of opportunity for government, education providers and industry to work collaboratively and effectively together to help meet Australia's future needs for STEM skills.

The UK experience

This report provides comparisons of STEM skills and innovation measures with two other countries – the UK and Switzerland. A survey conducted in the UK in 2011 also found a STEM shortage, with 28% of survey respondents agreeing that there was currently a shortage of STEM graduates. Along similar lines, 21% had encountered a lack of applications, although these shortages are expected to intensify as the economic recovery in the UK continues to gather pace.

There was also a strong message about the **shortfalls in 'soft skills' that many STEM graduates possess, with practical skills also an issue**. For example, 20% noted literacy issues and 32% issues in self-management. When asked how these issues might be best addressed, businesses wanted to see higher education institutions doing more to help students develop work-relevant skills and **improve the business relevance of undergraduate courses – very similar to the sentiments expressed by Australian businesses**.

The Switzerland experience

Unlike Australia, which has limited private sector investment and stronger government-based support for research and development, Switzerland relies primarily on its private industry. As a nation with limited natural resources, human capital is the most valued factor of production, and significant funding is invested in its higher education sector. This model appears to be paying dividends for Switzerland, which was ranked at the top of the World Economic Forum's Global Innovation Index in 2011, 2012 and 2013.

Despite its strong performance in the innovation rankings, Switzerland is also facing its own STEM shortage, particularly in the fields of computer science, engineering and construction. To counteract this, additional effort has been made to **boost the profile of the science curriculum throughout both primary and secondary schooling to attract students into science-related courses for their post-school education**, as well as targeting women who continue to be underrepresented in these fields.

Next steps

The findings from this project demonstrate that there is significant awareness, engagement, and in some instances, concern, regarding the current and future supply of adequate STEM skills available for Australian businesses. However as STEM skills are relevant to a very wide range of industries, it necessarily follows that business employing people with STEM qualifications are not a homogenous body. It is important to note that although 'STEM' is the focus of this project, it consists of four distinct disciplines – **Science, Technology, Engineering and Mathematics** – and that each of these disciplines contain a diverse mix of fields, qualifications, specialisations and relevant occupations.

As an example of the specific issues facing a particular cohort of STEM employers, a case study has been included on Regulatory Scientists. This case study is the outcome of a short series of focus groups with both industry and government to discuss the issues and potential solutions in ensuring there is an adequate supply of skills for the sector. Currently it is difficult for industry and government regulators alike to employ and retain staff with the relevant background and knowledge in Regulatory Science. Anecdotal evidence also suggests that **large investments are being made to build the capabilities of new employees in the workplace**. This is a result of a significant gap between the qualifications that students are obtaining and the minimum level of knowledge required to be effective in the workplace. This case study is presented as an addendum to this report.

Any solutions and strategies must also be considered in a global context, with nations all around the world increasingly focussed on **ensuring an adequate supply of STEM skills**. Not only are other countries a source of both supply and competition for STEM skills, but many of the lessons and policies implemented may also provide valuable directions for Australia as it moves to develop a national STEM strategy.

Deloitte Access Economics

1 Introduction

1.1 Objectives of this report

This report, commissioned by the Office of the Chief Scientist (OCS), seeks to understand the skills requirements of Australian businesses with regards to **Science, Technology, Engineering and Mathematics** (STEM). The research was conducted by Deloitte Access Economics, and included a literature scan, a series of consultation sessions and a large online survey targeted at businesses that employ people with qualifications in one or more of the STEM disciplines.

This research was commissioned in response to a recommendation made in an earlier report produced by the Australian Council of Learned Academies (ACOLA), released in May 2013; namely **that there is a lack of knowledge about the way that STEM skills are used by employers**. The focus of the ACOLA report was to identify what other comparable countries are doing in order to develop their STEM capabilities, and to draw out any lessons for Australia. This report also identified that most nations are closely focused on advancing STEM, and proposed that although Australia is currently positioned near the top, it currently lacks the national urgency seen in the United States, East Asia and much of Western Europe. The report also highlighted that **both businesses and tertiary education institutions have a responsibility to work collaboratively to produce graduates who are employable**.

One of the knowledge gaps highlighted by this report was the relative lack of data available within many countries relating to the education-employment nexus. While the supply of graduates could be quite readily quantified due to the regulatory and funding role that governments play in the education sector, relationships between education, skills and the use of skills in the workforce are not well understood.

Many of the issues identified as part of the initial literature scan were also consistent with the key findings of the consultation phase of this project. These included the importance of building awareness of STEM disciplines and STEM-related occupations among young people, an under-representation of females studying and working in STEM fields, and the importance of facilitating STEM partnerships between the education sector and industry.

This research also sought to build on existing research conducted in this space, in particular a recent survey of employer views by the **Australian Industry Group** (Ai Group) – the 'Survey of Workforce Development Needs 2012'. This survey found that employers indicated particular difficulty recruiting STEM-qualified technicians and trades workers (41%), professionals (27%) and managers (26%) across different industries. Of the employers who had experienced difficulties recruiting staff with STEM skills, 25% found a lack of available applicants with STEM skills to be the greatest barrier. Other key barriers included a lack of workplace experience (24%) and the content of qualifications not being relevant to business needs (18%).

In addition, successfully delivering the skills for a knowledge economy will depend not only on producing the right number of graduates, but also on the system supplying these graduates with the **right knowledge, competencies, and qualities**. Education not only meets demand from the economy, it also **drives the economy by supporting innovation**.

1.2 STEM in Australia

In July 2013, Australia's Chief Scientist Professor Ian Chubb, released a position paper on the development of a national strategy to guide STEM in Australia. This Strategy was directed to the Australian Government, and highlighted that there were four essential, interconnected elements:

- **Education**: formal and informal;
- **Knowledge**: ensuring a continuous flow of new ideas, and their dissemination;
- **Innovation**: using knowledge to produce high value goods and services; and
- **Influence**: collaboration, networks and alliances, to ensure that Australia earns its place in the world.

The key objective of the strategy is *to utilise fully Australia's capacity in STEM to secure social, cultural and economic prosperity for all Australian's while positing Australia to advantage in a changing world* (OCS, 2013). The strategy also recognises that education and industry linkages in STEM must be strengthened, with better integration of the public and private STEM sectors. In particular, it notes that 'Australia has much to learn about the business and economic benefits that can be found in the interplay between STEM and innovation that exists in places like the US and Europe' (p21).

According to the ACOLA report referred to earlier, '… Australia has travelled fairly well until now, but there are holes in capacity and performance. Furthermore, many countries are improving STEM provision, participation and performance more rapidly than us' (ACOLA, 2013). This therefore places both Australia's absolute and relative positions at stake. The report also highlights Australia's wide distribution in student achievement as a particular issue, with a long tail of underperforming students. This impacts on the number of students with the skills and capacity to study and pursue higher-level STEM careers, and influences the value placed on STEM disciplines within the wider Australian society.

Other concerns highlighted in the ACOLA report include:

- Relatively low tertiary entrants into mathematics (0.4% in Australia compared with an OECD average of 2.5%);
- Low proportion of Doctor of Philosophy (PhD) degrees awarded in engineering, and large proportion of growth in STEM PhDs due to international students;
- Severe gender imbalance in Australian tertiary enrolments in STEM, although this is notable in all countries around the world and especially in South Korea and Japan; and
- Capacity gaps in STEM teaching, with a clear indication that the supply is insufficient, particularly in rural and remote communities. This results in a large 'teaching out of field' problem with many mathematics teachers having no tertiary mathematics.

Results from the 2012 Program for International Student Assessment (PISA), conducted by the OECD, show that although Australia still sits above the OECD average in mathematical literacy and scientific literacy, both the absolute and relative performance have declined over time. In particular, as highlighted in an Australian Council for Educational Research (ACER) summary of the 2012 results, the proportion of Australian low performers in mathematical literacy has increased (by 5%), while the proportion of Australian top performers has decreased (by 5%) (Thomson, De Bortoli, & Buckley, 2012). The mean score for scientific literacy has not changed significantly.

1.3 Research methodology

The research conducted for this report was completed in three key phases:

1. Literature scan
2. Consultations
3. Survey of employers

Key findings from both the conclusions and survey are included in this report, the results from the literature scan are contained in a separate report.

1.3.1 Literature scan

The literature scan reviewed key national and international literature with a view to identifying any relevant employer surveys which had previously been undertaken on the use of STEM in the workplace.

The literature scan also provided a comprehensive, although not exhaustive, synopsis of current public research about the demand for STEM skills in the Australian and international labour force. Key findings from the literature scan were discussed during the consultation sessions.

1.3.2 Consultations

Consultations in the form of both semi-structured interviews and focus groups were conducted to gain insight into the role and demand for STEM skills, in the Australian work environment.

These sessions were held across Melbourne, Sydney and Canberra during 2013, with approximately 50 participants across a range of industries including the private and public sector. A mix of small, medium and large businesses was also represented. A full list of company participants can be found in Appendix A of this report.

The topics covered during the consultation sessions included:

- **STEM understanding**: explored the understanding of STEM skills and what is encompassed when describing these, as well as the types of jobs or qualifications included in this group;
- **Organisational value of STEM**: explored the value placed on the use of STEM skills, either explicitly through strategy or policy, or more implicitly through culture;

- **STEM-specific roles and demand for STEM**: explored the demand for, and supply of, STEM skills by using recent recruitment processes as an example. In addition explored the wider organisational demand for STEM skills; and
- **Recruiting STEM-qualified individuals**: discussed the methods used to attract STEM qualified individuals to the organisation, as well as any links to education or training institutions.

The structure of the consultations also allowed time for participants to discuss any other issues not included elsewhere in the discussion.

1.3.3 Survey

An online survey of employers was undertaken in the latter part of 2013. This survey was targeted towards organisations that either employed, or were looking to employ, at least one member of their staff with a qualification in **Science, Technology, Engineering and Mathematics.**

The topics covered as part of the survey included:

- Employment of STEM-qualified staff
- Importance and skill level of STEM skills and attributes
- Recruitment of STEM qualified people
- Future demand for STEM
- Links with post-secondary educational institutions
- Work placements
- Higher degrees by research

A copy of the online survey instrument is included in Appendix D.

1.3.3.1 Survey response

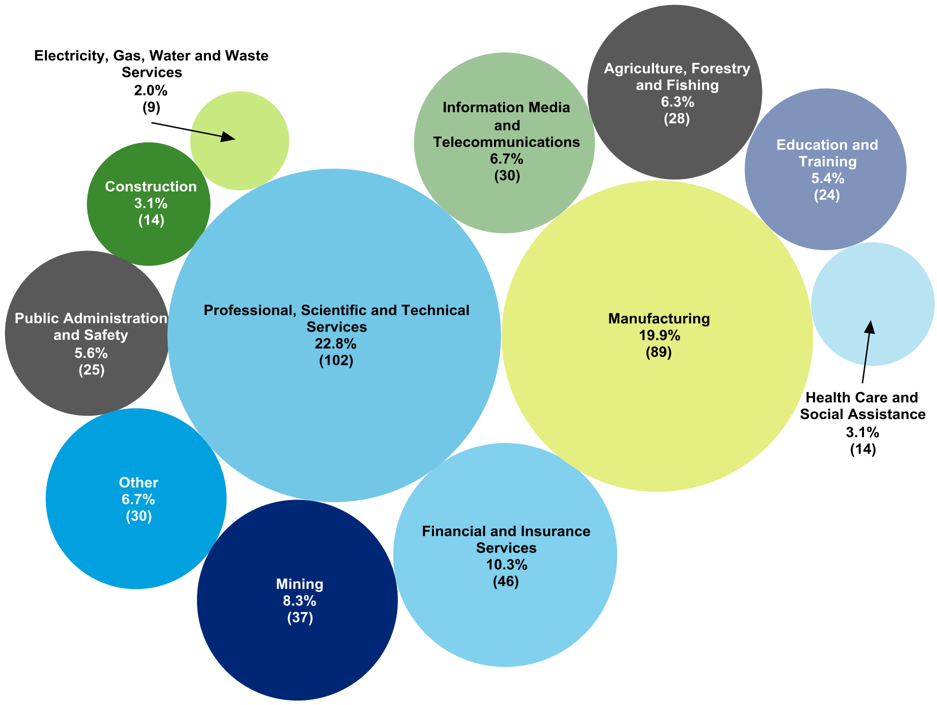
A total of 1,065 responses were received, with 491 (or 46.1%) of respondents fully completing the survey. Around one third (34.4%) of respondents were Chief Executive Officers, Managing Directors or business owners; 17.5% were Managers, and 15.8% occupied other Senior Executive roles. A further 26.2% of respondents occupied other roles within their organisations, such as analysts, researchers and teachers.

The distribution of responses by industry, business size, sector and employment of STEM is included below.

1.3.3.2 Industry

Chart 1.1 demonstrates the distribution of responses by industry. For the remainder of the analysis, several of the industries have been combined into an 'Other' category, as there are a small number of responses received from each group.

Chart 1.1: Responses by industry



* Other includes industries not listed above.
Source: Deloitte Access Economics, STEM Employer Survey (2013)

Together, the businesses which participated in this survey employ approximately 450,000 staff. Table 1.1 outlines an approximate number of employees represented by industry type where 28 or more individual organisations from that industry participated in the survey.

Table 1.1: Employee representation, by industry

Industry	Employees (no.)
Professional, Scientific and Technical Services	79,000
Mining	69,000
Financial and Insurance Services	44,000
Education and Training	33,000
Manufacturing	15,000
Agriculture, Forestry and Fishing	13,000
Information Media and Telecommunications	5,000
Other	197,000
Total	**450,000**

Note: These figures are approximate only, and take account of multiple responses from the same organisation (i.e. where different divisions/departments of the organisation were represented). As a result, double counting has been eliminated as far as possible by matching the names of organisations as provided by respondents.
Source: Deloitte Access Economics, STEM Employer Survey (2013)

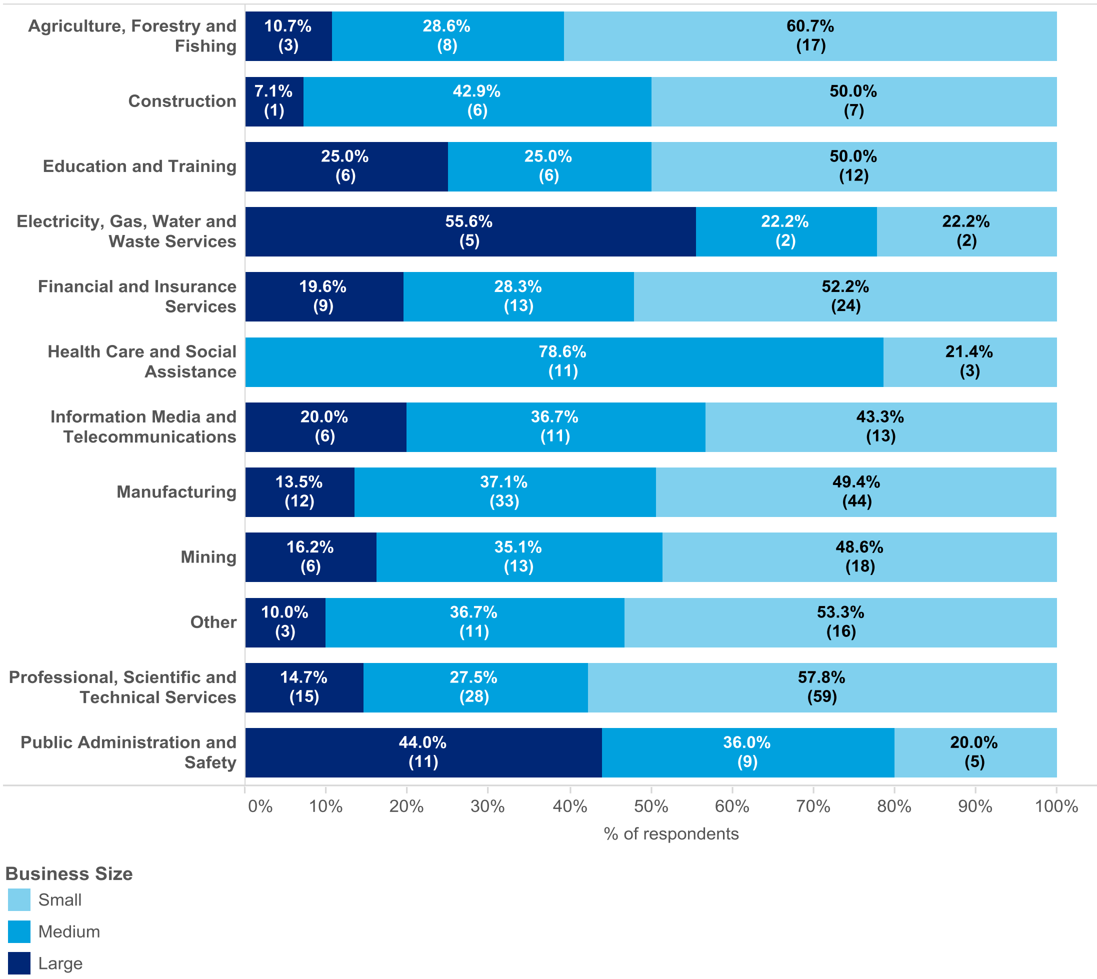
It is important to note that the industry stratification for this survey is based on a self-identified industry by the respondent. As such, the industry selected may differ from what may otherwise be used in official statistics and caution should be used when comparing the results.

1.3.3.3 Business size

The distribution of respondents by industry and business size is shown in Chart 1.2. The following definition was used to categorise businesses by their size:

- Small: less than 19 employees
- Medium: 20 to 199 employees
- Large: more than 200 employees

Chart 1.2: Responses by business size and industry

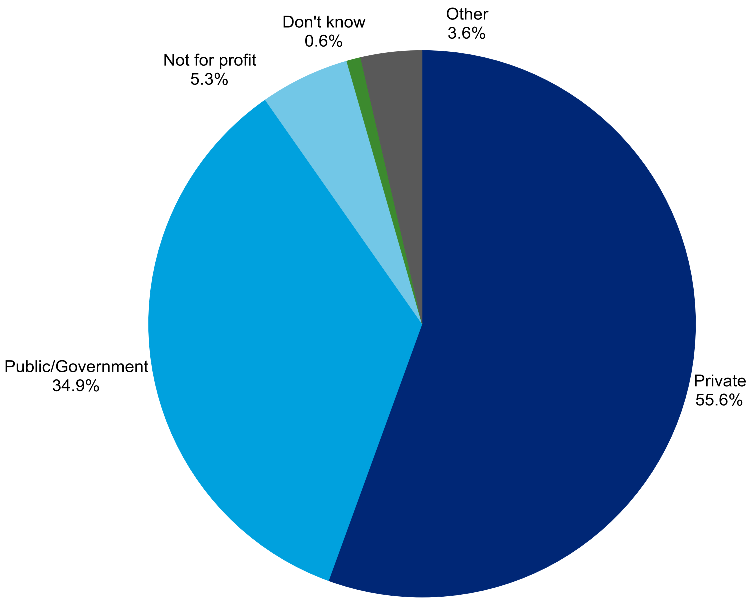


Source: Deloitte Access Economics, STEM Employer Survey (2013)

1.3.3.4 Sector

The majority of respondents (55.6%) are from organisations operating in the private sector, although the public (or government sector) was also well represented with over one third (34.9%) of all responses (see Chart 1.3).

Chart 1.3: Responses by sector



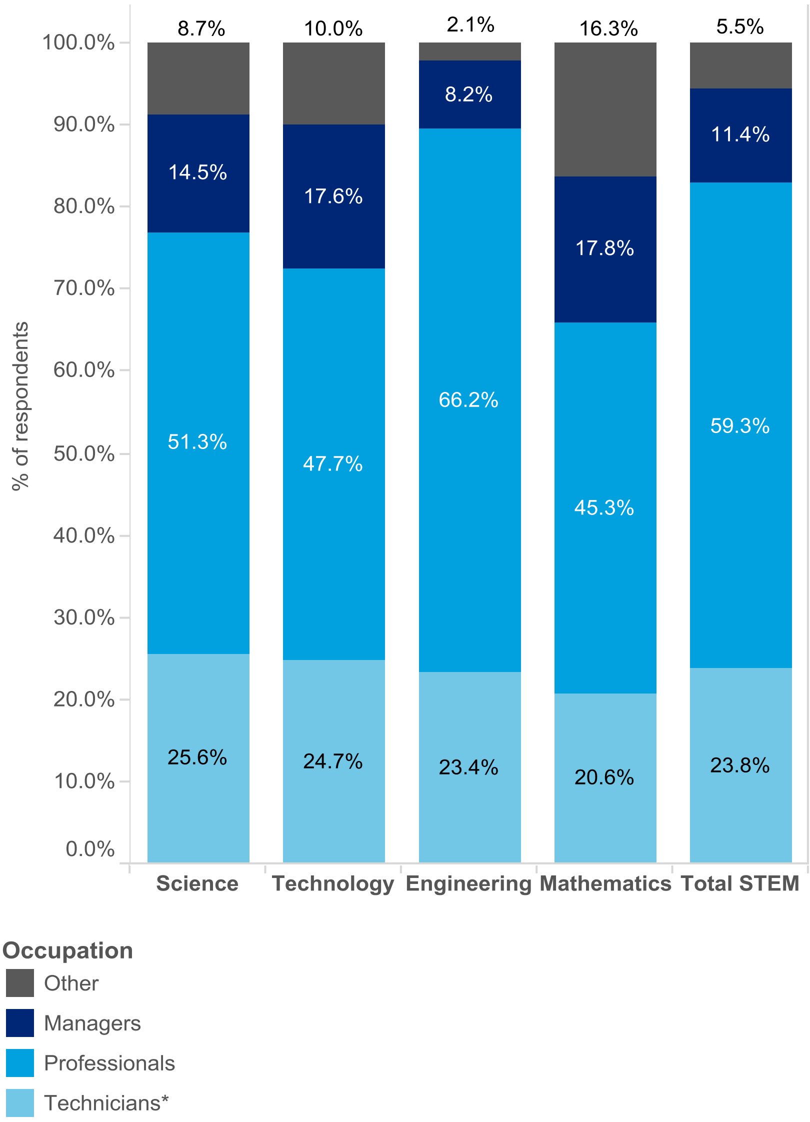
Source: Deloitte Access Economics, STEM Employer Survey (2013)

1.3.3.5 STEM employers

Survey respondents were also asked to nominate which of the four STEM disciplines (i.e. **Science, Technology, Engineering and Mathematics**) that their staff currently had qualifications in across various occupations. As expected, many employers noted that they employed staff in more than one STEM discipline.

Chart 1.4 shows the distribution of STEM-qualified staff by their level of occupation. Overall, people with STEM qualifications were most likely to be employed in professional occupations (59.3%), followed by technician and trades workers (23.8%), and managers (11.4%).

Chart 1.4: Employment of STEM qualified staff (%)



*Technicians and trades workers
Source: Deloitte Access Economics, STEM Employer Survey (2013)

2 STEM skills

The key area of focus for this research was to gain an understanding of the skills demanded across the STEM disciplines. Despite the importance placed on understanding both the supply and demand for STEM skills around the world, there remains no clear definition of specific STEM skills. In many cases, skills identified as being important to the STEM disciplines – such as the ability to think analytically, or communicate using technical language – may not necessarily be limited to STEM disciplines but are also applicable for other occupations and subject matter. This makes the definition of 'STEM skills' particularly difficult, as was reflected during the consultation sessions where no consensus was reached.

The insights gained throughout the research were diverse; however there were several themes which permeated through the research. These included the importance of creativity and innovative thinking; and the need for people with STEM qualifications to communicate, collaborate and operate effectively within a given industry environment. Many of the findings from the research based on the Australian context echoed those identified during the literature scan (including internationally).

2.1 Labour market skills

Research conducted as part of the literature scan identified the following typology of skills typically required in the labour market, based on research conducted by Aring (2012) as part of a background paper for a UNESCO report. This categorisation includes:

- **Cultural skills**: Considered the most difficult to teach, cultural skills are about understanding how the organisation works to get things done. These include decoding unwritten rules and navigating the unique culture of each workplace;
- **Interpersonal skills**: Essentially focuses on the ability to listen, speak and present information;
- **Intra-personal skills**: Considered extremely difficult to teach, these skills relate to the ability to manage emotions, be comfortable with uncertainty, and manage time and resources; and
- **Technical or job-specific skills**: Considered the easiest to teach, these skills relate to how to operate specific tools, processes, machines, software, etc. required for a particular job.

Based on this stratification, STEM skills are considered to sit within the **technical or job-specific classification**.

It should also be noted that the attribution of STEM-specific skills exclusively to those who hold STEM qualifications is not always a reasonable assumption. For example, data manipulation and interpretation skills can be gained through economics or econometrics degrees (not typically included as STEM fields). Similarly, analysis and problem-solving skills are obtainable through a psychology degree, as are technical drawing skills through architecture.

The list of STEM skills used for this survey is based on those identified in a report by Carnevale, Smith and Melton (2011). It includes a mixture of skills from each of the four categories listed by Aring. Although many of the skills are not considered to be exclusive to STEM, they were identified throughout the consultation sessions as important skills for people working in STEM fields to possess (although it was also noted that not every STEM person would possess each of these skills, especially those more relevant to specific occupations, such as *programming*).[2]

Figure 2.1: STEM skills included in survey

- Active learning (i.e. learning on the job)
- Complex problem-solving
- Creative problem-solving
- Critical thinking
- Design thinking
- Interpersonal skills
- Knowledge of legislation, regulation and codes
- Lifelong learning
- Occupation-specific STEM skills
- Programming
- System analysis and evaluation
- Time management

Throughout the consultations, a number of other skills and attributes were also highlighted as being important for STEM graduates to acquire. These included:

- Technology design
- Planning and project management
- Commercial/business acumen
- Strategic thinking

When asked what a well-rounded professional looked like today, answers included the ability to engage with technology, apply skills appropriately, and have strong communication skills.

2.2 Importance of STEM skills in the workplace

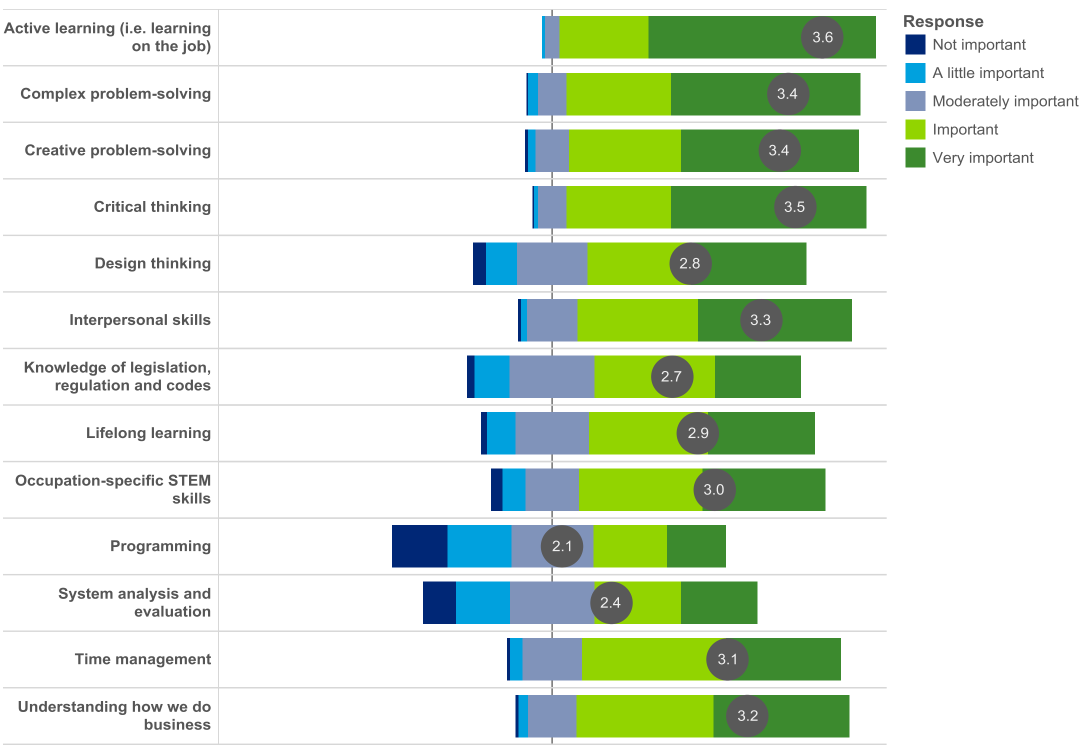
Based on the survey responses, on average, **the most important skill or attribute in the workplace is the ability to learn on the job** (active learning). This was followed closely by critical thinking and complex problem-solving.

[2] STEM can also be considered through a field of education – or qualifications - lens. A definition of STEM qualifications is included on page 8 of the survey, which is attached in Appendix B of this report.

Chart 2.1 shows the average rating of 13 different skills and attributes included in the survey. Respondents were asked to rate *skill importance* on the following Likert scale: Not important (0), A little important (1), Moderately important (2), Important (3), Very important (4). Each coloured bar presents the number of respondents for each category response to visualise the distribution of the importance for each skill. The bubble value presents the average importance for each skill. 'No response', 'don't know' and 'not applicable' have been excluded from this analysis.

Overall, the average rating indicates that all skills, except for the somewhat more specialised skills of 'systems analysis and evaluation' and 'programming' were rated as *Important* across all respondents. This is not to suggest that these more niche type skills are not important in specific workplaces, but rather that many workplaces may not require these skills, thus lowering the overall importance rating. In addition, not all people with STEM qualifications are employed in roles that require the use of their STEM skills and knowledge, particularly as they move into managerial or leadership positions.

Chart 2.1: Importance of skills and attributes in the workplace (avg rating)



Source: Deloitte Access Economics, STEM Employer Survey (2013), please see Appendix B for statistical testing

The skill rated as having the highest importance by respondents to the survey was 'active learning', with a mean response of 3.6. This was followed by 'critical thinking' (3.5), 'creative problem-solving' and 'complex problem-solving' (both 3.4) and 'interpersonal skills' (3.3). As shown in Chart 2.1, the distribution of responses differed across the different skills, with a standard deviation of 0.82 calculated for 'interpersonal skill's compared with 0.60 for 'active learning'. At the 95% confidence level, the standard error for each of the skills listed was between 0.03 and 0.06. Further information on the statistical testing performed on the data presented in this chart can be found in Appendix B.

During the consultations the importance of the technical skills of STEM qualified people were described as 'fundamental' and 'core to businesses' - the value given to other employability skills was emphasised during almost every consultation session. This echoed the research conducted as part of the literature scan, and is also consistent with the results of the survey.

In particular, the importance of **creativity**, **communication**, **collaboration** and **business acumen** were frequently highlighted as crucial skills in the current Australian workplace. In addition, the ability to combine these types of skills with technical STEM skills was commonly referenced as being of particular value (and in the shortest supply). This largely reflects the growing division of labour, in which **people undertake increasingly specialised roles within a collaborative environment.**

The importance of creativity, and problem-solving was also highlighted through the research. Some described creativity as the 'ability to think outside the box', others described it as a fluid process that reflected the ability to use a breadth of knowledge, technology and processes, and narrow these down to create an innovative and effective solution.

Throughout the research, high labour costs were associated with operating in Australia. The role of innovation is crucial to staying competitive within a global environment. **Design thinking** – the ability to pull together cognitive, behavioural, functional and technical skills to develop solutions to meet user needs – was seen as **critical to the innovation process**.

A number of companies with global operations cited that there was little research and innovation done in the Australian market, with one of the reasons being a **lack of access to adequate skills**. There was also acknowledgement that without a visible demand for these types of skills, they are unlikely to be supplied by the Australian education sector. Thus, this highlights the **importance of stimulating demand** for these skills in order to ensure long-term supply, which may in term support opportunities for innovative research and development within the Australian market.

Innovation can also be **fostered by an active curiosity**, which along with personal interest, was a highly valued characteristic among participants. In particular, some felt that natural curiosity, particularly in young children, was a distinct advantage that STEM fields had over other subjects, and that this characteristic should be more widely exploited throughout the school education system to foster interest in STEM at a young age.

Some participants speculated that in many STEM fields, the focus tends to be on teaching and encouraging critical or logical thinking which in many instances is a narrowing of facts, assumptions, and ideas into, conclusions. Whereas creative thinking requires a broadening of thinking to consider alternate possibilities and solutions.

On the whole, the findings from the consultations regarding the importance of employability skills were closely aligned with those published in a 2012 EU Skills Panorama report.

> *As STEM-driven technology and services become more embedded in everyday life, both in business and in society, STEM professionals need to be able to understand and respond to customer challenges, consumer choices and the*

> *opportunities they present. Employer surveys have shown that some STEM graduates are considered under-skilled in the requisite personal and behavioural competencies expected of them, such as team-working, communication and time management/organisational skills, as well as the more commercially-related skills including product development, customer service and business acumen.* (EU Skills Panorama, 2012)

2.2.1 Industry

As expected, different industries consider different skills to be of greater importance, reflecting the different type of work undertaken. Key findings by industry include:

- The most important skill in the **Construction** industry was 'active learning', with 62.5% rating it as *very important* and 37.5% rating it as *important*.
- 'Design thinking' was rated as only *moderately important* by 36.8% of respondents in the **Financial and Insurance** industry, with a further 13.2% rating it of *little importance* and 2.6% rating it as *not important*.
- As expected 'programming' and 'system analysis and evaluation' was rated as more *important* in the **Information Media and Telecommunications** industry than average, with 'knowledge of legislation, regulation and codes' rated as the *least important* skill.

  'Interpersonal skills' were rated as *very important* by 83.3% of respondents in the **Education and Training** industry, with a further 11.1% rating them as *important*. In contrast, only 41.7% of employers in the **Agriculture, Forestry and Fisheries industry** saw interpersonal skills as *very important*.

2.2.2 Business size

The importance placed on various STEM skills also appeared to differ by business size. Key findings by business size include:

- Almost two-thirds (65.1%) of employers working in **large businesses** (i.e. more than 200 employees) rated 'critical thinking' skills as *very important*, compared to 50.6% in **medium businesses** (20-199 employees) and 58.8% in **small businesses** (less than 20 employees); and
- **Interpersonal skills also appear to be more valuable in large organisations**, with 49.2% of respondents rating these as *very important*, compared with 42.4% in medium organisations and 47.2% in small organisations.

2.2.3 STEM employers

The value placed on different skills depending on whether the organisation employed STEM qualified individuals was variable:

- Employers of **Science** qualified individuals were closely aligned to the overall trend of skill importance, with marginally more importance for 'complex problem-solving' and 'creative problem-solving';
- Employers of **Technology** qualified individuals placed more importance on 'programming' with 54.0% rating this skill as important or very important;
- Employers of **Engineering** qualified individuals placed more importance on 'design thinking' with 80.4% rating this skill as important or very important; and

- Employers of **Mathematics** qualified individuals placed more importance on ‘critical thinking’ with 96.1% rating this skill as important or very important; also ranking ‘system analysis and evaluation’ as more important compared to the norm.

2.3 Other skills important for STEM

In recognition that the list of STEM skills included in the survey was not an exhaustive list of skills required in the workplace from people with STEM qualifications, respondents were also asked to list any additional skills which they considered important to their workplace. Overwhelmingly **communication skills were most predominantly mentioned, followed by writing, project management, marketing, financial** and **leadership skills**. The word cloud in Figure 2.2 illustrates the relative frequency of the additional skills identified.

Figure 2.2: Other skills important in the workplace: word cloud

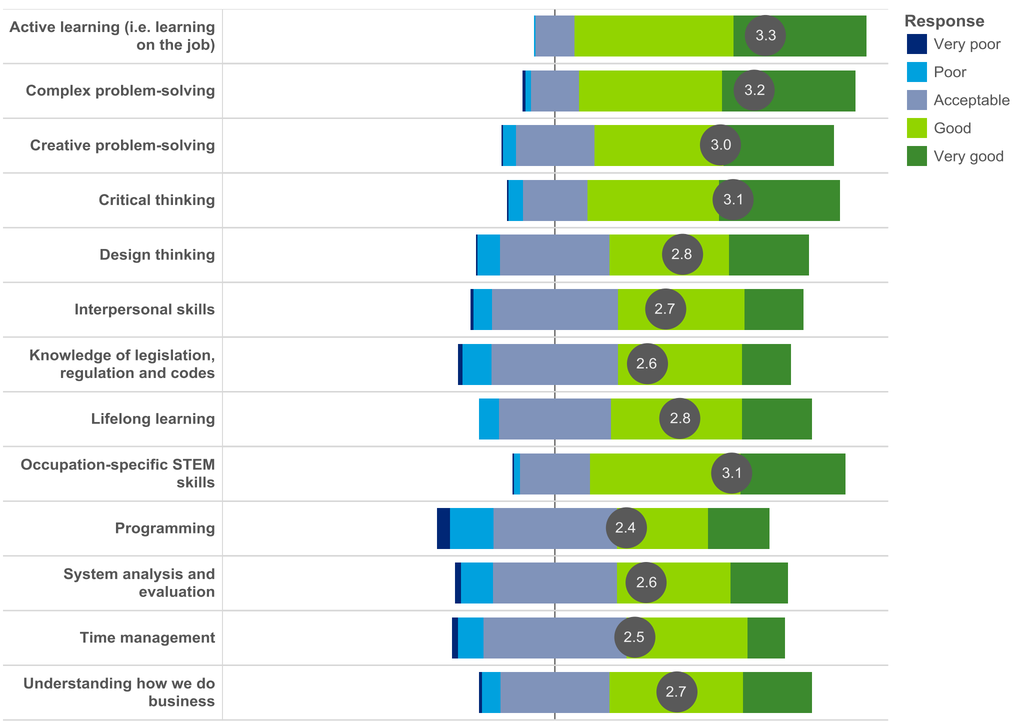
Source: Deloitte Access Economics, STEM Employer Survey (2013)

2.4 Average skill level

On average, people with STEM qualifications are ranked most highly on their active learning, complex-problem solving, critical thinking and occupation-specific STEM skills. According to Arings categorisation of skills referred to in Section 2.1, the skills that STEM-qualified people rank most highly on are those considered to be either **intra-personal skills** and **technical or job-specific skills**.

Chart 2.2 shows the average rating of 13 different skills and attributes included in the survey. Respondents were asked to rate the *skill level of STEM employees* on the following Likert scale: *very poor* (0), *poor* (1), *acceptable* (2), *good* (3), and *very good* (4). Each coloured bar presents the number of respondents for each category response to visualise the distribution of skill level. The bubble value presents the skill level. 'No response', 'don't know' and 'not applicable' have been excluded from this analysis.

Chart 2.2: Skill level in the workplace, STEM employees



Source: Deloitte Access Economics, STEM Employer Survey (2013), please see Appendix B for statistical testing

One in ten (11.5%) employers rated the level of 'time management' skills in their STEM employees as *very good*. This was the lowest proportion of *very good* responses received across all skills and attributes. In contrast, a significant proportion of employers rated the level of 'complex problem-solving' (40.3%) and 'active learning' (40.1%) as *very good.*

Very few employers rated any of the skills or attributes listed as *very poor*. Overall, the level of 'programming' skills was rated at the lowest level, although given this is a more specialised skill than many of the others included this is not necessarily unexpected.

Overall, the average skill rating for the listed skills for employees with STEM qualifications is 2.8 (between *acceptable* and *good*). At this total level, the standard error is 0.01, meaning that we are 95% confident of the actual value being between ±0.01 of the reported value (i.e. 2.8). The standard deviation for the level of skill for STEM qualified employees was 0.91. Further information on the statistical testing for individual skills can be found in Appendix B.

2.4.1 Industry

Survey findings indicate some difference between the skill level of STEM qualified individuals working across various industries. Key findings include:

- Assorted skill strengths are apparent across different industries within the Australian workforce, with the highest rating (3.4) given by the following industries to various skills: **Education and Training** (active learning), **Financial and Insurance Services** (complex problem-solving), **Health Care and Social Assistance** (active learning) **Information Media and Telecommunications** (creative problem-solving), **Professional, Scientific and Technical Services** (active learning, complex problem-solving, and occupation-specific STEM skills) and **Public Administration and Safety** (active learning and occupation-specific STEM skills);
- The lowest skill rating was in the **Construction** industry, with 'system analysis and evaluation' rated at an average of 1.5;
- In **Public Administration and Safety** time management and interpersonal skill were rated as the lowest at an average score of 2.2;
- Across all skills the **Professional, Scientific and Technical Services** industry more **positively ranked the skills** of STEM employees;
- In most cases the skill level rating in the **Construction industry** was **less than the average** apart from understanding how we do business, the average ranking for system analysis and evaluation had the greatest variance to the mean (-1.1); and
- **Electricity Gas and Water Services** was also less than the average with **interpersonal skills** showing the most difference compared to the mean (-0.5).

2.4.2 Business size

There were limited differences in the rating of the skills levels of STEM employees by business size. Key findings include:

- The highest rated STEM skills in **large businesses** were 'active learning' (3.3), 'complex problem-solving' (3.2) and 'occupation-specific STEM skills' (3.1). Less than half (45.7%) of large employers rated the 'interpersonal skills' of their STEM-qualified staff as *good* or *very good*;
- The three highest rated STEM skills in **medium businesses** were the same as for large businesses, although the ratings were slightly lower: 'active learning' (3.2), 'complex problem-solving' (3.1) and 'occupation-specific STEM skills' (3.0). However a larger proportion (57.0%) rated the 'interpersonal skills' of their STEM-qualified staff as *good* or *very good*; and
- For **small businesses**, employers were most satisfied with the level of 'active learning' skills (3.4), 'complex problem-solving' (3.3), 'creative problem-solving' (3.2) and 'critical thinking' (3.2). Small businesses were also the most satisfied with STEM employees'

'**understanding of how we do business'**, giving an average rating of 3.0, higher than both medium businesses and large businesses (2.6).

2.4.3 STEM employers

Overall STEM employers rated 'active learning' and 'complex problem solving' as the highest rated STEM skill (3.4). The lowest rated skill was 'knowledge of legislation, regulation and codes' (2.5); equal second lowest ranking was 'time management', 'understanding how we do business' and 'interpersonal skills'.

- Employers of **Science** qualified individuals rated '**active learning'** and '**complex problem solving'** high (3.3) and the lowest ranking included programming and time management (2.5);
- Employers of **Technology** qualified individuals rated 'active learning' high (3.3) '**programming' was ranked higher** (2.8) than the overall average rating;
- Employers of **Engineering** qualified individuals rated STEM specific skills higher than the average (3.1), ranking '**time management' the lowest** (2.4); and
- Employers of **Mathematics** qualified individuals rated STEM specific skills higher than the average (3.2), ranking '**time management' the lowest** (2.5) followed by 'interpersonal skills' and 'knowledge of legislation, regulation and codes'.

2.5 STEM versus non-STEM

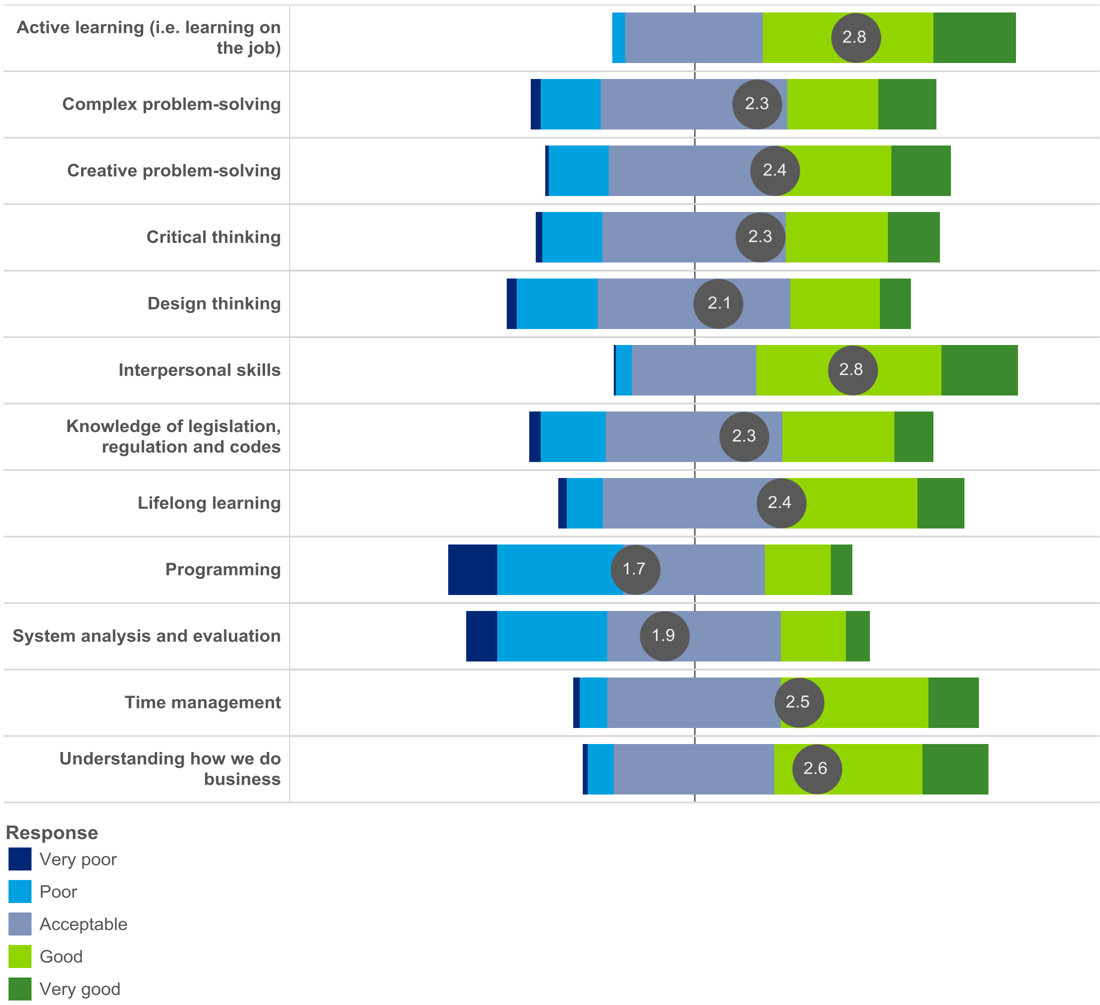
2.5.1 Overall skill levels

The average skill level of people with STEM qualifications across the range of attributes shown in Chart 2.1 is generally considered to be higher than those with non-STEM qualifications. This is true across all listed skills and attributes, except for 'time management' (where skill levels are seen as equivalent) and '**interpersonal skills', where people with STEM qualifications were rated slightly lower** than people with non-STEM qualifications. This indicates that **people with STEM qualifications bring important skills to the workplace, however it should also be noted that people with non-STEM qualifications would also contribute a range of other skills and attributes not listed as part of this survey**.

Chart 2.3 shows the average skill level of people with non-STEM qualifications in the workplace. As with the ranking of people with STEM qualifications, respondents were asked to rate the *skill level of STEM employees* on the following Likert scale: *very poor* (0), *poor* (1), *acceptable* (2), *good* (3), and *very good* (4). Again, each coloured bar presents the number of respondents for each category response to visualise the distribution of skill level.

Of the STEM skills and attributes listed, people with non-STEM qualifications were rated most highly on their 'active learning' (2.8) and 'interpersonal skills'. As expected, their level of skill in the more STEM based skills such as 'programming' (1.7) and 'system analysis and evaluation' (1.9) was rated the lowest.

Chart 2.3: Skill level in the workplace, non-STEM employees

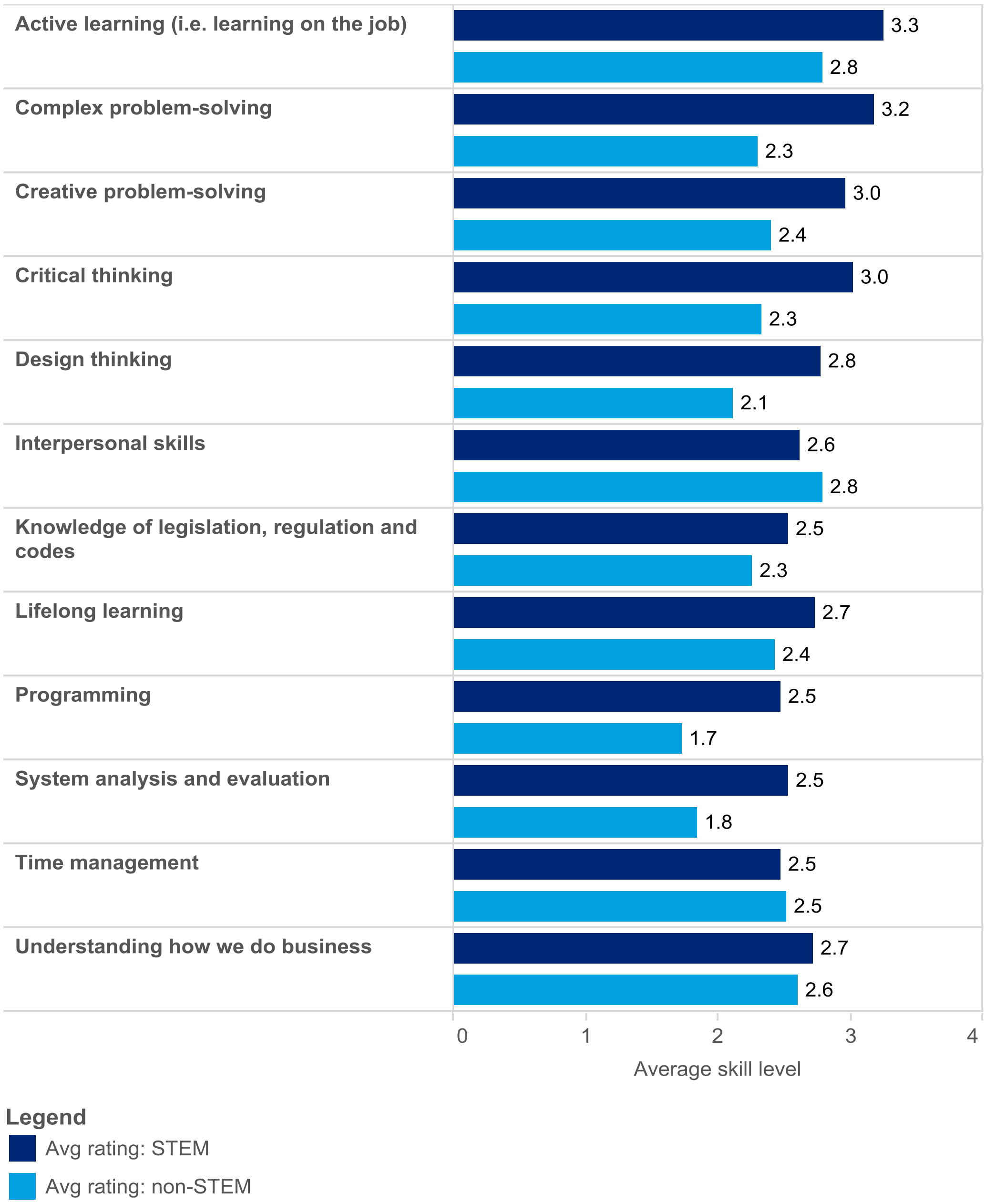


Source: Deloitte Access Economics, STEM Employer Survey (2013), please see Appendix B for statistical testing

Overall, the average skill rating for the listed skills for employees with non-STEM qualifications is 2.4 (between *acceptable* and *good*). At this total level, the standard error is 0.01, meaning that we are 95% confident of the actual value being between ±0.01 of the reported value (i.e. 2.4). The standard deviation for the level of skill for non-STEM qualified employees was 0.96, indicating a slightly higher distribution in responses than what was recorded for STEM qualified employees (0.91). Further information on the statistical testing for individual skills can be found in Appendix B.

Chart 2.4 compares the average skill rating for both STEM and non-STEM qualified people in the workplace. As noted above, the skill level of people with STEM qualifications is considered to be higher for all skills expect 'time management', which was rated as equal, and 'interpersonal skills' which was slightly lower for people with STEM qualifications.

Chart 2.4: Skill level (average rating) STEM and non-STEM



Note that the skills in this chart are listed in accordance with their overall importance ranking (as shown in Chart 2.2 above). This chart excludes respondents who did not provide ratings for both STEM and non-STEM qualified employees and as such may differ slightly from results shown in Charts 2.2 and 2.3 above.

Source: Deloitte Access Economics, STEM Employer Survey (2013)

The largest differences in skill levels between people with STEM and non-STEM qualifications were observed for **'complex problem-solving', 'programming', 'critical thinking' and 'system analysis and evaluation'**. As indicated above, the distribution of responses for non-STEM qualified employees (0.96) is higher than for STEM qualified employees (0.91). Further information on the statistical testing performed on this data can be found in Appendix B.

2.6 Interpersonal skills

The interpersonal skills of STEM qualified employees were often raised throughout the consultations as being a particular issue with STEM graduates. Some participants speculated that as roles are becoming increasingly specialised, the **importance of being able to work in a collaborative environment** will continue to grow.

The importance of collaboration skills, such as the ability to work within a team environment and communicate effectively, was also emphasised as critical in many workplaces. This ability was considered relevant regardless of whether the collaboration is undertaken face-to-face or via technologies in the case of virtual or multi-location-based teams; and in the latter the importance of these skills may be magnified.

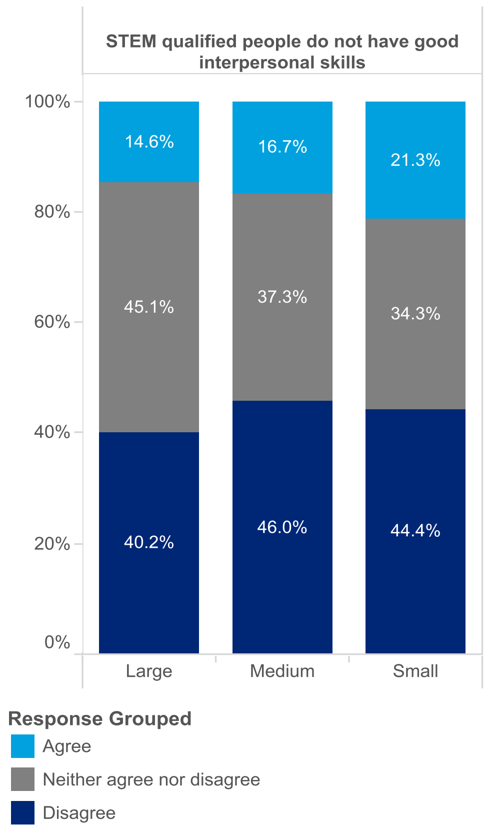
At its core, **the role of communication is to translate information**. Whether this is through the documentation of requirements, social media engagement activities, talking with clients, or collaborating with team members, communication is crucial. In addition to their importance in collaboration, communication skills are also more broadly needed to communicate both across organisations and to clients. Both written and oral communication skills were highlighted in this context, with the ability to tailor communication to different audiences a particularly valued skill.

The majority of participants in the consultation process represented companies that had a key function in collaborating with their clients (rather than developing products and selling these); for example, engineering firms, architects and specialised manufacturing companies. Although there was strong recognition that there remains a place in workplaces for purely technical people, the **ability to communicate with non-technical people** remains of great, and increasing importance. In particular, as solutions become more complex and technical, the chasm of knowledge between those who use technology and those who develop technology is likely to widen further.

Despite the sentiment expressed throughout the consultations, findings from the survey indicated that, on average, employers are only marginally more satisfied with the level of interpersonal skills that people with non-STEM qualifications bring to the workplace compared with STEM qualified individuals. In addition, although survey respondents viewed 'interpersonal skills' as *important,* they are not seen as the most important skill in the workplace, with less than half (46.4%) rating 'interpersonal skills' as *very important* in their workplace.

In addition, when asked later in the survey if they agreed with the following statement – *STEM qualified people do not have good interpersonal skills* – only 17.6% of respondents agreed, compared with 43.4% who disagreed (including 9.9% who strongly disagreed). The remaining 38.9% were neutral, noting that they neither agreed nor disagreed.

Chart 2.5: Response to statement 'STEM qualified people do not have good interpersonal skills', by business size (%)



Source: Deloitte Access Economics, STEM Employer Survey (2013)

When respondents were asked about recruitment processes for recently qualified STEM staff (i.e. less than five years' experience) it was identified that a lack of interpersonal skills was encountered during recruitment.

Although there is reasonable satisfaction with the interpersonal skills of STEM qualified people already operating in the workplace, a lack of interpersonal skills may be a barrier to employment for some recent STEM graduates.

3 Recruitment experiences

Australian businesses are having some difficulties in recruiting people with STEM qualifications with **40.5% of respondents having difficulty recruiting STEM-qualified technicians and trades workers and 31.5% having difficulty recruiting other STEM graduates**.

Although commonly referred to as a STEM skills shortage, there is some evidence to suggest that skills mismatches, and mismatches in applicant and employer expectations are also contributing to recruitment difficulties within particular industries.

The proportion of employers experiencing difficulty in the recruitment of STEM-qualified technicians and trades workers (40.5%) **is almost identical to the findings from the recent employer survey conducted by the Ai Group (41%)**. The relative difficulty in recruiting technicians and trades workers compared with STEM-qualified professionals and managers, as noted in the Ai Group study, was also verified through this research.

Throughout the consultations participants noted that the recruitment of more experienced personnel with STEM qualifications posed greater challenges than recently qualified. In particular, some participants noted that there was an abundance of newly qualified graduates, although some of the more niche specialities noted shortages.

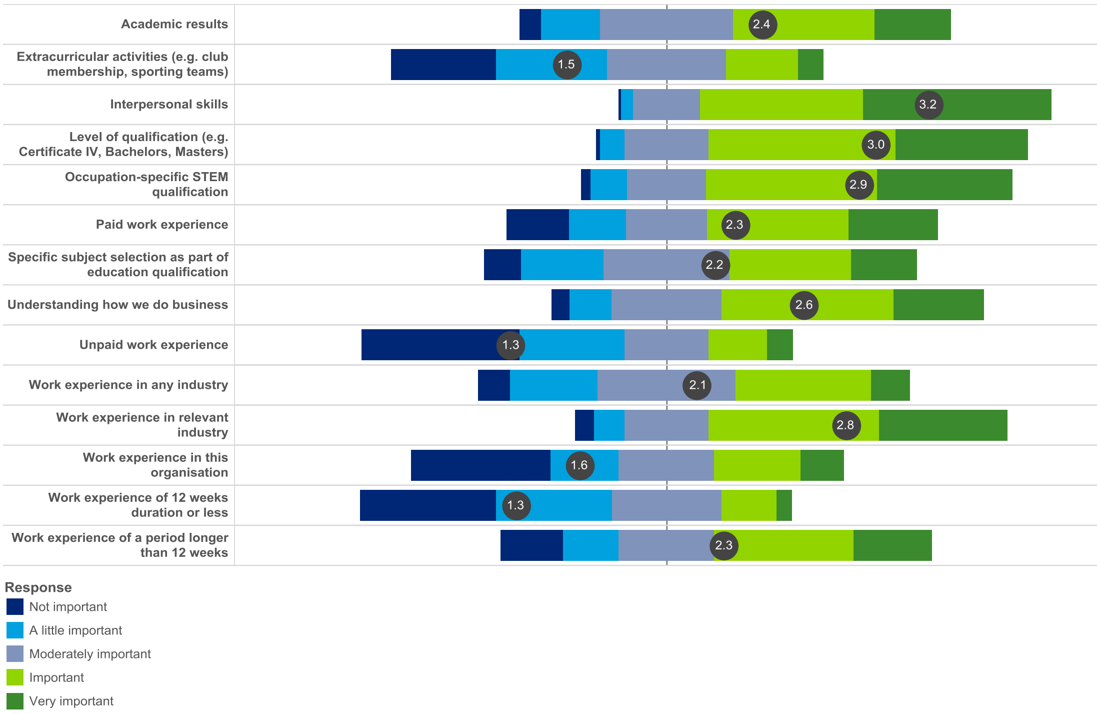
Based on the different recruitment experiences for recently qualified and more experienced candidates, the survey asked respondents to consider their recruitment of these two groups separately.

3.1 Candidate attributes

When looking for candidates, employers noted that the most important attribute was '**interpersonal skills'**, with 43.8% of respondents rating this as very important.

There was also a clear distinction in the average importance value attributed to various types of work experience. For example, while work experience was one of the most highly valued attributes that a candidate could possess, unpaid work experience and work experience of less than 12 weeks were the least valued of the candidate attributes listed. This indicates that there is a certain threshold for work experience before it becomes a valued attribute.

Chart 3.1: Importance of candidate attributes



Averages are calculated using the following rating scale: Not important = 0, A little important = 1, Moderately important = 2, Important = 3 and Very important = 4.

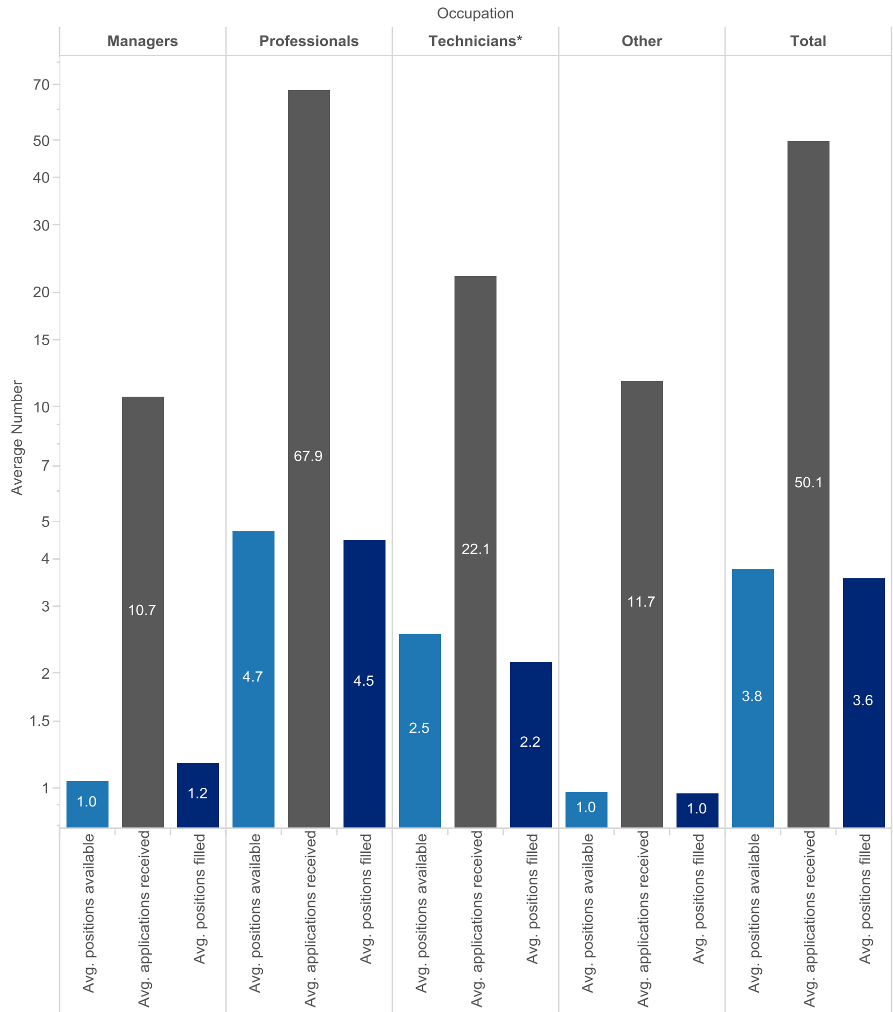
Source: Deloitte Access Economics, STEM Employer Survey (2013)

3.2 Recruitment of recently qualified employees

Overall, employers reported that, on average, **89.8% of positions advertised for STEM employees with less than five years' experience had been filled,** on average, 12.9 applications were received per position.

Chart 3.2 shows the recent recruitment experiences for employers who have tried to fill positions relevant to people with less than five years' experience. Measures included in the chart include the average number of positions available, the average number of applications received, and the average number of positions filled.

Chart 3.2: Recruiting STEM-qualified staff: less than 5 years' experience



Note: This chart uses a logarithmic scale. Prior to averaging, the Total group is calculated as the sum of the other four groups.
Source: Deloitte Access Economics, STEM Employer Survey (2013)
*Technicians and trades workers

Table 3.1: Recruiting STEM-qualified staff: less than 5 years' experience – average outcomes

Occupation	% of positions filled	Average applications per position
Managers	111.9%	10.2
Professionals	95.0%	14.4
Technicians*	84.8%	8.7
Other	99.6%	12.0
Total	89.8%	12.9

Source: Deloitte Access Economics, STEM Employer Survey (2013)

Note: The response for percentage of positions filled for managers could reflect the employment of more applicants than advertised positions
*Technicians and trades workers

3.2.1 Industry

Overall most industries did not appear to experience significant difficulties in recruiting people who have recently obtained STEM qualifications. Key industry findings include:

- In the **Professional, Scientific and Technical Services** an average of 14.1 applications were received for professional positions with 93.2% of positions filled;
- Manager positions in the **Public Administration and Safety** industry had an average of 25.0 applications per position with all positions filled. Contrary to this, in the professional occupations only 6.5 applications per positions received with 75.7% of positions filled; and
- **Financial and Insurance Services** had 13.3 applications per position in the professional occupations with 78.6% of positions filled.

3.2.2 Business size

There are some differences in recruitment experiences for business of different sizes.

- Overall, **large businesses** appear to have the least difficulty in recruiting people who have recently gained a STEM qualification, although on average, not all technicians and trades worker positions had been filled (75.9%);
- In contrast, **medium businesses** had slightly more difficulty, although they noted a relatively high number of applicants, with 17.0 applicants per manager position, 19.0 applicants per professional position with 94.9% of positions filled, and 7.7 applicants per technicians and trades worker position, with 91.8% of positions filled; and
- **Small businesses** experienced difficulty in the recruitment of professional occupations; with an average of 13.0 applicants per position, only 72.8% of total positions were filled. For technicians and trades worker occupations, an average of 13.4 applications were received per position, with 82.2% of positions filled.

3.2.3 STEM employers

Although the differences in the recruitment of **Science, Technology, Engineering and Mathematics graduates** cannot be separated due to the design of the survey, results provided below are based on overall employment of STEM qualified individuals.

- Employers of **Science** qualified individuals had an average applicant rate of 14.7 applications per position for professionals and 12.9 per position for technicians and trades workers;
- Employers of **Technology** qualified individuals had an average applicant rate of 14.9 applications per position for professionals and 11.4 per position for technicians and trades workers. Manager positions attracted 17.8 applications per position;
- Employers of **Engineering** qualified individuals had an average applicant rate of 17.1 applications per position for professionals and 10.3 per position for technicians and trades workers. Manager positions attracted 13.7 applications per position; and
- Employers of **Mathematics** qualified individuals had an average applicant rate of 15.5 applications per position for professionals and 6.0 per position for technicians. Manager positions attracted 12.0 applications per position.

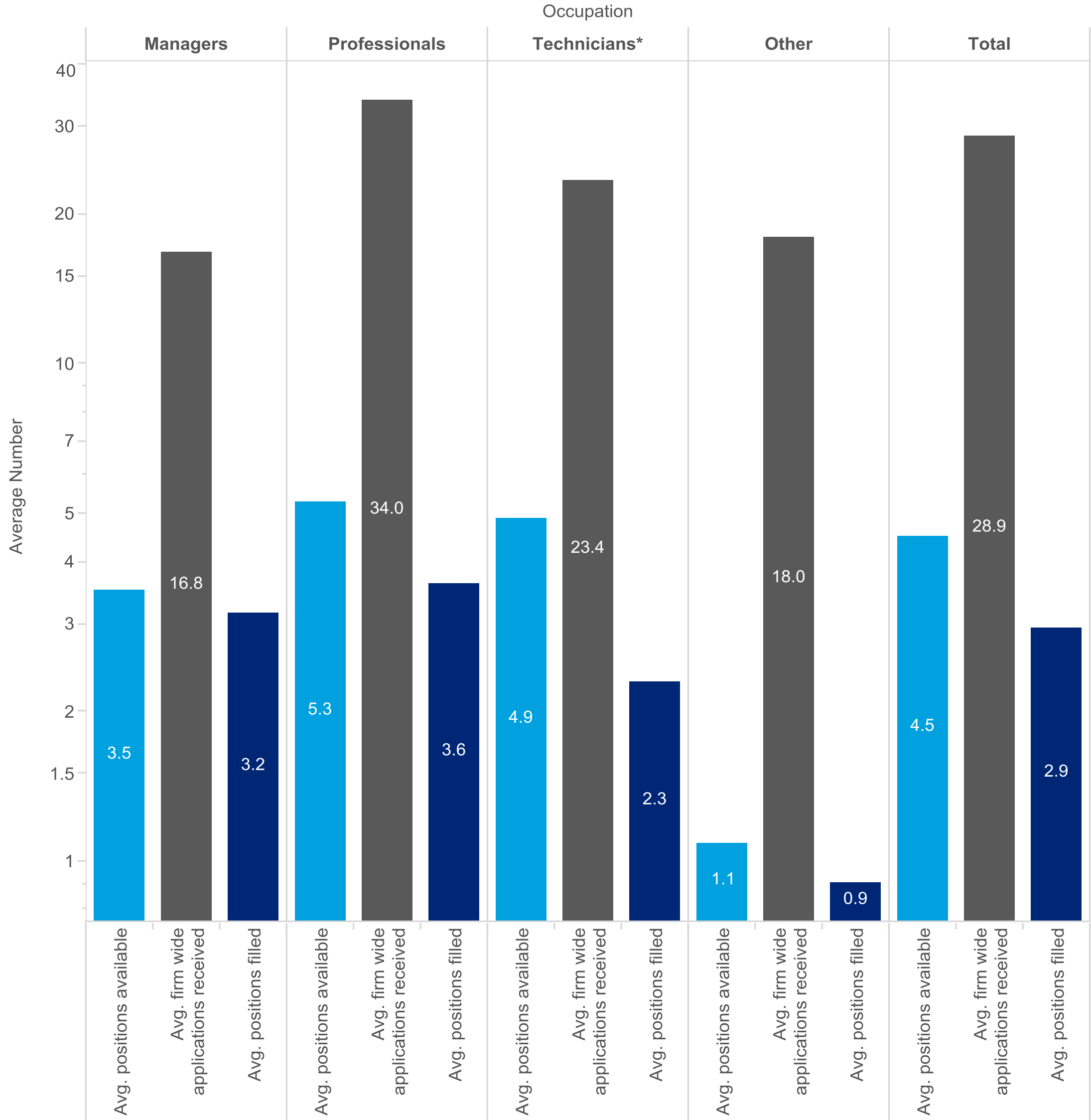
3.3 Recruitment of experienced employees

For this research, experienced employees were considered to be individuals who had more than five years' experience in the workplace. Based on the findings of the consultation process, it was expected that the recruitment of experienced employees would be more difficult than those recently qualified, and this was reflected in the survey results.

Overall, employers reported that, on average, **84.8% of positions advertised for STEM employees with over five years' experience had been filled.** The number of applicants per position (9.2) was also lower than for recently qualified candidates (14.1).

Chart 3.3 shows the recent recruitment experiences for employers who have tried to fill positions relevant to people with more than five years' experience. Measures included in the chart include the average number of positions available, the average number of applications received and the average number of positions filled.

Chart 3.3: Recruiting STEM-qualified staff: more than 5 years' experience



Note: This chart uses a logarithmic scale. Prior to averaging, the Total group is calculated as the sum of the other four groups.
Source: Deloitte Access Economics, STEM Employer Survey (2013)

Table 3.2: Recruiting STEM-qualified staff: more than 5 years' experience – average outcomes

Occupation	% of positions filled	Average applications per position
Managers	90.2%	6.4
Professionals	86.2%	9.4
Technicians*	79.6%	8.6
Other	92.8%	10.7
Total	84.8%	9.2

Source: Deloitte Access Economics, STEM Employer Survey (2013)

*Technicians and trades workers

As with more inexperienced positions, employers were less successful in filling technicians and trades workers jobs, with 79.6% of positions filled and an average of 8.6 applicants per position.

3.3.1 Industry

Most industries appeared to have more difficulty in recruiting for more experienced positions, although this was not the case for the Education and Training, and Information Media and Telecommunications, which both appeared to have more difficulty in the recruitment for less experienced positions. Other key industry findings include:

- The **Manufacturing** industry**,** which had expressed particular difficulties in the recruitment of experienced staff during the consultations, appeared to have a particularly low level of success, with only 22.4% of professional positions and 39.4% of technician and trades worker positions filled. Although the findings from the consultations indicated that these positions were attracting large numbers of unsuitable candidates, survey respondents indicated that there were only an average of 2.7 applicants per professional position, and 4.3 applicants per technician and trades worker position;
- The **Professional, Scientific and Technical Services** industry noted that, despite an average of 9.9 applications being received per professional occupation position, only 89.6% of vacancies were filled. For technician and trade workers occupations 10.0 applications per position were received and 89.6% of roles filled;
- The **Agriculture, Forestry and Fishing** industry had similar difficulties, with an average of 8.2 applicants per professional position and 85.7% of positions filled;
- **Public Administration and Safety** had the highest number of applications per position for manager occupations at 38.8 applicants per position, with over 100% of positions filled, indicating that additional roles were filled beyond the initial roles available;
- The **Health Care and Social Assistance** industry had the largest average applications per position in professional occupations with 19.2 applicants per position filling only 83.3% of positions; and
- The **Other** industry group had the highest number of application per position for technician and trade workers at 19.2, with only 80% of positions being filled. This group consists of medium and small enterprises and a variety of specialist organisations.

3.3.2 Business size

Overall, **medium businesses** appeared to attract the largest number of applicants per position (12.9) as well as have the highest rate of positions filled (87.9%). Other key findings include:

- During recent recruitment processes (i.e. over the past 12 months), **large businesses** were looking to fill, on average, 82.4 positions across their organisation. Overall, 86.2% of positions were filled, with approximately 9.1 applications received per position. There were 9.3 applications per position received for professional occupations, with

87.8% of positions filled. In comparison, only 5.9 applications were received for manager positions, although a greater proportion of these were filled (94.2%);

- **Medium businesses** looked to fill an average of 4 positions per organisation, with around 12.9 applications received per position and 87.9% of positions filled. Around 10.1 applications were received for each technicians and trades worker position, with 102.0% of these positions filled (i.e. more positions filled than initially sought); and
- Over the year **small businesses** looked to fill an average of 2.6 positions per organisation, with 6.2 applications received per position and 63.0% of positions filled. The proportion of positions filled was relatively low across all occupations for small businesses; 65.6% for manager positions (4.3 applicants per position), 60.6% for professional positions (4.8 applicants per position) and 66.7% for technicians and trades worker positions (12.4 applicants per position).

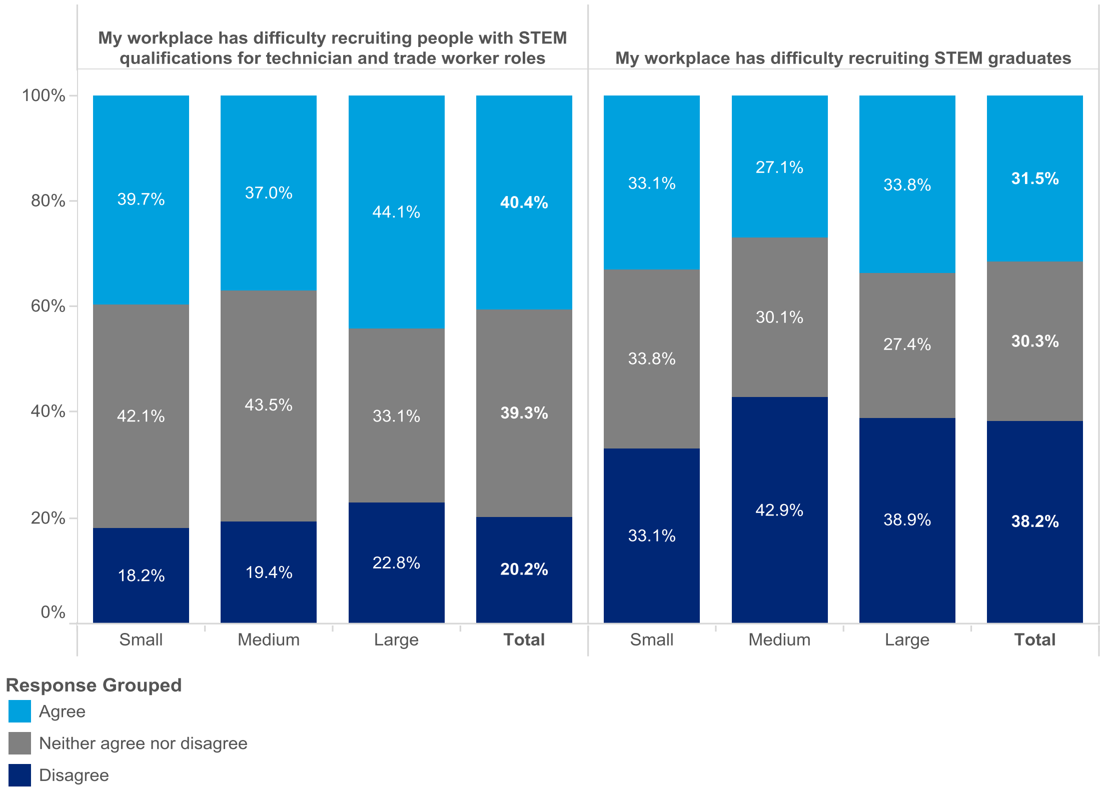
3.4 Recruitment difficulties

Despite the relatively large proportion of positions filled, **31.5% respondents reported having difficulty recruiting STEM graduates, while 40.4% had difficulty recruiting STEM-qualified technicians and trades workers**.[3] This implies that although many of the required positions were filled, the actual candidates hired may not have possessed all the skills and attribute that employers were looking for.

Chart 3.4 shows the proportion of respondents who agreed and disagreed with two statements about the recruitment of STEM qualified people.

[3] Note that this question was asked of all survey respondents, whereas the answers about actual recruitment processes reflected only those who had recruited in the past 12 months.

Chart 3.4: Difficulties recruiting people with STEM qualifications



Source: Deloitte Access Economics, STEM Employer Survey (2013)

This potential skills mismatch was also reflected in the consultations, where participants were generally satisfied with the number of candidates who were applying to either vacancies or submitting unsolicited resumes. However, many had significant concerns about the skills of those applying, and there were also some mention made **around the relatively small number of local candidates applying** for many positions – particularly those advertised as senior/experienced positions.

Through the consultation there was a general perception by larger firms that an adequate number of newly qualified STEM individuals were entering the labour market. This is demonstrated in the number of applicants for entry-level positions.

Issues in regard to the quantity of applicants were largely highlighted by smaller firms and were in relation to hiring of more senior positions. Some participants noted that highly specialised positions may take years to fill and that in some instances they had to hire from overseas as the positions could not be filled by the Australian labour market.

One participant noted that the shortage of more experienced applicants in STEM industries was related to talented STEM graduates moving quickly into management and consultative roles. Highlighting through the observation that there are a significant proportion of Chief Executive Officers (CEOs) of Australian Stock Exchange (ASX) companies with an engineering degree. This is echoed by research from *Leading Company*, which in 2012 found that 35 of the CEOs heading ASX100 companies had studied either science or engineering at the undergraduate level (Robin, 2012). Other participants observed that talented employees working in STEM fields were often attracted to other non-STEM industries, as well as overseas roles.

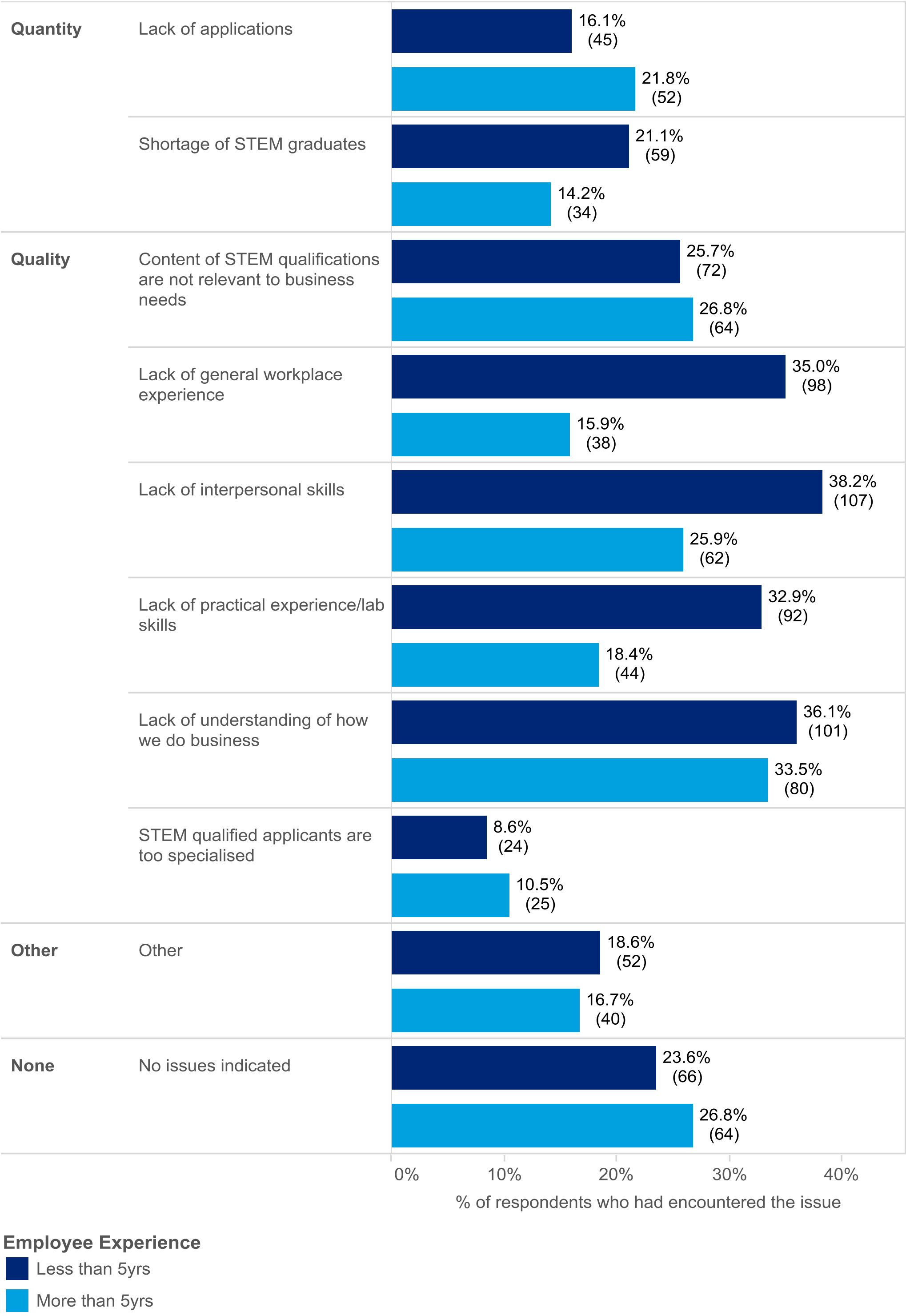
It should also be noted that some companies do have a good volume and quality of applicants – and this was largely considered to be related to their market share and reputation. Despite this, many still noted that they faced issues with attracting and retaining a diverse range of applicants, with a lack of female employees often cited as an example of an area of undersupply.

3.5 Issues encountered

These findings were largely reflected through the survey, where 'a lack of interpersonal skills' and 'a lack of understanding of how we do business' were both noted as being issues that employers had encountered.

Chart 3.5 illustrates some of the difficulties encountered throughout recent recruitment processes. Respondents were asked whether or not they had encountered the listed issues in recruiting STEM qualified people with both less than and more than five years' experience, and were prompted to select all that applied. Note that only respondents who indicated that they had conducted recruitment in the past 12 months were included in this analysis. The percentages shown in the chart represent the proportion of total respondents that encountered each issue.

Chart 3.5: Issues encountered during recent recruitment processes (%)



Note that only respondents who indicated that they had recruited (or attempted to recruit) STEM qualified people in the past 12 months with less than (or more than) five years' experience were included in the analysis. The percentages shown indicate the proportion of these respondents who encountered each issue. Respondents were asked to select all that applied. Source: Deloitte Access Economics, STEM Employer Survey (2013)

It appears that although work experience, as rated in Chart 3.1 indicates that employers generally place a relatively low weighting on short term and/or unpaid work experience. Chart 3.5 shows that a lack of general workplace experience is a commonly encountered issue, particularly with more recently qualified graduates. One interpretation of these results is that employers do not feel that the type of work experience is adequately equipping recently qualified graduates with appropriate skills relevant to the role. Further research is required to confirm this assumption.

The most common issues encountered by employers who were recruiting for positions with less than five years' experience were **'lack of interpersonal skills' (38.2%), 'lack of understanding of how we do business' (36.1%)** and 'lack of general workplace experience' (35.0%).

However, almost **one quarter (23.6%) of employers** who had conducted recruitment processes in the past 12 months for people with less than five years' experience **had not encountered any of the issues** listed.

The most common issue encountered when recruiting for positions with more than five years' experience was '**lack of understanding of how we do business'** (33.5%), although a 'lack of general workplace experience' was only noted by 15.9% of respondents.

Over one quarter (26.8%) of employers who had conducted recruitment processes in the past 12 months had not encountered any of the issues listed.

Several of these findings were also consistent with the recent study conducted by the AiGroup. AiGroup found that **25% of employers found a lack of available applicants with STEM skills**, and that this was the greatest barrier. Despite this not being the biggest barrier identified in this survey, **21.0% of employers recruiting less experienced STEM-qualified people noted this issue**. It was also noted as an issue by 29.7% of employers recruiting more experienced STEM-qualified individuals.

Similarly, the other key barriers identified by the AiGroup study were a lack of workplace experience (24%) and the content of qualifications not being relevant to business needs (18%). These were also identified as key concerns in this research. Although these differences may be due to slightly different samples and methods, the messages are consistent.

3.5.1 Industry

During the recruitment for less experienced positions, a shortage of STEM graduates was most commonly experienced by those in Construction (60.0%), Information Media and Telecommunications (29.4%), and Mining (26.7%). In contrast, Education and Training (33.3%) and Professional, Scientific and Technical Services (22.2%) were the industries which reported the highest incidence of 'shortage of STEM graduates' in their recruitment for more experienced positions.

Although a lack of interpersonal skills in recent graduates was an issue encountered across most industries, it appeared to be of particular concern for those in Financial and Insurance Services (73.3%), Public Administration and Safety (66.7%), Information Media and Telecommunications (47.1%) and Professional and Scientific Services (46.0%).

3.5.2 Business size

The most common issue reported by large businesses was a 'lack of interpersonal skills' with 32.1% of businesses reporting that they encounter this issue. **Large businesses** also noted that they had encountered the issue of a 'lack of understanding of how we do business', with 30.4% reporting this issue. This suggests that although candidates may have general work experience, employers were concerned with more relevant experience, whether this is in a particular industry or a particular type of company (e.g. start-up). This is further supported by the fact that 29.5% of respondents from large businesses noted that a 'lack of general workplace experience' was encountered as an issue.

The most frequently encountered issues for **medium businesses** during their recruitment for less experienced positions were:

- lack of interpersonal skills (46.1%)
- lack of practical experience/lab skills (40.2%)
- lack of general workplace experience (37.3%)

For recruitment of personnel with more than 5 years experience, 14.6% of respondents belived that aplicants were too specialised. The most frequent issues encountered by medium sized businesses during their recruitment for more experienced positions were:

- lack of understanding of how we do businesses (33.7%)
- lack of interpersonal skills (33.7%)
- content of STEM qualifications not relevant to business needs (32.6%)

Small businesses encountered similar issues, with a lack of understanding of how we do business a particular concern across both types of recruitment.

3.5.3 STEM employers

In examining the challenges based on the employment profile of the organisations, there was a difference in those who employ technology qualified individuals in terms of the challenges experienced with less than 5 years' experience and more than 5 years:

- 39.5% of respondents identified a lack of interpersonal skills as a recruitment challenge for those with less than 5 years' experience, whereas for over 5 years' experience only 23.1% identified this as an issue;
- The issue regarding a lack of practical experience/lab skills was identified by 38.0% of respondents for less than 5 years' experience and was only 17.9% for those with over 5 years' experience;

For employers of mathematics qualified individuals a 'lack of general workplace experience' showed the greatest gap between the cohorts with 33.0% experiencing this issue with under 5 years and 15.0% experiencing this issue with the over 5 years' experience cohort.

3.5.5 Other difficulties

Respondents were also to record other issues encountered that didn't appear on the list presented. Many of these responses noted **specific deficiencies in applicants, such as communication skills or cultural fit**. Some examples of specific responses included:

- Lack of commercial awareness
- Lack of leadership experience
- Poor writing and presentation skills
- No evidence of relevant experience
- Unrealistic job and salary expectations
- Lack of strategic/cultural fit
- Poor STEM skills
- Poor performance at interview
- Not as many years of experience as required
- Applicants not specialised enough

Some respondents also noted the receipt of large numbers of applications for overseas qualified students, with some of the relevant issues noted including:

- Language issues
- Job seeking to cement visa application
- Overseas qualifications failed accreditation
- Inability to employ non-Australian citizens

Participants in the consultations also noted difficulties in the recruitment of particular cohorts, including those from a diversity of backgrounds as well as females.

3.6 Diversity

Where companies were relatively content with the quantity and quality of applicants that they were receiving, the focus tended to turn towards diversity. In particular, the issue of gender diversity was raised by several participants – particularly those in the technology sector – and many of who had active policies to attract more females to their company. The lack of female applicants was a concern identified by a number of participants, many of who pointed to clear benefits in employing a combination of male and female employees, as well as a number who noted specific and targeted strategies aimed at increasing the gender balance within certain areas of the organisation.

More broadly, there were some suggestions that many of the STEM shortages experienced by various industry sectors could be reduced through attracting capable females to complete STEM qualifications and encouraging them to work in STEM-specific occupations, rather than those more tangentially related to STEM, such as teaching.

In a 2010 report by the American Association of University Women (AAUW) a number of social and environmental factors were identified which are thought to contribute to the under-representation of women in STEM. These include the societal beliefs that men are mathematically superior and therefore innately better suited to STEM fields than women; that women are not interested in STEM; and environmental issues in the STEM workplace ranging from work-life balance to bias.

Through the consultation, there were a number of participants who valued the different knowledge and skills that people who had been educated at different universities brought to the company. This also extended to aiming for a diverse set of cultural backgrounds.

3.6.1 Overseas applicants

Consultations reported that large numbers of **international applicants** are applying for advertised positions. This finding spread across a number of industries, including the public service, manufacturing and technology services. Although international migration essentially provides a global recruitment pool for Australian companies (pending visa restrictions, etc.) it also means that Australia is competing with global competitors to attract and retain skills within the Australian economy.

Aside from certain restraints on the recruitment of overseas employees (for example the Australian citizenship requirement across much of the public service), there was also significant concern around the employability skills of these candidates. In particular, English skills, as well as communication skills in general, were often cited as being a key reason as to why such candidates were not suitable.

3.7 Image, career paths and attitude to STEM

Based on the prevalent use of qualifications as a proxy for skills, the mismatch of educational qualifications has received significant attention, particularly in OECD countries. There are emerging fears that an increased supply of university and college graduates in recent decades may lead to a situation of over-qualification (Quintini, 2011). Literature has highlighted that qualification mismatches may be partially explained by skill heterogeneity among workers with the same qualifications – in particular, the occupation-specific skills required. With greater proportions of people holding post-secondary education qualifications, this heterogeneity in skills is likely to further increase.

4 Future STEM requirements

There is clear consensus that STEM qualified people will play an important role in shaping the future of the Australian economy.

4.1 Future workplace requirements

Just under half (45.1%) of respondents expect that their workplace requirements for STEM-qualified employees will increase over the next 5-10 years, with just 8.8% expecting a decline in demand. The remainder (46.0%) predict their staffing levels to remain about the same. This supports more general expectations established during the literature scan that **the role of STEM will become increasingly important in a modern society.**

Table 4.1 shows the proportion of respondents who expect their workplace requirements for STEM-qualified staff to decrease/remain about the same/increase over the next 5-10 years, by occupation.

Table 4.1: Workplace requirements for STEM qualified applicants over the next 5-10 years

		Changes in STEM requirements over next 5-10 years			
Occupational level		Decrease	About the same	Increase	Grand Total
Managers	% of total respondents	7.8%	61.4%	30.8%	100.0%
	Number of respondents	(33)	(261)	(131)	(425)
Professionals	% of total respondents	7.5%	39.0%	53.4%	100.0%
	Number of respondents	(34)	(176)	(241)	(451)
Technicians*	% of total respondents	9.6%	40.9%	49.4%	100.0%
	Number of respondents	(33)	(140)	(169)	(342)
Other	% of total respondents	7.8%	66.5%	25.7%	100.0%
	Number of respondents	(21)	(179)	(69)	(269)
TOTAL	% of total respondents	8.8%	46.0%	45.1%	100.0%
	Number of respondents	(29)	(151)	(148)	(328)

Source: Deloitte Access Economics, STEM Employer Survey (2013)
* Technician and Trades Workers

More specifically, employers expect additional demand to be **particularly strong for people working in professional occupations, with 53.4% expecting their requirements for STEM-qualified professionals to increase.** On the other hand, only 30.8% of respondents expect their requirements for STEM-qualified managers to increase. This suggests that demand will be highest in STEM-related roles that directly use the STEM skills and knowledge acquired through qualifications and experience rather than for those in broader management positions.

These increases are expected to be particularly driven by an increased demand for STEM qualified people working in professional occupations (53.4%) and technicians and trades worker occupations (49.4%). Fewer than one in ten (8.8%) expect the workplace requirements for STEM qualified people to fall over the next decade.

4.1.1 Industry

The view across industry appears to be mixed, with some industries expecting increases in their future workplace requirements for STEM qualified people, while others expect about the same level of demand over the next 5-10 years. Key industry findings include:

- Nine in ten (90%) of employers in the **Construction** industry expect an increase in workplace requirements for STEM qualified people in Professional occupations;
- Over one quarter (28.6%) of employers in the **Mining** industry expect workforce requirements to decrease over the next 5-10 years; and
- The majority of employers in the **Education and Training** (81.8%) and **Electricity, Gas, Water and Waste Services** (80.0%) industries expect their medium-term workplace requirements to remain about the same.

4.1.2 Business size

The outlook for future STEM requirements differs across businesses of different sizes, with 50.9% of small businesses and 48.4% of medium businesses and expecting their requirements for STEM qualified personnel to increase over the next 5-10 years, compared with only 39.0% of large businesses. Other key findings include:

- Overall, 13.0% of **large businesses** expect their demand for STEM-qualified workers to decline in the future, including 14.3% who expect a decline in the requirements for technicians and trades workers, and 11.7% who forecast a decline in the demand for managers;
- For **medium businesses**, future demand appears to be strongest for the technicians and trade worker occupation, with 57.8% expecting an increase in their demand for these types of workers; and
- In comparison, **small businesses** predict the strongest level of demand in the professionals occupation (56.0%); future demand for technicians and trades workers is also strong with over half (53.1%) expecting their demand for this type of employee to increase.

4.1.3 STEM employers

Organisations which hire people with Engineering qualifications are the most likely to expect an increase in future STEM requirements (53.9%), however almost one in ten (9.2%) organisations with Engineering staff expect a decrease. Other findings include:

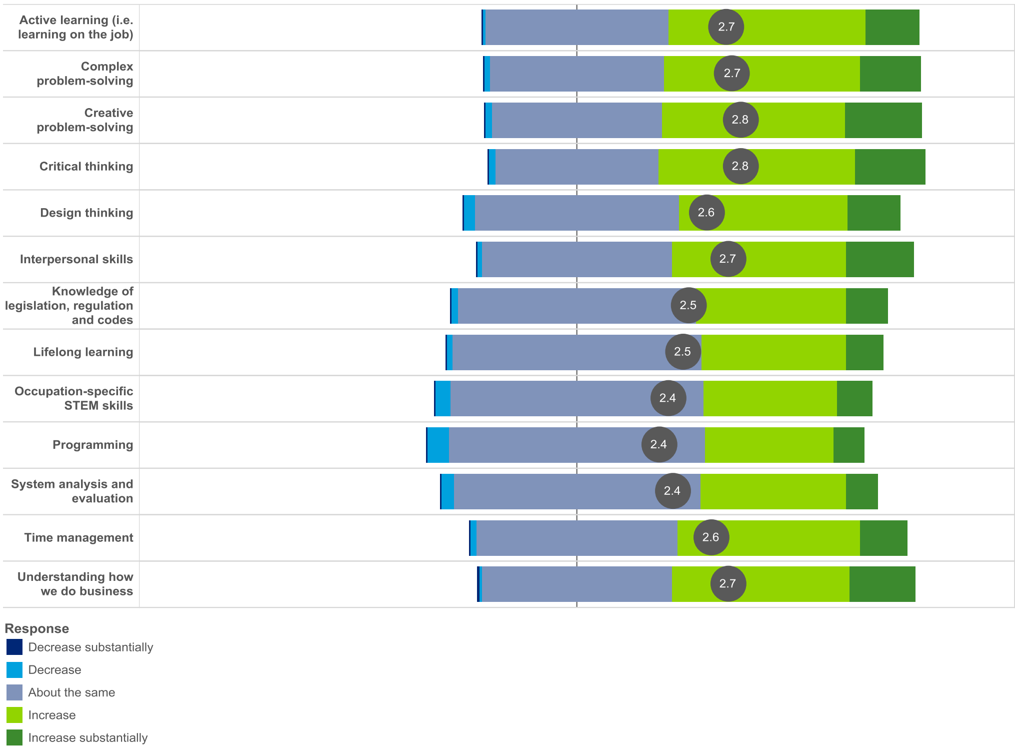
- The **strongest future demand for people in manager occupations** is also from organisations which hire staff with **Engineering** qualifications (39.4% expect an increase), compared with 31.4% of organisations which hire staff with **Mathematics** qualifications; and
- Organisations which hire staff with **Science** qualifications are the least likely (1.4%) to expect their STEM requirements to decrease over the next 5-10 years.

4.2 Future skills requirements

Looking at individual skill requirements, **three in five employers (60.9%) expected their requirements for critical thinking to increase,** compared with only one third (36.5%) who expected their need for programming skills to increase over the next five to ten years.

Chart 4.1 shows the percentage of respondents who expect their requirements for each of the following STEM skills and attributes to decrease/remain about the same/increase over the next 5-10 years.

Chart 4.1: Changes in requirements for skills over the next 5-10 years (%)



Averages are calculated using the following rating scale: Decrease substantially = 0, Decrease = 1, About the same = 2, Increase = 3 and Increase substantially = 4.

Source: Deloitte Access Economics, STEM Employer Survey (2013)

Overall, the majority of respondents noted that their requirements for any of the listed skills and attributes would increase over the next 5-10 years.

4.2.2 Industry

Across all industries, there were few employers who indicated that their requirements for any of the listed skills or attributes would decrease over the short to medium term. However there were different expectations from different industries as to which skills would increase in demand over the next 5-10 years than they are currently. Key industry findings include:

- Only 21.1% of survey respondents from the **Agriculture, Forestry and Fishing** industry thought that their requirements for **'design thinking'** would increase over the next 5-10 years compared with 71.4% in the **Education and Training** industry;
- More than nine out of ten (90.9%) of respondents from the **Construction** industry indicated that the need for their employees to '**understand how we do business'** would increase into the future;
- In the **Mining** industry, 71.4% of respondents noted that their demand for **'active learning skills'** would increase over the medium-term; and
- All respondents from the **Health Care and Social Assistance** industry expected their requirements for **'interpersonal skills'** would increase over the next 5-10 years.

4.2.3 Business size

The expected demand for the listed skills and attributes did not differ considerably by business size, although a greater proportion of **large businesses** (61.9%) expected their demand for **'interpersonal skills'** to increase over the next 5-10 years. Other key findings by business size include:

- Two thirds (66.0%) of **large businesses** expected their requirements for 'creative problem-solving' and 'critical thinking' skills to increase over the next 5-10 years; and
- Only 39.3% of **medium businesses** expected their requirements for 'programming' skills to increase in the medium term, and 6.6% expected them to decrease.

4.2.4 STEM employers

There are minor differences in the future skills requirements across organisations which employ different combinations of STEM graduates. Key findings include:

- Over half (50.7%) of organisations that employ **Science** graduates expect their demand for **'design thinking'** skills to increase, compared with 39.1% of organisations that employ **Engineering** graduates;
- The majority (54.9%) of organisations that employ **Engineering** graduates expect their demand for **'time management'** skills to increase, compared with 44.8% of organisations that employ **Mathematics** graduates; and
- Some 7.4% of organisations that employ **Technology** graduates expect their demand for **'programming'** skills to decrease over the next 5-10 years.

4.3

4.4 Future recruitment outlook

The general outlook from the consultations is that **recruitment** of STEM skills will become more and more difficult. For example, in the teaching profession Australian organisations could look overseas, but most other countries that are culturally similar to Australia (and would therefore need similar on-boarding) are also having the same experiences. This appeared to be particularly the case for the recruitment of more experienced staff (nominally defined as those with more than five years of relevant experience).

The key determinant of the future recruitment outlook for STEM depends significantly on the types of qualifications being undertaken by students as they leave school. Although STEM sectors are seen as drivers of productivity, innovation and economic growth (Federation of Australian Scientific Societies, 2002), many careers in the STEM sector suffer from what was often described by participants as an 'image' problem. There was some **concern that the value of people with STEM qualifications was often underrated** by the general population, particularly where there was not a clear understanding of the occupations of STEM individuals.

The **valuation of STEM skills** was also raised as an issue, both in terms of societal value and monetary compensation. Some participants in the consultation noted that there is a role for **marketing occupations** to promote STEM within the wider society and encourage young people to pursue STEM related careers. In particular, this could assist with repackaging STEM into an exciting career, with campaigns targeted at both students and parents.

Many of the suggested methods of improving awareness of possible STEM careers mirrored those identified through the ACOLA report (as shown below):

- Awareness campaigns to enrich public understanding of career options in STEM and the nature of STEM work, and to alert young people to the range of possible future STEM-related careers;
- Strategies at school level designed to involve families in mathematics and science learning and in building positive attitudes to STEM-related careers;
- Role models, in the form of student interaction with practicing STEM professionals, or web-based presentations of narratives of STEM professionals (such as those on the Academy of Technological Sciences and Engineering (ATSE) Science and Technology Education Leveraging Relevance (STELR) website).
- Career advice that includes images of people working in STEM-related careers, delivered through information workshops for careers teachers, and mathematics and science teachers;
- The inclusion, in curriculum resources, of materials that speak to the identity needs of the diverse range of students. This includes girls (e.g. science material related to health, or the environment), Indigenous students (e.g. materials that embody respect for Indigenous knowledge), and contextual science that relates to youth interests;
- The expansion of opportunities for families and the general public to engage positively with science and mathematics through events, exhibitions and other approaches; and
- Enrichment programs whereby students are engaged in science or mathematics projects that entail linking to members of local communities.

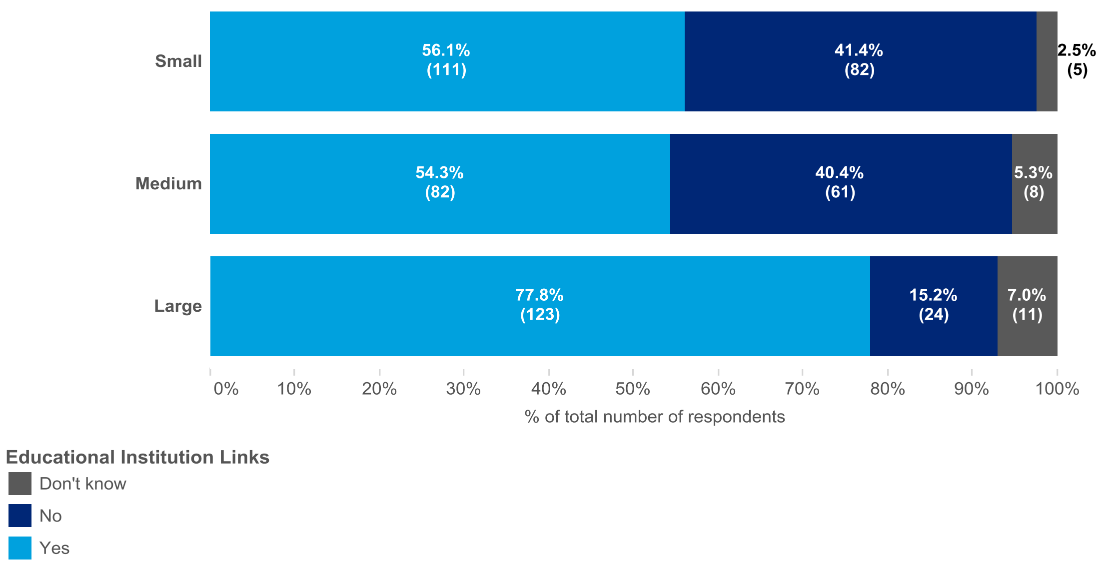
Finally, to many of the participants, the stereotypical image of a STEM graduate typically typecasts them as ‘focused’ and ‘narrow thinking’; and many also noted that this is often a deserved profile. One participant noted that in the 1980s and 1990s, programming was “cool”. Now, programming is not seen as very interesting (only for a certain type of person – armed with a computer, in a dark room, filled with pizza boxes).

5 Industry relationships with post-secondary educational institutions

The collaboration, linkages and relationships between industry and education institutions was noted several times throughout the consultations as being relatively limited compared with many other nations around the world. This view is also confirmed through the most recent OECD Innovation Scorecard, which ranks Australia 29th on its collaboration indicator, with only 27.4% of Research and Development (R&D) active firms involved in any collaboration activity (OECD, OECD Science, Technology and Industry Scoreboard 2013: Innovation and Growth in Knowledge Economies., 2013).

Overall, 62.3% of respondents indicated that they had some type of relationship with post-secondary education institutions, with those representing **large businesses the most likely to have developed these relationships**. There was no statistically significant difference in the proportion of small and medium businesses who noted linkages (Chart 5.1). Responses by business size for selected industries are also included in Table 5.2.

Chart 5.1: Workplace links with post-secondary educational institutions, by business size



Note that this chart represents responses to this survey only and is not intended to represent the overall proportion of relationships between Australian workplaces and post-secondary educational institutions.
Source: Deloitte Access Economics, STEM Employer Survey (2013)

Table 5.2: Workplace links with post-secondary educational institutions, by selected industry and business size

Industry	Business size, % with links (no.)		
	Small	Medium	Large
Agriculture, Forestry and Fishing	57.1 (8)	83.3 (5)	100.0 (1)
Financial and Insurance Services	31.8 (7)	50.0 (6)	83.3 (5)
Information Media and Telecommunications	60.0 (6)	55.6 (5)	100.0 (2)
Manufacturing	55.3 (21)	50.0 (14)	90.9 (10)
Mining	64.3 (9)	60.0 (6)	100.0 (5)
Professional, Scientific and Technical Services	66.0 (33)	57.7 (15)	100.0 (12)
Public Administration and Safety	60.0 (3)	57.1 (4)	66.7 (4)
All industries	56.1 (111)	54.3 (82)	77.8 (123)

Source: Deloitte Access Economics, STEM Employer Survey (2013)

5.1 Type of relationship

Respondents were asked to rate their level of involvement and their relationships with post-secondary educational institutions across a number of facets. On average, workplaces appeared to be **most engaged with universities through research functions**, namely; (1) development of research projects and (2) partnerships with universities for research and innovation.

Although there were very mixed experiences and intensity of engagement with industry-education partnerships across our consultations, almost all participants described some level of engagement with higher education institutions – particularly universities. The large **majority of these had been formed in an ad hoc manner**, either through personal networks or chance meetings. Participants largely felt that there was a **poor understanding of demand** regarding what industry needs and wants. Some issues noted included a **lack of responsiveness** from universities to engage with industry, and **unclear channels of communication** around who to approach to build these relationships.

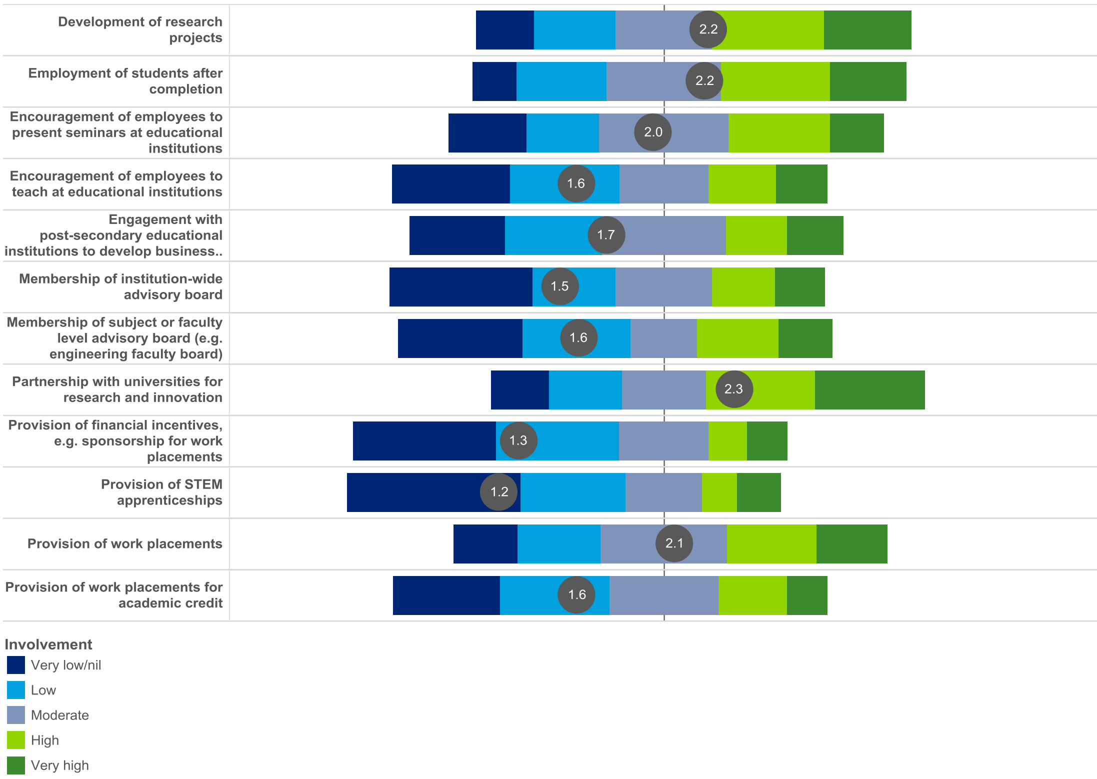
There was a clear frustration from many participants over the general key performance indicator (KPI) framework that universities in Australia tend to operate under. Many participants also cited overseas examples of where they felt the interactions between tertiary education institutions and industry was much more successful. In particular, the German university system was mentioned by several participants as a good example of the integration between the teaching of theory and practical skills.

Respondents were **least likely** to be involved with the **'provision of STEM apprenticeships'** and the **'provision of financial incentives, e.g. sponsorship for work placements'**, with an average level of involvement of *Low*.

Ironically, during both the consultation phase and later in the survey, when asked about teaching method, the role of work placements, as well as previous **work experience was generally seen as favourable**.

Chart 5.2 shows the level of workplace involvement with post-secondary educational institutions across a range of different activities. Respondents were asked to rate their level of involvement using the following scale: 0 = *very low/nil*, 1 = *low*, 2 = *moderate*, 3 = *high* and 4 = *very high*.

Chart 5.2: Workplace involvement with post-secondary educational institutions



Average rating based on the following scale: 0 = Very low/nil, 1 = Low, 2 = Moderate, 3 = High and 4 = Very High. Source: Deloitte Access Economics, STEM Employer Survey (2013)

Overall, businesses who responded to the survey appear to be most engaged with post-secondary educational institutions through research activities and the employment of students once they have completed their studies. Low engagement was identified for the provision of STEM apprenticeships and the provision of financial incentives. The response to STEM apprenticeships is not unexpected given that these are predominately associated with the VET sector which forms only a portion of the identified group (i.e. post-secondary educational institutions).

5.1.2 Industry

There were several key differences between the levels of engagement with post-secondary educational institutions across the various industries. Key findings include:

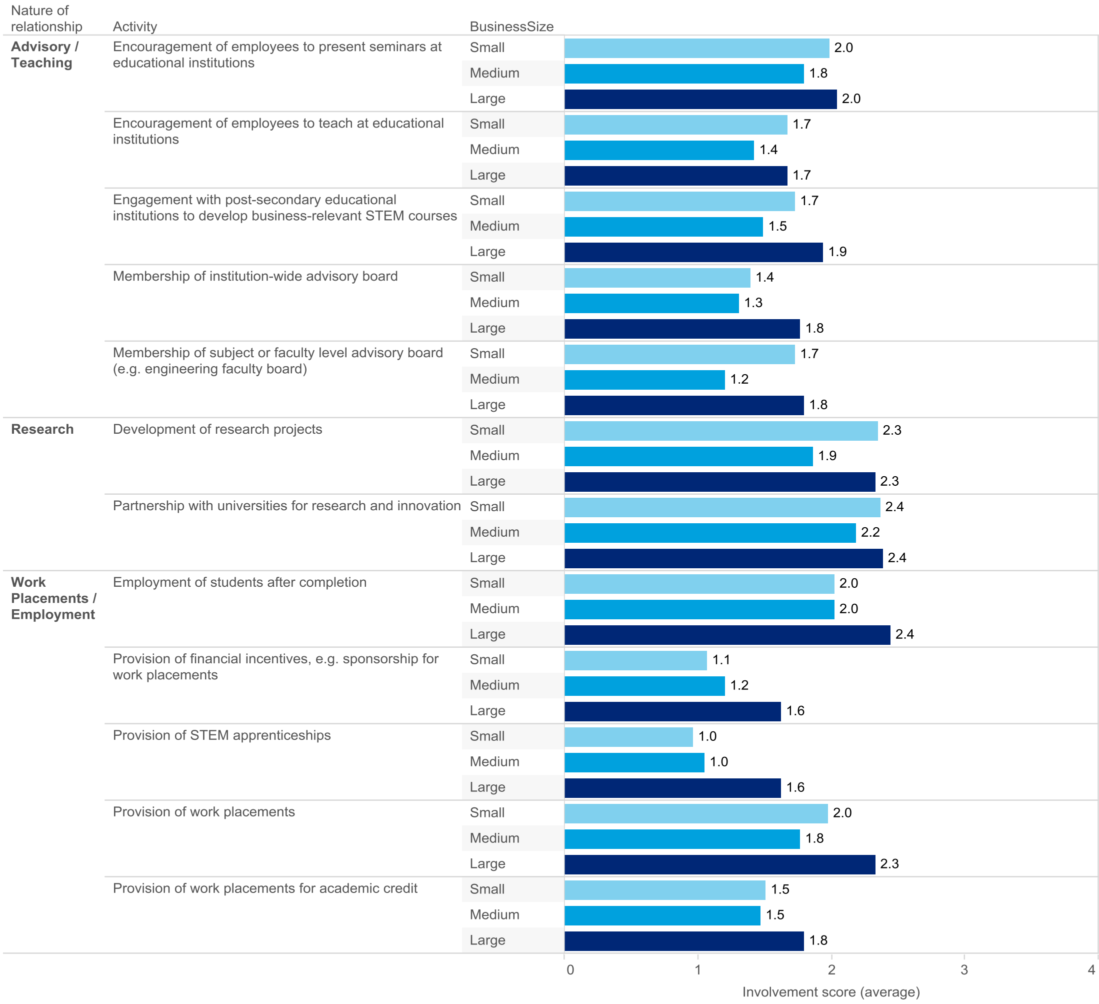
- Employers in the **Agriculture** industry appear to be more involved in the 'provision of work placements' than the average across all industries (2.5 compared with 2.1) and the 'provision of work placements for academic credit' (2.1 compared with 1.6). This may reflect the more practical nature of many of the qualifications undertaken by employees in this industry;
- The **Construction** industry had, on average, a much higher level of engagement than average through the 'provision of STEM apprenticeships' (3.0). This represents the importance of VET to this industry relative to others included in the survey; and
- Employers in the **Mining** industry had a higher level of engagement in research activities than the average, namely 'development of research projects' (2.8 compared with 2.2) and 'partnership with universities for research and innovation' (2.9 compared with 2.3).

5.1.3 Business size

Chart 5.3 shows the level of workplace involvement with post-secondary educational institutions by business size.

- Overall, **large businesses** are the most likely to be engaged with work placements/employment across all activities listed, including the 'provision of work placements' and the 'employment of students after completion';
- **Medium businesses** appear to have the lowest average levels of engagement with post-secondary educational institutions in the form of research activities, including the 'development of research projects'; and
- **Small businesses** have similar average levels of engagement to large businesses across many activities in the advisory/teaching and research space, although are less engaged across work placements/employment activities.

Chart 5.3: Workplace involvement with post-secondary educational institutions, by business size



Source: Deloitte Access Economics, STEM Employer Survey (2013)

5.1.4 STEM employers

Overall the level of workplace involvement did not appear to differ by the type of STEM discipline. Key findings include:

- Businesses which employed people with **Engineering** qualifications (including those who employed Engineering plus other STEM) reported the highest level of partnership with post-secondary educational institutions in the 'provision of work placements', while those which employed people with **Mathematics** qualifications had the lowest average level of involvement. For engineering, this result it partially a reflection of the requirement of a work placement for accreditation by the engineering peak body, Engineering Australia. Specifically, in order to be accredited as a professional engineer, Engineers Australia requires, as a condition of accreditation, that professional engineering degree programs must include 12 weeks (or the equivalent) of appropriate exposure to professional engineering practice; and

- Similarly, business which employed people with **Engineering** qualifications also had, on average, the highest level of involvement with the 'provision of STEM apprenticeships'. This may not necessarily reflect their involvement with engineering faculties but, may represent the likelihood of these companies also employing people with STEM qualifications from the VET sector.

5.2 Length of relationship

The majority of relationships with post-secondary educational institutions have been established for 10 or more years, with relatively few established in the past year. In particular, **almost two thirds of research partnerships (62.1%) have been established for more than five years**.

Table 5.3 shows the distribution of length of relationship with post-secondary educational institutions across various activities.

Table 5.3: Length of relationships with post-secondary educational institutions

		Less than 1 year	1 year to less than 3 years	3 years to less than 5 years	5 years to less than 10 years	10 years or more
Advisory / teaching	Encouragement of employees to present seminars at educational institutions	3.6%	14.5%	16.9%	21.7%	43.4%
	Encouragement of employees to teach at educational institutions	3.0%	11.4%	17.4%	22.7%	45.5%
	Engagement with post-secondary educational institutions to develop business-relevant STEM courses	1.6%	17.1%	14.7%	31.0%	35.7%
	Membership of institution-wide advisory board	6.6%	13.2%	19.8%	20.8%	39.6%
	Membership of subject or faculty level advisory board (e.g. engineering faculty board)	7.5%	11.7%	18.3%	25.0%	37.5%
Research	Development of research projects	5.5%	15.3%	17.5%	21.3%	40.4%
	Partnership with universities for research and innovation	4.7%	13.2%	20.0%	22.1%	40.0%
Work placements / employment	Employment of students after completion	5.0%	11.0%	12.2%	27.1%	44.8%
	Provision of financial incentives, e.g. sponsorship for work placements	4.3%	14.0%	9.7%	35.5%	36.6%
	Provision of STEM apprenticeships	6.4%	15.4%	6.4%	21.8%	50.0%
	Provision of work placements	1.7%	17.5%	15.3%	28.2%	37.3%
	Provision of work placements for academic credit	1.7%	18.3%	14.2%	30.0%	35.8%

Note: Calculations exclude 'Don't know' and 'Not applicable'.
Source: Deloitte Access Economics, STEM Employer Survey (2013)

The majority of relationships with post-secondary educational institutions have been in place for five of more years.

5.2.1 Industry

There appears to be some differences in the average length of relationships across the sectors. However, caution should be used when interpreting results, as many industries contain only a small number of responses, and may not accurately reflect the industry as a whole. Key findings include:

- Where relationships have been established between employers in the **Public Administration and Safety** industry and post-secondary educational institutions, almost all have been in place for ten years of more;
- Over half (57.1%) of organisations in the **Information Media and Telecommunications** industry have started their engagement with post-secondary educational institutions in the past three years; and
- A third (33.3%) of organisations in the **Mining** industry have been partnering with universities for research and innovation for more than ten years. Similarly, 36.7% of organisations in the **Manufacturing** industry have been developing research projects with post-secondary educational institutions for more than ten years.

5.2.2 Business size

Large businesses are the most likely to have long-term relationships with post-secondary educational institutions, with more than 63.6% of those who had a relationship indicating that they had been involved in the provision of STEM apprenticeships for more than ten years. Other key findings include:

- Over half (55.8%) of **large businesses** which are members of institution-wide advisory boards have been so for ten years or more;
- Around one third (36.1%) of **medium businesses** who provide work placements for academic credit have had this arrangement established for more than ten years. A further 30.6% have been engaged in this activity for between five and ten years; and
- One quarter (23.3%) of **small businesses** have been engaged with post-secondary educational institutions to develop business-relevant STEM courses for between one and three years.

5.2.3 STEM employers

Key findings include:

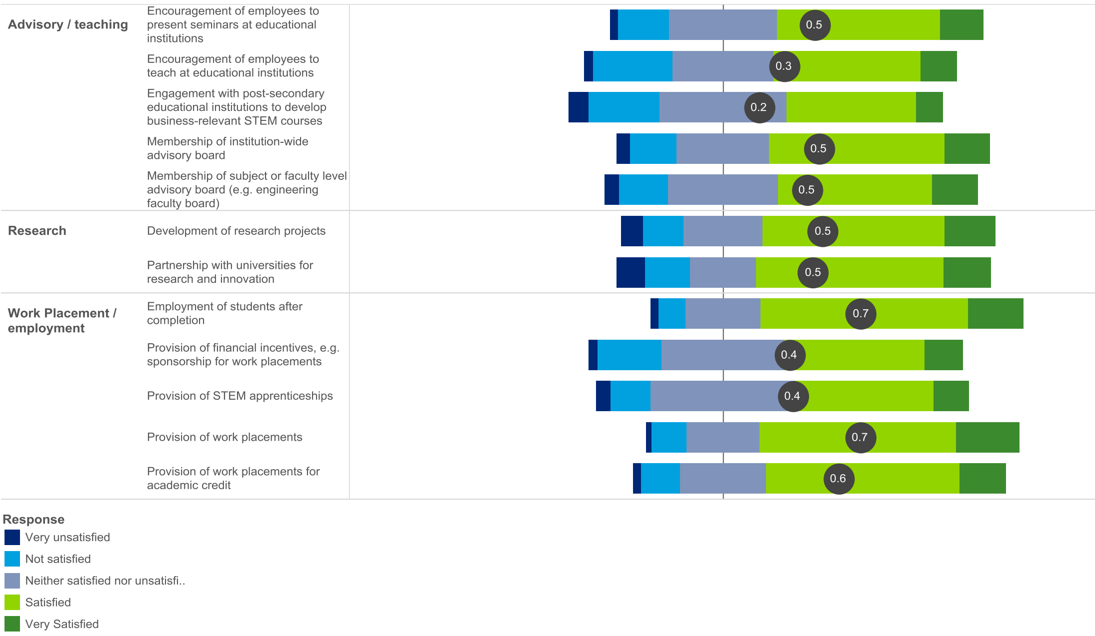
- Organisations with **Science** qualified staff are most likely to have long-term (i.e. more than ten year) relationships with post-secondary educational institutions through an encouragement of employees to teach at educational institutions (44.2% of those with a relationship); and
- Organisations with **Technology** qualified, **Engineering** qualified and **Mathematics** qualified staff are most likely to have long-term relationships through the provision of STEM apprenticeships (51.3%, 47.7% and 53.8% respectively of those with a relationship).

5.3 Satisfaction with relationship

On the whole, workplaces with relationships with post-secondary educational institutions appear to be largely neutral (i.e. neither satisfied or unsatisfied), with the most satisfactory aspects of the relationship being 'employment of students after completion' and 'provision of work placements'.

Chart 5.4 shows the average level of satisfaction of workplaces with their relationships with post-secondary educational institutions. Respondents were asked to rank their satisfaction using the following scale: -2 = *very unsatisfied*, -1 = *not satisfied*, 0 = *neither satisfied nor unsatisfied*, 1 = *satisfied*, 2 = *very satisfied*.

Chart 5.4: Satisfaction with relationships with post-secondary educational institutions



Average rating based on the following scale: -2 = Very unsatisfied, -1 = Not satisfied, 0 = Neither satisfied nor unsatisfied, 1 = Satisfied, 2 = Very satisfied.
Source: Deloitte Access Economics, STEM Employer Survey (2013)

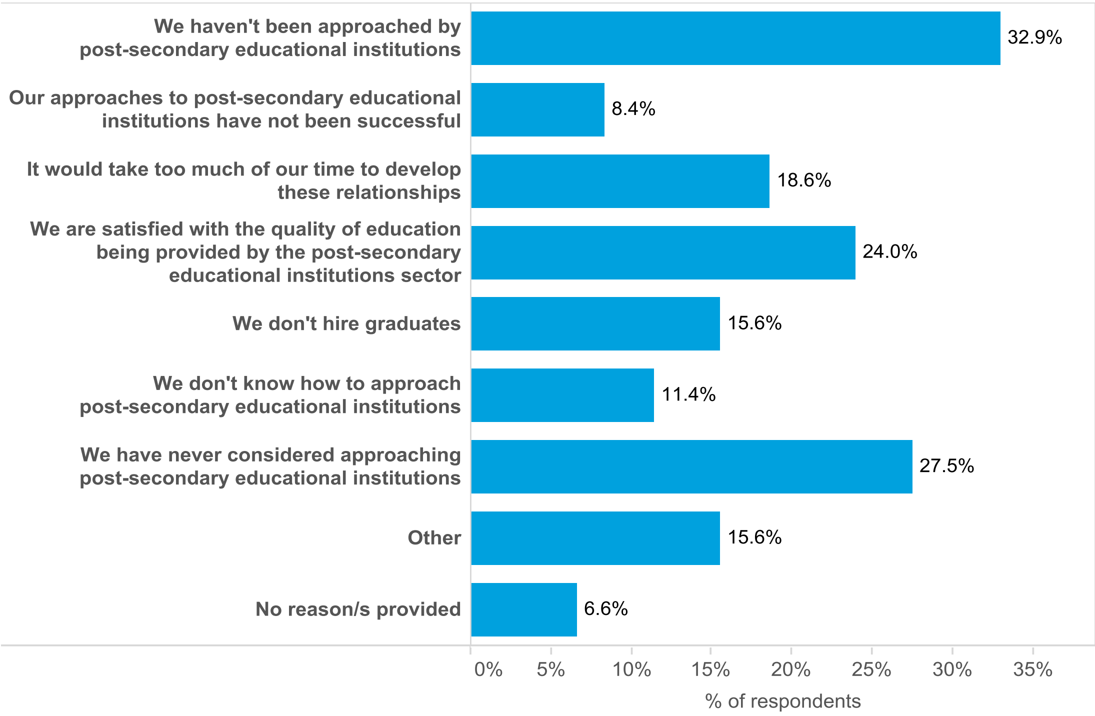
The lowest level of satisfaction was recorded as 'engagement with post-secondary educational institutions to develop business-relevant STEM content'. This was particularly true for **medium businesses, who noted on their relationship in this area, on average, that they were *neither satisfied nor unsatisfied***.

5.4 Reasons for no relationship

Of those workplaces which did not have links with post-secondary educational institutions, 32.9% said that they hadn't been approached by post-secondary educational institutions, while 27.5% said that they had never considered approaching post-secondary educational institutions.

Chart 5.5 illustrates the reasons why workplaces do not have links with post-secondary educational institutions. Respondents were asked to tick all of the reasons that were applicable for their workplace.

Chart 5.5: Reasons why workplaces do not have links with post-secondary educational institutions (%)



Source: Deloitte Access Economics, STEM Employer Survey (2013)

Respondents were also able to list other reasons, which included a wide variety of responses, such as:

- Past links not resulting in successful recruitment activity
- Merit-based recruitment means a relationship with a single institution is not sought
- Company is too small for institutional interest
- Future plans to engage, but not currently ready

5.4.1 Industry

- Eight in ten (85.7%) employers in the **Information Media and Telecommunications** industry noted that they had not developed any relationships because 'we haven't been approached by post-secondary educational institutions';
- Similarly, half (50.0%) of employers in the **Construction** industry also noted that they 'haven't been approached by post-secondary educational institutions'; and
- Two thirds (66.7%) of employers in the **Public Administration and Safety** industry were satisfied with the quality of education being provided by the post-secondary educational institutions sector' and as a result had not developed any relationships.

5.4.2 Business size

There were some apparent differences in the reasons as to why relationships had not been established across businesses of different sizes. Key findings include:

- One third (33.3%) of **large businesses** had not developed relationships because they were already satisfied with the quality of education being provided by the post-secondary educational institutions sector;
- Almost one in ten (9.8%) **medium businesses** noted that their approaches to post-secondary educational institutions had not been successful; and
- **Small businesses** were the most likely to note that they hadn't been approached by post-secondary educational institutions (37.8%) compared with 34.4% of medium businesses and 12.5% of large businesses.

5.4.3 STEM employers

The biggest difference in the reasons listed as to why workplaces did not have links with post-secondary educational institutions by organisations which employ different types of STEM graduates, is that four in ten (44.3%) businesses which employ people with **Engineering** qualifications state that they 'haven't been approached by post-secondary educational institutions'. In comparison, 22.9% of organisations which employ people with **Mathematics** qualifications noted the same reason.

6 Work placements

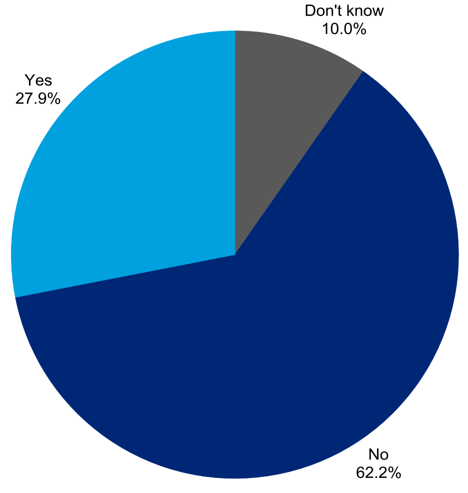
The role of work placements in providing students with experience in the workforce was considered by many consultation participants, as an important step to ensure newly qualified employees are able to get up to speed to contribute to the organisation.

6.1 Offering of work placements

Despite many respondents noting they encountered an issue regarding a lack of general workplace experience in their recruitment processes, and that work placements and work experience were one of the most effective teaching methods, **the majority (62.2%) indicated that they did not currently offer structured work placements**.

Chart 6.1 shows the proportion of survey respondents who currently offer structured work placements.

Chart 6.1: Offering of structured work placements (%)



Source: Deloitte Access Economics, STEM Employer Survey (2013)

Chart 6.2: Difficulty in recruiting STEM graduates (average) by offering of work placements

Note: Chart excludes survey respondents who answered 'don't know' or who did not answer this question. Source: Deloitte Access Economics, STEM Employer Survey (2013)

6.1.1 Industry

The offering of structured work placements differed across the industry groups. Key findings include:

- Based on the responses to this survey, employers in the **Electricity, Gas, Water and Waste** services industry were the most likely to offer structured work placements (42.9%), while those in the **Financial and Insurance Services** industry were the least likely (5.1%); and
- Around one third (33.0%) of employers in the **Professional, Scientific and Technical Services** industry offer structured work placements.

6.1.2 Business size

The proportion of employers offering structured work placements appears to differ by business size. Key findings include:

- Over one third (36.3%) of **large businesses** in this survey offered structured work placements; and
- The proportion of businesses which offer work placements decreases as businesses becoming smaller, with 31.1% of **medium businesses** and 18.8% of **small businesses** surveyed indicating that these were offered.

6.1.3 STEM employers

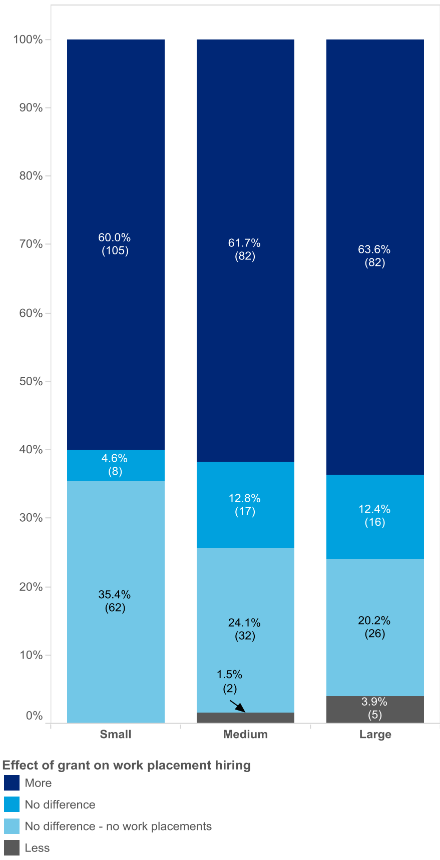
The type of STEM employees hired by businesses also appeared to have an influence on offering of structured work placements. Key findings include:

- Businesses which employed STEM people with qualifications in **Mathematics** (noting that they may also employ people with other STEM qualifications) were the least likely to offer structured work placements (26.0%). The proportion was similar for those who employed people with qualifications in **Science** (28.6%); and
- Employers of people with **Engineering** (35.7%) and **Technology** (32.7%) were somewhat more likely to offer structured work placements.

6.2 Impact of grants on work placements

When asked whether the provision of a grant to cover some of the costs of structured work placements would boost the number of places offered, the majority of employers indicated that it would. This was relatively consistent across small, medium and large businesses, despite the fact that small businesses are less likely to offer work placements in the first place.

Chart 6.3: Effect of grant on work placement hiring, by business size



Source: Deloitte Access Economics, STEM Employer Survey (2013)

6.2.2 Industry

The offer of a grant on work placement hiring appears to impact the potential offering of placements in some industries more than others. Key findings include:

- Over seven in ten businesses in the following industries would increase their provision of structured work placements if a grant were to become available: **Education and Training** (76.9%), **Agriculture, Forestry and Fishing** (72.2%), **Information Media and Telecommunications** (71.4%) and **Construction** (70.0%);
- The industry in which the availability of a grant would have the least impact on the provision of structured work placements were **Electricity, Gas, Water and Waste Services** industry (25.0%); and
- The availability of a grant is also unlikely to significantly influence the provision of structured work placements in the **Financial and Insurance Services** industry (32.4%). Around three quarters (64.7%) of organisations in the Financial and Insurance Services industry that said that the grant would not impact their provisions, do not currently offer any work placements.

6.2.3 STEM employers

Overall, organisations which employ people with **Engineering** qualifications were the most likely to increase their provision of work placements based on the availability of a grant (66.8%), while those which employ people with **Mathematics** qualifications were the least likely (52.4%). As has been noted previously, this finding may reflect the type of organisation, rather than its hiring requirements for employers with particular STEM qualifications.

7 STEM Postgraduates in the workplace

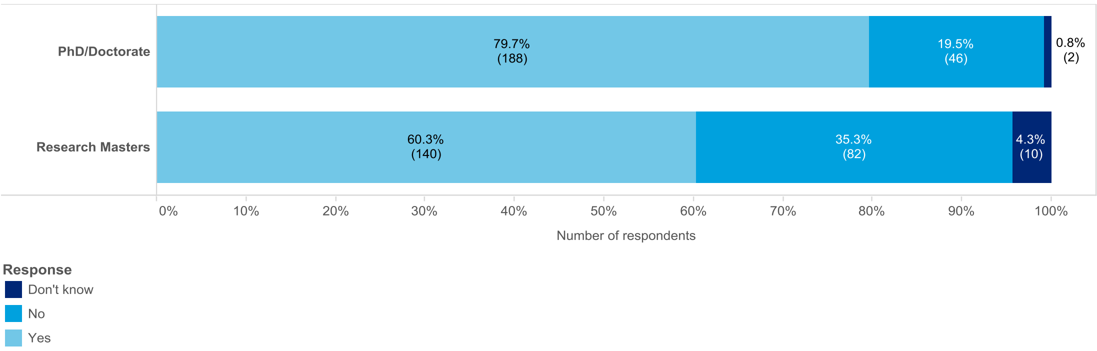
The employment and demand for people with higher degree qualifications (i.e. PhDs and Research Masters) was noted as a subject of particular interest to the Office of the Chief Scientist. During the consultations, there was quite a diverse view on the value, skills and roles that people with higher degree qualifications can play in the Australian workplace.

7.1 Hiring of STEM PhD/Doctorate and Research Masters

During the consultations the value placed on people with post-graduate level qualifications in STEM fields was one area in which the views of participants were particularly diverse. In particular, PhD qualifications were most often specifically mentioned, both in a positive and negative light.

Respondents were explicitly asked if they had any views on the topic of STEM higher degrees. As such, the following data only represents the responses of those who answered 'Yes' to this question, and therefore is not a representation of the wider respondent cohort. In total, 233 respondents indicated that they had views on STEM higher degrees. Of these, **more than three quarters (79.7%) employed people with STEM PhD and three fifths (60.3%) employed people with Research Masters** (Chart 7.1).

Chart 7.1: Employment of people with PhD/Doctorate or Research Masters in STEM



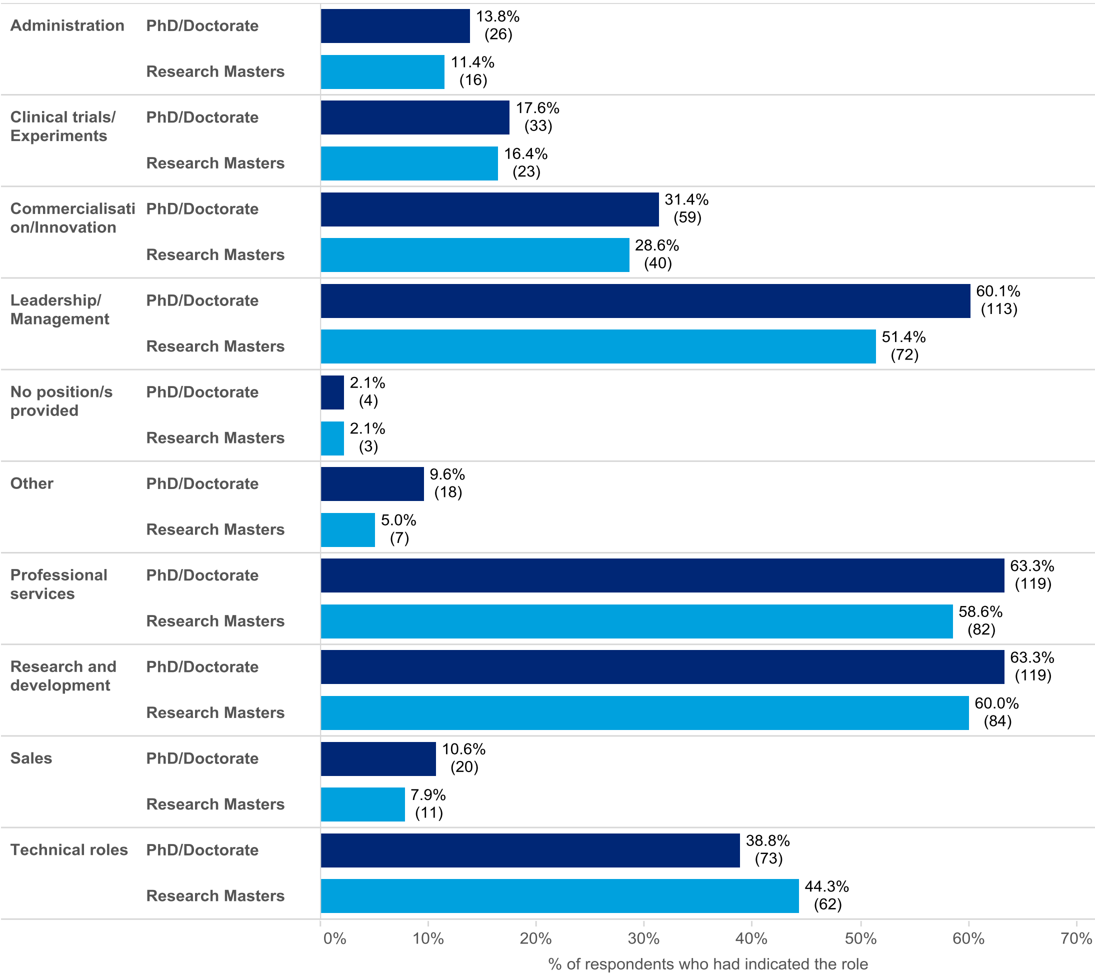
Source: Deloitte Access Economics, STEM Employer Survey (2013)

7.2 Roles in the workplace

Of those who employ people with STEM-related PhD/Doctorate qualifications, **the majority are employed in research and development activities (20.7%), professional services (20.5%) and leadership/management (18.0%)**. The patterns are very similar for those holding Research Masters qualifications.

Chart 7.2 shows the various roles that are undertaken in the workplace by those with PhD/Doctorate and Research Masters qualifications in the workplaces of survey respondents. To reflect the fact that not all people with this level of qualifications are likely to be undertaking the same roles in the workplace, respondents were asked to tick all roles that applied in their organisation.

Chart 7.2: Role of PhD/Doctorate/Research Masters in the workplace



Source: Deloitte Access Economics, STEM Employer Survey (2013)

Almost three quarters of respondents noted that people with PhD/Doctorate qualifications undertook the following roles in their workplace: professional services (63.3%), research and development (63.3%) and leadership/management (60.1%).

Other roles which people with these qualifications are hired include:

- Experimental design
- Teachers
- University lecturers
- Subject matter experts

Due to the relatively small number of respondents to this question, analysis by industry and STEM employees has not been undertaken.

7.2.1 Business size

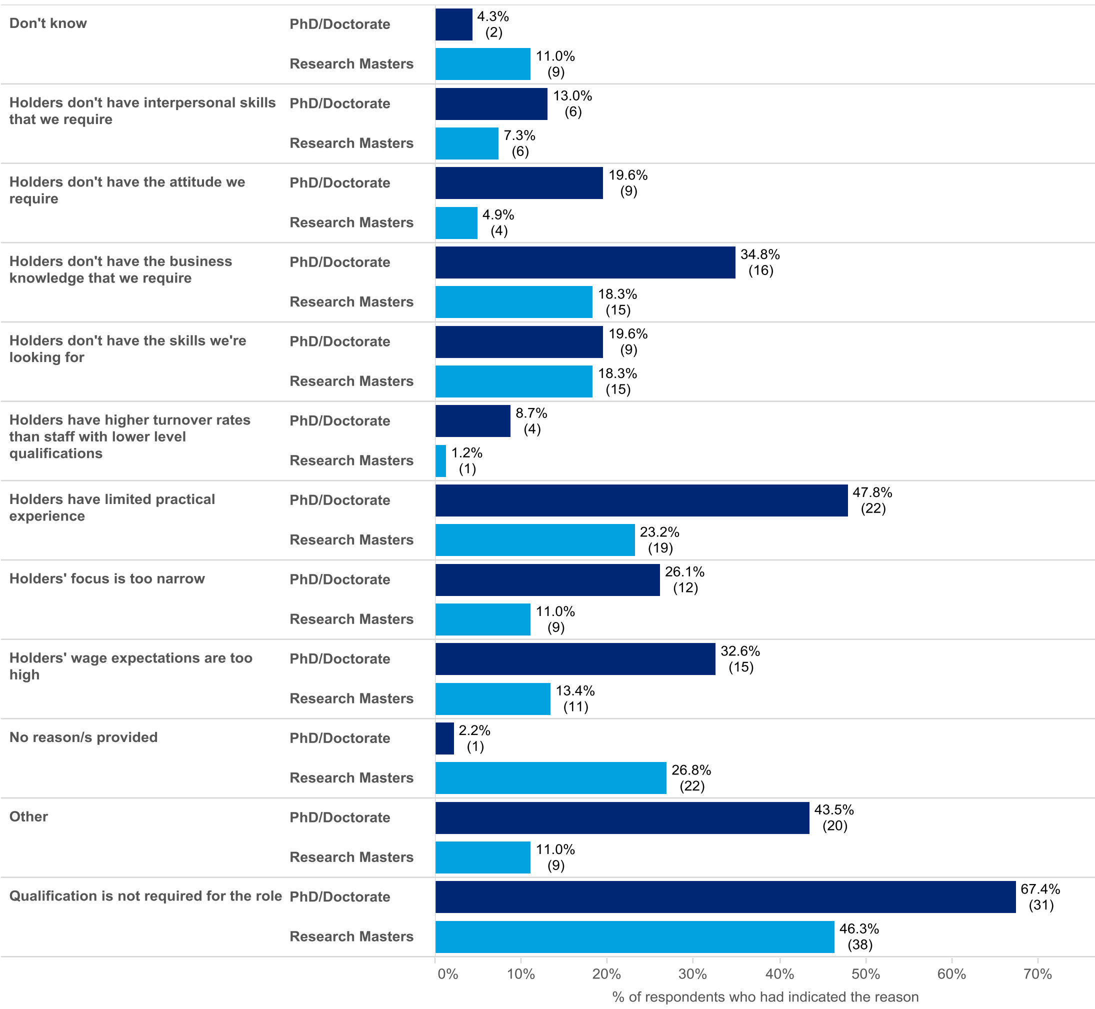
The roles which people with PhD/Doctorates and Research Masters undertake in the workplace appears to be somewhat influenced by business size. Key findings include:

- Over seven in ten (70.6%) **large businesses** recorded that people with PhD/Doctorate qualifications undertake leadership/management roles in their workplaces. In comparison, only 51.9% of **medium businesses** and 56.1% of **small businesses** employed people with PhD/Doctorate qualifications for these roles; and
- In **large businesses**, the least prevalent roles for people with Research Masters were Sales (9.5%) and Administration (17.5%). Similarly, only 5.0% of **medium businesses** and 8.1% of **small businesses** noted that people with Research Masters have roles in Sales.

7.3 Reasons for not hiring

For those who noted that they had views on PhD/Doctorates and Research Masters, but did not employ people with these qualifications, they were asked their reasons as to why this was the case. The majority (67.4%) **indicated that the qualification was not a requirement** for the role.

Chart 7.3: Reasons why people with STEM PhD/Doctorate and Research Masters qualifications are not employed in workplace



Source: Deloitte Access Economics, STEM Employer Survey (2013)

Other reasons, noted in the response text box included:

- Lack of applications/difficulty in attracting candidates
- Limited recognition of these qualifications by senior management
- Cannot afford to hire/company does not have the resources
- Salary expectations too high

Many consultation participants stated that experience in the workforce, and particularly industry-based experience was more important than the acquisition of a PhD qualification. Other participants noted that, from their perspective, many PhDs did not appear to be practical or outcomes focused.

It was also noted that PhDs tend to be specialised in a certain field, and often do not have a commercial focus. Other participants, particularly those in specialised research-based organisations, specifically looked for candidates who held PhD qualifications in areas of relevance to the commercial and research components of the organisation.

8 STEM education

Although the main purpose of this research was to build an understanding of the demand-side element of the STEM requirements in the workplace, the supply side was also discussed as a concern by many of the consultation participants.

8.1 STEM in school

Throughout the consultations, there was discussion that both primary and secondary schools, have a key role in both promoting the study of STEM related subjects and qualifications, also ensuring a basic level of understanding of STEM disciplines across all students. As one participant pointed out, although the level of engagement with technology is increasing, there is little understanding of how the technology works. In-depth knowledge is not required but, some level of understanding is both useful to the student themselves, and helped to develop an appreciation for the roles that people with STEM qualifications undertake in the labour market.

There was particular concern from some participants that some students, particularly those considered to be "smart", are being counselled away from undertaking STEM subjects at the post-secondary level. Some participants speculated that this was due to career paths being better understood by the wider community.

Many of the participants noted that, subjects such as Science and Mathematics were often taught by teachers who were not fully qualified in the particular discipline. This is echoed in the ACOLA report, which notes that unlike Australia, many of the countries who are strongest in STEM are those which have a commitment to discipline-based teaching qualifications and development (ACOLA, 2013).

It was highlighted by several participants that there are identified issues with the way Mathematics is taught in school. In particular they highlighted the need for the teaching methods to show how Maths relates to the real world, including the role of technology.

8.1.1 STEM in the curriculum

Although a STEM qualification offers an almost endless array of career opportunities – described by one participant as **'endless possibilities'** - this variety of choice can also translate into an uncertain career path. When students are entering their final years of schooling, rather than focussing on the opportunities, many teachers, parents and students are concerned with uncertainty. In addition, as many of the STEM sectors and industries develop at a relatively fast pace, many of those giving advice within schools may be unaware, or wary, of the vast opportunities a STEM qualification will offer.

The role of career advisors was seen by many participants as critical. As one participant noted, there are 16 and 17 year old students making decisions about subject choices that may affect their careers, and that they should be made with high-quality guidance from schools. It was also noted that in many cases, careers advisors were not fully aware of the career pathways of STEM qualifications, nor were they aware of the full range of opportunities in the STEM fields.

Over recent decades there has been a transition from almost a fully analogue environment, towards an almost fully digital environment. This has happened within the course of some people's careers.

Across the board, there was a general feeling that technology should be **integrated** across the school curriculum, rather than taught as a separate stream. This would help to mirror the workplace, where technology is becoming increasingly assimilated into a diverse range of industry environments. For example, robotics is used in mining and online communication tools in nursing.

It was also proposed that the use of technology throughout the school curriculum could help to **maintain the level of engagement** with both science and mathematics, and that making these subjects 'fun' would help to promote the integral roles that both of these subjects play in the world.

Some participants were also concerned that **creative thinking is actively discouraged** through the school education system, which tends to reward (through the giving of higher marks) to those with a deep understanding on particular issues, rather than those who tend to see the 'bigger picture'. This was also summarised as having a '**macro view versus a micro view' of the world**.

8.2 Post-school STEM education – niche specialisations

Some participants also identified that the market solution for the provision of post-secondary school education (i.e. through demand and supply) does not always work, with a selection of niche – but important – subject matter areas not catered for. For example, one public sector participant noted that, while employees that work in their organisation are required to have a particular degree, the small numbers meant that universities did not see value in providing the course; therefore they were required to run it themselves.

Another example was given by a construction industry participant who noted that there were no construction degrees offered in a certain location for a period of time, and this was only restarted through a combination of industry, government and private support.

8.3 Teaching methods

A lack of practical skills was a considerable concern throughout the consultations for participants who employed technical and trades workers. Some participants pointed to the privatisation of public assets as a reason for the decline in apprentices in some areas as an issue which had not been adequately addressed through the educational training system.

This is reflected in the proportion of people who nominated practical teaching methods as one of their preferred methods of education in post-secondary educational institutions.

The word cloud below represents the frequency in which various teaching methods were mentioned in response to an open-ended question about their preferred teaching methods. The mention of a word was also included if it was in a positive context. For example, the comment '*I do not personally think online content delivery can be effective'* did not contribute to the frequency count for 'Online'. It should be noted that given the method of data collection, the results presented in Figure 8.1 should be taken as an approximate reflection of survey respondent views.

Figure 8.1: Preferences for teaching methods: word cloud

Source: Deloitte Access Economics, STEM Employer Survey (2013)

Many of the responses noted several different teaching methods (each of which is reflected in Figure 8.1); with some specifically noting that flexibility and a combination of methods is what is most important.

Overall, there was some confidence from consultation participants that more recent graduates were coming out of university with additional hands-on experience, particularly for those studying engineering qualifications. Partnerships with industry were highlighted as having a key role, as were the role of both short-term and long-term work placements.

Finally, some consultation participants debated the role of universities and other education institutions in **teaching people to be creative**. This was largely discussed within the context of the emerging importance of skills such as design thinking. It was noted that there are already some existing courses which teach a mixture of science and design quite successfully, such as architecture and software design, although no conclusion was drawn about the role that post-secondary educational institutions should play in ensuring that this skill is acquired.

9 International comparison

9.1 Background

The key findings of the survey conducted for this research were compared with two countries that scored highly on the Innovation Score Card published by the Organisation for Economic Co-operation and Development (OECD). The choice of countries for comparison was informed by research undertaken as part of a literature scan completed for this report.

Suitable comparator countries were selected based on the following criteria:

- Consistent high ranking on selected indicators on the OECD Innovation Score Card;
- Available surveys in the area of STEM skills; and
- Economic and population characteristics comparable to Australia.

The two countries selected by the Office of the Chief Scientist for comparison with Australia were **the United Kingdom (UK) and Switzerland**.

The OECD Scorecard considers a broad range of measures. A sub-set of indicators were selected for their relevance to creating a strong environment for the development of STEM skills and workers. The following table summarises the ranking of Australia, Switzerland and the UK across these measures in the 2013 OECD Scoreboard. This table demonstrates the relative strengths of both the United Kingdom and Switzerland in a selection of indicators. For example, the United Kingdom rated as the top performer on the measure of 'Broader innovation', whilst Switzerland was strong in 'Higher education and basic research'. For further information on the measures presented in the table below, please see the OECD Science, Technology and Industry Scorecard 2011: Innovation and Growth in Knowledge Economies. The selected indicators are not intended to be a full analysis of the innovation systems of the countries, but instead provide important contextual information regarding the relative strengths of the systems in relation to the results of the research.

Table 9.1: Scoreboard performance across measures relating to STEM

	Australia	United Kingdom	Switzerland
Business research and development	N/A	22	6
Higher education and basic research	10	15	4
Researchers	16	21	10
Collaboration on innovation	29	1	22
Skills mobility	15	10	6
Green innovation	8	28	36
Health innovation	13	2	36
Mixed modes of innovation	23	31	n/a

	Australia	United Kingdom	Switzerland
Broader innovation	19	1	n/a
Technological advantage	6	11	13
Young innovative firms	n/a	14	7
Firm size	28	11	1

Source: OECD 2013

9.2 United Kingdom

The UK country comparison focuses on UK results in the OECD Science, Technology and Industry Scoreboard 2013, the Global Innovation Index 2013 and in three identified surveys:

- Education Skills Survey (CBI, 2011)
- Employer Perspectives Survey
- National Employer Skills Survey

In each section, UK results are compared to equivalent Australian statistics, and opportunities for improvements in Australia are identified.

9.2.1 OECD Science, Technology and Industry Scoreboard 2013

The OECD Science, Technology and Industry Scoreboard is a biennial statistical publication that considers over 200 measures of innovation and the role of science and technology in countries within the OECD. These figures are used to help examine emerging policy issues in science and technology.

This section of the report considers the top three indicators for the UK in the 2013 OECD Scoreboard, from the sub-set of indicators selected to focus on innovation. These indicators and the scores for the relevant countries are outlined in Table 9.1.

The UK ranked highly across the following three measures:

- Collaboration on innovation (1st)
- Broader innovation (1st)
- Health innovation (2nd)

The UK's performance across these three measures is discussed in detail below.

Collaboration on innovation

The UK ranked first for the measure 'collaboration on innovation', while Australia ranked 29th for this indicator. Amongst R&D active firms in the UK, 77.9% are involved in collaboration, as are 50.1% of firms without R&D. In Australia, 27.4% of R&D active firms are involved in collaboration, as are 23.4% of firms without R&D. This discrepancy was also highlighted by some of the participants in the consultations, who reflected that the research sectors in many other nations appear to play a more active role in industry innovation than is the case in Australia.

The OECD Scorecard defines collaboration as involving ‘active participation in joint innovation projects with other organisations’. Contracting out of innovation-related work is excluded from this definition.

The Scorecard observes that collaboration is an important source of innovation-related knowledge flows, both for firms that use R&D and for those that are not R&D active. However, for most countries R&D-active firms tend to collaborate more frequently on innovation than non-R&D-active firms. The two exceptions to this are South Korea (manufacturing only) and Australia, in which both types of firms have similar rates of collaboration.

A 2012 report by Wilson et al into business-university collaboration in Britain noted that since the 2003 Lambert Review there has been a significant increase in both the quantity and quality of business-university collaboration. This review recommended a series of measures to improve business-university interactions. These included improving intellectual property negotiations and reducing the focus on university spin-out companies (Wilson et al 2012). Wilson et al (2012) observed that in addition to the increased acknowledgement of the value of business-university relationships spurred by the Lambert report, the UK government has recently introduced a range of funding initiatives to encourage collaboration (Wilson et al 2012).

In contrast to this, **in Australia there appears to be less business-university collaboration**. In a Chief Scientist Issue Paper, Pettigrew (2012) noted that while the bulk of Australia’s world-class R&D takes place in its universities, the low level of researcher employment in Australian businesses indicates that this research training primarily results in employment in higher education rather than industry.

Pettigrew (2012) referenced 2006 data that indicated only 4% of Australia’s doctorate holders are employed in manufacturing. These statistics suggest that there is scope for Australia to increase collaboration between universities, private industry and government in an effort to improve levels of innovation.

As was noted in chapter 5, there was clear frustration from consultation participants over the general KPI framework that universities in Australia tend to operate under. Many participants pointed to other countries as examples of where collaboration and relationships are much stronger.

Broader innovation

The UK ranked first across the measure ‘broader innovation’, while Australia ranked 19th for this indicator. In developing this indicator, the OECD Scorecard noted that a significant share of product innovative firms in manufacturing introduce new services alongside new goods. The UK has a high percentage of product innovative firms that produce both goods and services. 72.7% of manufacturing product innovators produce both goods and services, as do 63.7% of service product innovative firms.

In Australia, this percentage is 15.9% for manufacturing firms and 18.7% for service firms. Australia has a high rate of manufacturing businesses that produce innovative goods only, at 70.1% of all product innovative firms. From these results, there is scope for manufacturing and service industries to **consider how innovation can inform a broader range of products**, e.g. both goods and services.

The OECD Scorecard notes that part of this apparent blurring of the distinctions between manufacturing and services activities may be due to the fact that some large enterprises are involved in both manufacturing and service activities, but are classified as a single industry. It is unclear to what extent the UK results reflect the dominance of large businesses across both manufacturing and services.

Health innovation

The UK ranked second (behind the United States) across the measure 'health innovation', while Australia ranked 13th for this indicator. The OECD Scorecard notes that health care for ageing populations, long-term chronic illnesses such as diabetes, drug resistant disease and global pandemics present important social challenges for countries and regions. Innovation can improve the capacity of health systems to address these problems and help contain costs. Direct government support for health-related R&D in OECD countries was about 0.1% of their combined Gross Domestic Product (GDP) in 2012. Rankings for this measure were based on three factors:

- Government budget appropriations or outlays for research and development (GBAORD);
- Funding for 'advancement of knowledge' in medical sciences; and
- Other health related funding (OECD, 2013).

According to the definition used by the OECD, direct health GBAORD includes government budget appropriations or outlays for R&D primarily committed to the socio-economic objective of protecting and improving human health. The US is significantly ahead of other countries in its spending on GBAORD, at 0.216% of GDP.

The UK recorded the second largest spend in this area at 0.127% of GDP. In Australia, 0.075% of GDP was spent on GBAORD. The UK spends more as a proportion of GDP on the advancement of medical knowledge than the US (0.03% of GDP in the UK; 0.005% of GDP in the US). Figures for the advancement of knowledge in medical sciences and other health related funding were not available for Australia.

It is difficult to compare Australia to the UK across this measure, given this missing data. Furthermore, the amount of investment in health research and development may not fully capture innovation associated with this. For example, countries may invest in cheaper areas of medical research – investment in methods of prevention and early intervention rather than developing or improving detection and treatment technologies may be more expensive, and may result in innovative technologies that have a more significant impact on population health.

While these caveats should be considered in interpreting this information, the OECD Scorecard does suggest that there may be **scope for Australia to increase its investment GBAORD**, and achieve associated improvements in innovation.

9.2.2 Global Innovation Index 2013

The Global Innovation Index is published annually by Cornell University, European Institute of Business Administration (INSEAD), and the World Intellectual Property Organisation (WIPO). The Global Innovation Index (GII) sampled 142 countries around the world using 82 indicators, including the quality of top universities, availability of microfinance, venture capital deals – gauging both innovation capabilities and measurable results (Cornell University et al 2013).

The UK scored highly on the GII 2013, ranking third overall in 2013 (up from fifth in 2012 and 10th in 2011, behind Switzerland and Sweden (Cornell University et al 2013).

In contrast, Australia was ranked 19th overall. Although Australia appears to be performing well in the same categories as the UK, perhaps reflecting the strong relationship and similar economic structure between the two countries, there are also areas of improvement for Australia. For example, for the measure 'ease of protecting investors' Australia was ranked 65th, 58th for the measure, 'non-agricultural market access weighted tariff', and 74th for 'R&D financed by abroad'. These measures suggest that there is **scope for Australia to improve global investment opportunities**, create legal structures that better protect investors and reduce tariffs in an effort to improve innovation.

9.2.3 Surveys

The UK also has a small range of available surveys conducted in relevant areas of research for which to compare the results of this research. The surveys that have been identified as comparison points for this research are outlined in Table 9.2.

Table 9.2: Employer and employee perspective surveys

Survey	Company	Sample sizes
Education and Skills Survey	Confederation of British Industry, 2011 (CBI, 2011)	566 Employers employing 2.2 Million people
Employer Perspectives Survey	UK Commission for Employment and Skills, 2012 (UCES, 2012)	All business > 2 employees
National Employer Skills Survey	UK Commission for Employment and Skills, 2011 (UCES, 2011)	87,500 employers

Source: CBI 2011; UCES 2011 and 2012

Education and Skills Survey (CBI, 2011)

The Education and Skills Survey (CBI, 2011) appears to be the most relatable to the survey conducted as part of this research. The CBI survey comprises of nine main sections where the questions within each section give a broad overview on the employment situation in the UK whilst also incorporating areas centred on STEM skills.

The base questions used in this survey are directly comparable to the Confederation of British Industry (CBI) survey – they focus on the number of employees a business has, what that business does and where the business is located. The CBI survey also incorporates questions on current economic conditions and their impact on training/investment, basic skill improvement across preschool to work age ranges, training mechanisms and foreign language skills. These areas were not applicable to the brief of this project; however they do help give a comprehensive overview of the economic conditions and the business position of companies in their employment strategies.

The 2011 CBI survey showed that employers are aiming to increase their investment in training and development and recognise the importance of certain skills to unlocking business opportunities and growth (CBI, 2011). Far more businesses expect to increase the number of jobs requiring leadership and management skills, than those that expect a reduction.

Most employers consider skill levels among their employees to be satisfactory for their current activities, with two thirds (66%) rating their high-skilled employees as good. Employers also expect to increase their demand for higher-skilled employees (+58%). While most employers are confident there will be enough people available to fill their low-skilled vacancies in the future, over half (52%) are not confident of meeting their need for high skilled employees. (CBI, 2011).

The CBI survey also includes questions related to STEM skills, many of which are relevant to the survey conducted for the Office of the Chief Scientist. These include employability of STEM skilled graduates/employees, skill importance for graduates, barriers to employing STEM skilled staff, and attitude towards STEM study promotion.

The CBI Survey found that engagment with secondary schools and univerisites is a clear priority for all employers, with companies already having links or having set plans to do so in the future. Another key finding is that one in five jobs in the UK now require a degree – this rises to 70% in the professional services industry. It has been found that business have a strong preference for STEM degrees, although employabilityskills are the most important factor taken into account when businesses recruit graduates (CBI, 2011).

Results from the most recent survey showed that **STEM skills shortages are widespread** – 43% of employers in the UK currently have difficulty recruiting staff, rising to more than half of employers expecting difficulty in the next three years (CBI, 2011).

The CBI survey found that the widespread views from employers is that government must tackle shortages by **promoting science and maths in schools** (62%) and supporting STEM related apprenticeship programs (54%). However the survey also found that STEM qualifications alone aren't enough – many employers find that applicants lack employability skills (36%) and workplace experience (37%). The businesses surveyed understand they have a key role – many employers offer STEM-related work experience (31%) and engage with schools to promote STEM subjects (28%) (CBI, 2011).

Demand

The survey conducted for this report found that two-fifths (40.0%) of respondents expected the **demand for people with STEM qualifications to increase** in their workplace over the next five to ten years. Similarly, the Education and Skills Survey found that STEM skills are in widespread demand and nearly two in five firms (39%) have difficulties recruiting staff. A similar proportion (41%) reported that they expect those difficulties to persist in the next three years.

Supply

The survey conducted for this report found that one in five (20.8%) of respondents agreed that they had encountered a 'lack of applications', and just over one quarter (27.8%) agreed that there was a **'shortage of STEM graduates'.** The percentage reported in the Education and Skills Survey was lower, and appears to be falling; from 17% in the previous survey to 12% in the most recent iteration. However, the Education and Skills Survey reported that these shortages differ significantly in different industries. Specifically, this survey notes that shortages of STEM-qualified technicians (29%) and graduates (26%) are widespread among firms in the engineering, hi-tech/IT and science areas and are expected to intensify as the economic recovery in the UK continues.

Respondents to the survey undertaken for this report further noted that there is a **lack of applicants with the requisite 'soft skills'** or practical experience required undertaking particular roles. Respondents further noted that a qualification is used as a screening device (essentially a tick-box), with hiring decisions made predominately on employability skills. Similar findings were reported in the Education and Skills Survey. Some 20% of respondents reported shortcomings in graduate applicants' literacy/use of English, 27% in problem solving and 32% in self-management. When asked how these issues might be best addressed, businesses wanted to see higher education institutions doing more to help students develop work-relevant skills (49%) and improving the business relevance of undergraduate courses (49%).

Interpersonal skills

In the survey undertaken for this report, half (50.0%) of all respondents indicated that they had encountered a **'lack of interpersonal skills'** when recruiting STEM qualified people with less than five years of experience. Similarly, the Education and Skills survey reported that employers would like to see graduates who have developed personal qualities like self-management (54%) and attitude to work (35%). The consistency of these findings across the two surveys suggests that an increased focus on the development of strong interpersonal skills could be a valuable component of any STEM qualification.

Recruitment

The survey undertaken for this report observed that the general outlook is that **recruitment will become more and more difficult**. This was particularly the case for the recruitment of more experienced staff. This finding was reflected in the observation of the Education and Skills survey that recruitment channels are changing in response to an increasingly competitive and global employment market. The survey noted that while traditional graduate recruitment channels such as advertisements (used by 78%) and recruitment fairs (37%) are widely used, a third (33%) of business now use 'sandwich placements' or internships in an effort to identify graduate talent early.

Education

Respondents to the survey conducted for this report concluded that **technology should be integrated across the school curriculum**, rather than taught as a separate stream. This sentiment was reiterated in the Education and Skills survey, which identified a number of priority areas for action in primary education. Specifically, this survey found that 69% of respondents supported a focus on clear goals for literacy and numeracy, 14% thought communication skills should be a priority area, 7% believed a less prescriptive national curriculum was important, and 6% believed a focus on technology skills should be a priority. These results suggest that there is a broad consensus towards the development of a primary curriculum that reflects the changing needs of the workplace. That is, developing a technology focused and creative skills base for the next generation of workers.

9.2.4 Employer Perspectives Survey

The two other UK surveys are the Employer Perspective Survey by UCES in 2012 and the National Employer Skills Survey by UCES in 2011. These surveys both follow a similar framework and provide a broad overview of employment possibilities in the UK, focusing on the stage of company's lifecycle, vacancies in particular areas and difficulty levels in filling these vacancies. There is also a focus put on training of current or future employees, work experience, internships and apprenticeships. There is no focus on STEM skill sets or education of employees.

The Employer Perspectives Survey explored employers' awareness of, use of and satisfaction with a range of business support services, initiatives and organisations. The survey found that employers tend to use a range of channels when looking to recruit new staff. Overall, **employers tend not to perceive much of a role for government in supporting their recruitment activity** (UKCES, 2010).

9.2.5 National Employer Skills Survey

Supply

The National Employer Skills Survey noted that a relatively small proportion of employers are affected by hard to fill vacancies and skill shortage vacancies. Only a minority of employers are affected by skill gaps and most of the workforce is considered fully proficient. Two fifths of employers had taken on young staff in the past year and around a quarter had recruited someone under 24 straight out of education (UKCES, 2007).

The National Employer Skills Survey reported that the labour market is largely able to meet the requirements of most establishments. Just 5% of respondents had a vacancy they considered to be 'hard-to-fill'. A total of 115,500 hard-to-fill vacancies were reported, equivalent to 22% of all vacancies; this is the same proportion that were hard-to-fill in 2009. Just 4% of establishments reported having vacancies at the time of the survey that they had difficulties filling specifically due to a lack of skills, qualifications or experience in applicants for the role (i.e. a "skill-shortage vacancy"). A total of 85,500 skill-shortage vacancies were reported and 16% of all vacancies were due to skill shortages.

Specifically, this survey reported that it is amongst **skilled trades** occupations where employers experience the **greatest difficulties in meeting their demand for skills** from the available labour market (in this occupation, which includes jobs such as butchers, carpenters, chefs, electricians, farmers, mechanics and plumbers, a third of all vacancies were hard-to-fill as a result of a lack of skills).

The West Midlands and the North West are the areas affected most by a high density of skill-shortage vacancies; for both regions every one in five vacancy is a skill-shortage vacancy. Kirklees, Coventry and Northamptonshire are the Local Education Authorities with the highest density of skill-shortage vacancies.

The survey conducted for this report found that Australian businesses are having some difficulties in recruiting people with STEM qualifications, with 31.5% having difficulty recruiting STEM graduates and 40.5% of respondents having difficulty recruiting STEM-qualified technicians and trades workers. This indicates that recruiting STEM-qualified technicians is slightly more difficult in Australia than in the UK (40.5% compared to 33.3%). It is unclear as to whether Australia is experiencing difficulties in employing the same group of workers as reported in the National Employer Skills Survey.

9.3 Switzerland country comparison

The Switzerland country comparison focuses on Swiss results in the OECD Science, Technology and Industry Scoreboard 2013 and The Global Innovation Index 2013. Unlike the UK comparison, no Swiss studies could be located relating to employer or employee perspectives. Within the OECD and GII sections, Swiss results are compared to equivalent Australian statistics, and opportunities for improvements in Australia are identified.

9.3.1 OECD Science, Technology and Industry Scoreboard 2013

The section considers the top four indicators for Switzerland, from the sub-set of indicators selected to focus on innovation. Four were included as Switzerland achieved the same ranking across three measures. These indicators and the scores for the relevant countries are outlined in Table 9.1.

Switzerland ranked highly in the OECD Science, Technology and Industry Scoreboard across the following three measures:

- Business research and development (6th)
- Higher education and basic research (4th)
- Skills mobility (6th)
- Firm size (1st) (OECD 2013)

Switzerland's performance across these four measures is discussed in detail below.

Business research and development

Switzerland ranked sixth across the business research and development measure. Business expenditure on research and development is an important driver of innovation and economic growth (OECD, 2013). Investment in research and development is closely linked to the creation of new products and production techniques, which have the capacity to contribute positively towards economic growth (OECD, 2013).

Business investment in research and development grew from 1.55% of GDP in 2001 to a peak of 1.63% in 2008, and declined slightly to 1.59% in 2011. In 2011, Switzerland recorded business enterprise expenditure on research and development above the OECD average at 2.11% of GDP in 2011, up from 1.82% in 2001 (OECD, 2013). Given that Switzerland has high GDP per capita – PPP $US 42,285.80 – this is a significant absolute investment in research and development (Johnson Cornell University et al, 2013). The State Secretariat for Education, Research and Innovation report noted that private sector investment amounts to two-thirds of total research funding (SERI, 2013).

The OECD scoreboard notes that a country's research and development is generally concentrated in a limited number of large firms. In Switzerland, 18.4% of investment in research and development comes from firms with 50 to 249 employees, and 10.6% of investment comes from firms with fewer than 50 employees (OECD, 2013).

Australia was ranked 18th across this measure, with 1.27% of GDP in 2011 being spent on business research and development, up from 0.82% in 2001 (OECD, 2013). In Australia, more research and development research comes from firms with fewer than 50 employees (19.6% of total investment) than firms with 50 to 249 employees (15.7%) (OECD, 2013). This may suggest that there is **scope for larger Australian firms to increase their investment in research and development**.

These differences in research and development may reflect economic infrastructure differences between the countries. Switzerland has a well-developed focus on scientific research (Global Edge, 2013). Expenditure on research and development is a significant cost for this industry – in 2008, chemical, pharmaceutical and healthcare services in Switzerland had the highest growth in research and development spending (CTI, 2013). In contrast to this, Australia's economic focus is its abundant natural resources and mining and refining associated with this. Investment in research and development may be less costly in this area, compared to medical science.

In comparing business research and development levels, the OECD scoreboard cautions that differences in internal accounting systems and other frameworks (such as research and development tax credits) and the complexity of research and development sourcing strategies may make countries difficult to compare. For example, Australia offers a tax incentive scheme, called the R&D Tax Concession, which allows firms a 45% refundable tax offset for turnover of less than AU$20m p.a. and a 40% non-refundable tax offset for all other eligible entities.[4] While this may indicate potential difficulties in comparing Swiss and Australian figures, it also further emphasises the difference between Swiss and Australian business research and development.

As Switzerland has limited natural resources, knowledge in human capital is the most valued factor of production. In particular, human skills are essential for economic efficiency in order to remain competitive. Switzerland's ageing population is shifting the human capital base. Employment in innovative-intensive industries is increasing more than traditional industries, particularly in scientific and health care services. In 2008, 65% of

[4] More information about this tax concession can be found here: www.ausindustry.gov.au

research and development employees were working in the private sector (62,000 people) (CTI, 2013).

Higher education and basic research

Switzerland ranked fourth for the higher education and basic research measure. The OECD scorecard defines the higher education sector as tertiary education institutions, research institutes and experimental stations. Basic research is defined as experimental or theoretical work undertaken primarily to acquire new knowledge without any particular application or use in mind.

Total higher education spending on research and development accounts for 0.4% of GDP in the OECD area and has increased in most countries over the last decade. Investment in higher education and basic research in Switzerland is above the OECD average at 0.77%, up from 0.62% in 2001. Some 49% of this investment is funded by universities. This is the second highest percentage of university funding, only behind top ranked Denmark at 51%. Australia was ranked 10th across this measure at 0.58%, up from 0.43% in 2001, with 33% of this investment in Australia is funded by universities.

On average, units in the government and higher education sector perform more than three-quarters of all OECD basic research. In Switzerland, the vast majority of basic research is undertaken by universities. As a percentage of domestic expenditure on basic research, 71.5% is conducted by higher education institutes and 0.1% by government departments. In contrast to this, 59.4% of domestic expenditures on basic research are made by higher education institutes and 18.2% by government departments.

Switzerland's investment in higher education is evident in its scientific impact. The country was ranked first in the world for its scientific impact in the fields of 'Technical Sciences and Engineering, Information Technology', 'Physic, Chemistry, Earth Sciences' and 'Life Sciences', and fourth in the world for its scientific impact in the field of 'Agriculture, Biology and Environmental Sciences' (SERI, 2013).

Switzerland's strong investment in higher education and basic research is further reflected in the country's national knowledge output. Switzerland produces the highest number of scientific papers per capita, and files the highest number of patents per capita. A report by the Swiss Federal Department of Home Affairs produced a paper that this is in part due to an efficient system of education and research, but also the values and research culture that has been developed in Switzerland (SERI, 2011). Specifically, this paper identified the following values as relevant to Switzerland's success in this area:

- Complementary nature of public and private initiatives;
- Ensuring that higher education institutions, researchers and research bodies enjoy the greatest possible autonomy and take individual responsibility;
- Fostering competition and quality when allocating public funds;
- Continuous search for ideal operating conditions for public and private participants, especially with regard to research; and
- Openness towards the world (SERI, 2011).

One higher education measure across which Australia and Switzerland are similar is their success at attracting foreign students. In Switzerland in 2008, international students made up 14.1% of all tertiary enrolments (SERI, 2011). In the same year, international students made up 20.6% of all tertiary enrolments in Australia, is the highest share across all OECD countries (SERI, 2011). The SERI regards this measure as an indication of a broader openness towards the world.

The OECD Scorecard notes that there are some limitations associated with comparing countries across this measure. As the higher education sector is not a formal sector in the System of National Accounts (SNA), measurement of investment in this area is based on institutional surveys. As such, this information is particularly sensitive to institutional differences that influence the data universities and other organisations are able to provide.

Skills mobility

Switzerland ranked 6th across the skills mobility indicator, while Australia ranked 15th. This measure is based on the number of international and foreign students enrolled in tertiary education in each country. The OECD Scorecard notes that students moving abroad to study are an important source of knowledge flows between countries. This measure divided students across six key study areas:

- Sciences
- Engineering, manufacturing and construction
- Health and welfare
- Humanities, arts and education
- Social sciences, business and law
- Services and agriculture

The OECD Scorecard separates students in this way as the distribution of international students by subject reveals key strengths in a country's knowledge base. Interestingly, the Scorecard notes that in most OECD countries, the share of international students in science and engineering exceeds that of domestic students.

The number of students in each of these categories in Australia and Switzerland are summarised in the following table.

Table 9.3: Students enrolled in tertiary education ('000)

	Australia	Switzerland
Sciences	11.33	17.57
Engineering, manufacturing and construction	11.92	16.56
Health and welfare	10.24	7.47
Humanities, arts and education	8.75	21.44
Social sciences, business and law	54.58	33.74
Services and agriculture	3.16	3.21
Total international or foreign students	263	42

Source: OECD 2013

While Australia has a higher absolute number of international students, Switzerland has a higher number of students enrolled in the sciences and engineering, manufacturing and construction. Given the impact these industries have on innovation and economic growth, more students in these categories is regarded more favourably by the OECD Scorecard.

There are clear geographic factors that influence scores across this measure, and Australia's ranking is quite strong considering its geographic isolation from the rest of the world. Given this, **Australia should continue to develop the quality of its tertiary education system** to ensure students choose to come here, and improve systems and regulations associated with international students studying in Australia. According to the OECD Scorecard, this is particularly important in the fields of science and engineering.

Firm size

Switzerland ranked 1st across this measure, while Australia ranked 28th. The OECD Scorecard notes that business dynamics have a significant impact on an economy's overall productivity growth. Both small business and large businesses bring different elements of value – while small businesses are important drivers of growth and innovation, larger businesses typically have competitive advantages owing to economies of scale, cheaper credit and direct access to global value chains. Switzerland was ranked 1st across this measure based on the high percentage of enterprises with Less than 49 employees. In Switzerland, 17.1% of businesses have between 10 and 19 employees, and a further 8.9% have between 20 and 49 employees. Australian figures for companies with 10-19 employees were not available, and 4.4% of enterprises had between 20 and 49 employees. While data limitations restrict the conclusions that can be drawn regarding this measure, there is perhaps **scope for Australia to increase support for the creation of smaller enterprises**.

9.3.2 Global Innovation Index 2013

Of the 142 countries sampled as part of the GII, Switzerland ranked first in the 2013, 2012 and 2011 reports. In the 2012 and 2013 reports Switzerland was ranked first in the Innovation Output Sub-Index[5] and in 'knowledge and technology outputs'. It placed second in 'creative outputs'. Switzerland achieved a spot in the top 25 countries in all pillars and sub-pillars with only four exceptions:

- Education (ranking 56th)
- Knowledge Absorption (34th)
- Tertiary education (32nd)
- Business Environment (31st) (GII, 2013)

The education measure is based on current expenditure on education as a percentage of Gross National Income (GNI), school life expectancy, Programme International for Student Assessment (PISA) scales in reading, maths and science, and pupil to teacher ratios in secondary school. Switzerland's low ranking across this measure is primarily due to its low expenditure on education as a percentage of GNI. Switzerland is ranked fifth internationally in terms of GNI per capita (World Bank, 2012). Given this high level of GNI, a low ranking for this measure is to be expected. Switzerland's low score for knowledge absorption was primarily based on foreign direct investment inflows as a percentage of GDP. At 0.1%, Switzerland ranked 134th out of 142 countries. The tertiary education score was based on a low ranking for the percentage of tertiary enrolments as a percentage of the total population, and for the gross tertiary outbound enrolment. The low business environment score was based on low scores associated with the ease of starting a business and with resolving insolvency.

For knowledge and technology outputs, Australia ranked 46th. This was based on low scores in domestic resident patent ap/bn PPP$ GDP (47th), growth rate of PPP$ GDP/worker (93rd), high- & medium-high-tech manufactures (48th), high-tech exports less re-exports (60th), and comm., computer & info. services exports (77th). Low scores across these measures perhaps reflect Australia's focus on natural resources and mining, rather than technology outputs.

9.3.3 Shortage of STEM professionals

Despite Switzerland's strong performance in innovation rankings, the country is experiencing a shortage of STEM professionals (Schweizerische Eidgenossenschaft, 2010). This trend is particular evident in the fields of computer science, engineering and construction (Schweizerische Eidgenossenschaft, 2010). This article argues that entry into STEM professions is contingent on the development of an interest in the sciences during primary and secondary school (Schweizerische Eidgenossenschaft, 2010). The article concludes that well-developed science curriculums are essential to improving the shortage of STEM workers, and that this is particularly relevant for female students, as women continue to be under-represented in these fields (Schweize Survey Instrument).

[5] The GII is based on two sub-indices – the Innovation Input Sub-Index and the Innovation Output Sub-Index. Innovation outputs are the results of innovative activities within the economy. There are two output pillars: 'knowledge and technology outputs' and 'creative outputs.'

10 Case Study: Regulatory Scientists

As a component of the Employer research into views regarding STEM, a specific case study has been developed to demonstrate current issues experienced within STEM related roles. The case study chosen is in relation to Regulatory Scientists. This case study is based on discussions from focus groups held with industry representatives and senior staff from a range of government regulators.

A range of issues currently affecting the Regulatory Science workforce, including those which may affect the future workforce, have been identified. As with workforce planning more broadly, key issues for the Regulatory Science workforce include ensuring the right number of people are in the right jobs at the required time to meet the relevant goals and objectives of stakeholders. Furthermore, it involves ensuring that the pipeline of supply of skilled workers will adequately meet future demand.

Regulatory Scientists cover a diverse cohort of different scientific, administrative and legislative skills and knowledge. Although many different definitions were discussed, it was largely agreed that a Regulatory Scientist is someone who (1) has some level of scientific knowledge, preferably across a range of fields and (2) understands and/or can apply the relevant regulatory framework and associated activities such as risk assessments. The overarching aim of many activities is to ensure that products going on to the market have been adequately assessed for their risk to both humans and the wider environment.

Overlaying the existing workforce issues is the Australian regulatory system itself. In particular, the uniqueness of many of the Australian systems, requiring on-the-job knowledge, as well as the various State/Territory variations which need to be understood and accounted for. In addition, the regulatory environment, although consisting of three main regulatory frameworks, also covers more than 100 pieces of separate legislation. Moreover, it is continuously changing environment which requires all Regulatory Scientists to remain aware and up-to-date with these changes and developments.

10.1 Current workforce

Currently it is difficult for industry and government regulators alike to employ and retain staff with the relevant background and knowledge in Regulatory Science. Anecdotal evidence also suggests that large investments are being made to build the capabilities of new employees in the workplace. This is a result of a significant gap between the qualifications that students are obtaining and the minimum level of knowledge required to be effective in the workplace.

10.1.1 Current demand

The current demand for Regulatory Scientists is driven by two key sectors within the Australian economy, namely industry and government regulators. Within industry, Regulatory Scientists are a key conduit between the specialised scientific data generated through laboratory work and government regulators. From a government regulator perspective, Regulatory Scientists evaluate applications against risk assessment frameworks to inform decisions regarding products going to market.

There was also some discussion within the focus groups that the skills required to work in this area are becoming increasingly complex. Although there are a set of core competencies underlying the role of a Regulatory Scientist, there is also a significant element of job-specific knowledge that must be acquired.

Although demand from the government sector is currently supressed due to overarching budget constraints imposed across the public service, there was a general feeling amongst the group that the demand for well qualified, and particularly experienced Regulatory Scientists remains relatively robust.

10.1.2 Current supply

Overall, there appears to be some existing difficulties in both recruiting and retaining people in Regulatory Science roles. Throughout the consultations, industry expressed their concerns that there may not be enough adequately qualified people within government available to do the work. Over time, this has resulted in extended period of induction and on-the-job training in order to ensure new staff are adequately trained and functional in their new roles.

One of the main sources of current supply is the recruitment of people who have done PhDs in a science field. Although these candidates often have the capacity to understand the regulatory environment, they have often had little exposure to it throughout their education. In addition, by nature a Regulatory Scientist is often applying their scientific knowledge in a broad based sense, which is often misaligned with the skills and interests of PhD qualified employees who tend to specialise in a particular scientific field.

There was acknowledgement from all parties that a main constraint on current supply, particularly relating to the retention of Regulatory Scientists in the workforce, is the lack of a career path. As described by industry and government representatives, the bulk of the workforce is in the government, which largely means that opportunities for promotion and/or salary increases are constrained by the overarching Australian Public Service (APS) framework.

In addition, as is currently the case, there may be constraints on the ability of government regulators to attract and hire additional employees which are not related to the current level of demand for the regulator itself (e.g. whole of government recruitment freezes). Further, the ability to offer opportunities to staff outside their prescribed Key Performance Indicators (KPIs), such as the ability to lecture for relevant courses, is limited by the model of service delivery used by government.

The career path of a Regulatory Scientist, particularly the ability to move freely between industry and government, is also somewhat constrained by the nature of the work performed. In particular, issues of confidentiality and independence may arise where employees, who have previously had access to confidential documents, move to industry competitors.

There was also a specific issue identified around the current **shortage of toxicologists** in the Australian workforce, which will likely be further exacerbated in the future as there is currently no available training in the Australian education system. For the most part, industry is currently drawing on overseas expertise to fill these gaps, while the government workforce is reliant on a shrinking pool of qualified toxicologists.

10.1.3 Current issues

Table 10.1 outlines the current key issues existing in the Regulatory Science workforce in Australia. In addition, it identifies some of their impacts, as well as the underlying source(s) of the issue. It should be noted that this list only included those discussed through the consultations, and should not be seen as definitive.

Table 10.1: Current issues for Regulatory Science workforce identified in consultation

ISSUE	IMPACT(s)	SOURCE(s)
Lengthy induction process for new staff	• Delay in new staff becoming functional in the workplace • Cost of training new staff, including opportunity cost of trainers	• Nature of the job generally requires significant induction • Limited availability of external training and courses
Retention of staff within the workforce	• Churn between agencies	• Lack of clear career path
Shortage of toxicologists	• Reliance on overseas expertise	• Limited education and training opportunities in toxicology
Cultural differences between industry and government work environments	• Difficulty in transferring between industry and government workplaces • Limited understanding from industry as to how regulators operate	• **Actual or perceived** independence issues • Actual or perceived inability to have open dialogue between industry and regulator
Lack of coordination between relevant stakeholders	• Lack of coordination in addressing workplace planning issues	• No bodies that are designed to take on or coordinate response to issues
Funding pressures for	• Limited interaction between government and	• Limited funding at government level

regulators	industry • Time and cost implications for industry • Actual or perceived move to more risk adverse decision-making	

10.2 Future workforce

There are genuine concerns that the future sustainability of the Regulatory Science workforce will present an ongoing challenge for both industry and government regulators. This appears to be largely related to future supply, as although demand is expected to increase, this growth is not expected to be exponential.

10.2.1 Future demand

Overall, participants noted that there would be increased demand in the number of Regulatory Scientists required, although this number is not likely to increase substantially. However, there was clear agreement that the workforce would grow from its current numbers, introducing issues around both retaining the current size of the workforce, as well as attracting additional applicants over and above what has previously been achieved.

Future demand will be dependent on a number of factors, including the complexity of the regulatory environment, the level of R&D activity being conducted, and the economic cycle.

Depending on the solutions implemented, there may also be additional demand for Regulatory Scientists in the education sector to provide the education and training proposed.

A key task over the medium term is to quantify, as far as possible, the level of future demand in order to build an adequate pipeline of supply. As well as addressing the quantity of Regulatory Scientists required, this work should also identify the skills – both now and into the future.

10.2.2 Future supply

In a market environment, the level of supply will over time be largely driven by the level of demand. However, in the Regulatory Science workforce, particularly as the government is a major employer, there can be some considerable divergences. For example, the level of compensation, or salary, available to attract relevant talent to the government Regulatory Science workforce is considerably restricted by the overarching Australian Public Service (APS) remuneration framework, which significantly restricts the ability for government regulators to attract staff in times of diminished supply.

Although there are only limited expectations that there will be an absolute shortage of applicants, there is significant concern that there will be a requirement to substitute the workforce with lesser qualified people than would ideally be the case. This has several impacts, particularly in an increasingly complex regulatory environment, including longer time frames for government approval and a diminished quality of regulatory applications.

For industry, this shortage or shortfall in skills may mean an increased reliance on overseas expertise. In addition, there may be some need to supplement domestic supply with a structured skilled migration program to ensure that the required skills are available within the Australian workforce.

The quantity and quality of future supply of both Regulatory Scientists in general, as well as toxicologists more specifically will be significantly affected by the availability of education and training for these skills. A long term solution to ensure adequate supply requires co-ordination across government, industry and education providers to ensure that the needs of all stakeholders are met.

10.2.3 Future issues

Table 10.2 outlines potential issues that the Regulatory Science workforce in Australia may face in the future. In addition, it identifies some of the impacts of these issues, as well as the underlying source(s) of the issues. As noted for the current issues in Table 10.1, the table below only includes those issues identified through the consultation.

Table 10.2: Future issues for Regulatory Science workforce identified in consultation

ISSUE	IMPACT	SOURCE
Ageing workforce	• Retirement of large numbers of experienced Regulatory Scientists within a short period. • Potential workforce shortages.	• The role has not attracted new entrants to the workforce at the level required for replacement.
Shortage of graduates	• Increased time taken to process regulatory applications.	As above
Shortage of toxicologists (ongoing issue)	• Increased reliance on overseas specialists	• Limited availability of external training and courses.
Increasingly complex regulatory environment	• Increasingly complex chemistries and assessments required, increasing time of assessments	• Changes to regulatory requirements

10.3 Where to from here?

There was some concern amongst participants of the focus groups that the issues identified had been discussed over a number of years, with no clear pathways or work undertaken to either identify or implement possible solutions. In light of this, participants were asked to identify some of the actions that could be undertaken to address many of the issues.

Deloitte Access Economics has synthesised these actions into the diagram below, identifying short, medium and long term actions to work towards the objective of **ensuring that the right number of people are in the right jobs at the required time to meet the relevant goals and objectives of the stakeholders involved.** These actions should be seen as a guide only based on the focus group discussions, and should be further developed by the relevant stakeholders.

In each of the stages identified, a significant level of coordination is required to ensure that all needs are addressed and that the solutions implemented are sustainable over the long term. In particular, it is important to acknowledge that no individual organisation will have the resources or influence to adequately address the workforce issues on their own. In addition, it is important to acknowledge that an appropriately skilled government Regulatory Science workforce is in the best interest of industry, and vice versa.

Figure 10.1: Potential future actions for Regulatory Science workforce

Potential Future Actions

- Understand the current workforce, including its size
- Identify required core competencies and skills
- Map career paths of current staff (including case studies)
- Look at past workforce trends
- Estimate future demand and understand its drivers
- Develop a clear road map, including timelines
- Pool resources across the sector to support a position dedicated to the development of a strategy and baseline data
- Investigate use of APS graduate program as a method of recruitment

- Identify opportunities for cross-industry/government experiences
- Identify methods of training (e.g. short courses, Masters degrees) (including the potential pooling of resources)
- Develop and market career paths to potential students

- Implement training and education courses
- Promote internship and vacation program opportunities
- Encourage experienced staff to mentor new staff

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Appendix A: Consultation list

The following organisations participated in semi-structured interviews or focus groups as part of this project. Deloitte Access Economics thanks them for their participation.

- 3M
- Agriminds
- Arnold Bloch Leibler
- ATSA Defence Systems
- Aurecon
- Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)
- Australian Nuclear Science and Technology Organisation (ANSTO)
- Australian Rollforming
- BHP Billiton
- Bureau of Meteorology (BoM)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Defence Science and Technology Organisation (DSTO)
- DHL
- Ewater
- Forrest Hotel
- Freshcare
- GE Global Operations
- Google
- Grey Innovation
- HDM Metal
- Hewlett-Packard (HP)
- Hindmarsh
- Horticulture Supply Chain Services
- IBM
- Icognition
- Lockheed Martin
- Lowy Cancer Research Centre
- MathWorks
- Meltwater Group
- Minerals Council Australia
- NSW Education & Communities
- ReadingRoom

- ResMed
- Royal District Nursing Service
- Sienna Cancer Diagnostics
- Small Quinton Coleman Architects
- Tanner James Management Consultants
- TNT
- Universal Biosensors
- Westpac

Appendix B: Statistical testing

The one-way ANOVA tests undertaken for the following three charts compare the means of multiple distributions (skills) to test whether the distributions are statistically significant.

- The *independent variable* selected was the skill (i.e. 'Active learning' etc.)
- The *dependent variable* selected was the response (i.e. 'Acceptable', 'Good', etc.)

The significance level selected was 95% for all tests.

Chart 10.1 Question 19: To what extent are the following skills and attributes important to your workplace?

STEM Skill	N	Mean of Total	Std. Dev. of Total	Std. Error of Total
Active learning (i.e. learning on the job)	544	3.6	0.60	0.03
Complex problem-solving	544	3.4	0.78	0.03
Creative problem-solving	544	3.4	0.81	0.03
Critical thinking	544	3.5	0.74	0.03
Design thinking	532	2.8	1.12	0.05
Interpersonal skills	547	3.3	0.82	0.03
Knowledge of legislation, regulation and codes	543	2.7	1.03	0.04
Lifelong learning	537	2.9	1.01	0.04
Occupation-specific STEM skills	537	3.0	1.04	0.04
Programming	524	2.1	1.33	0.06
System analysis and evaluation	520	2.4	1.26	0.06
Time management	541	3.1	0.87	0.04
Understanding how we do business	541	3.2	0.85	0.04
TOTAL	6,998	3.0	1.05	0.01

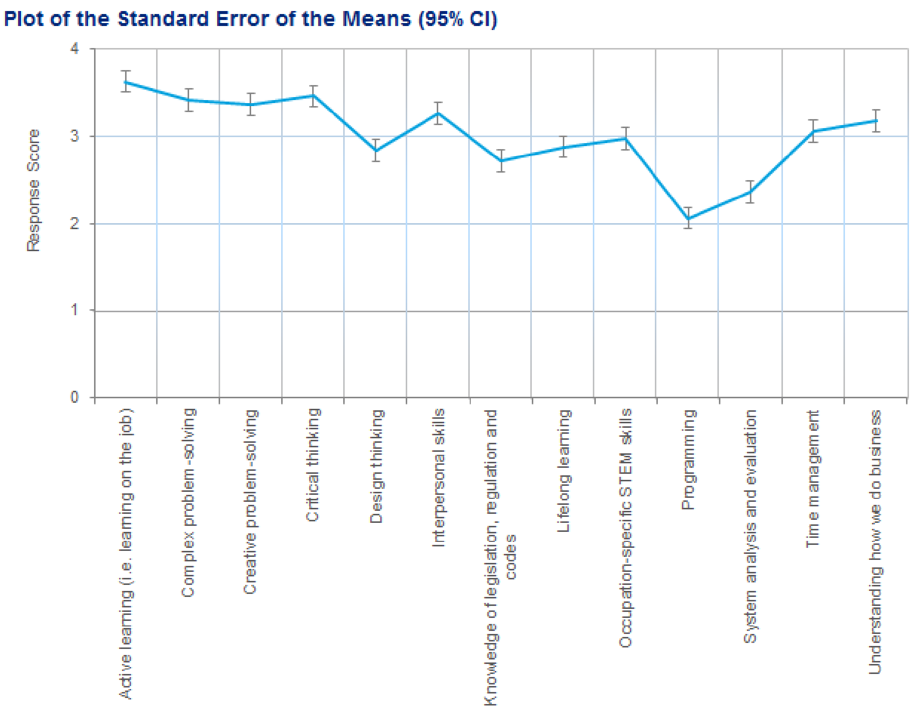


Chart 10.2 - Question 21: Overall, how would you rate the skills level of those in your workplace who have STEM qualifications for the following skills and attributes?

STEM Skill	N	Mean of Total	Std. Dev. of Total	Std. Error of Total
Active learning (i.e. learning on the job)	516	3.3	0.68	0.03
Complex problem-solving	519	3.2	0.79	0.03
Creative problem-solving	518	3.0	0.87	0.04
Critical thinking	520	3.1	0.86	0.04
Design thinking	489	2.8	0.91	0.04
Interpersonal skills	519	2.7	0.86	0.04
Knowledge of legislation, regulation and codes	510	2.6	0.89	0.04
Lifelong learning	511	2.8	0.85	0.04
Occupation-specific STEM skills	505	3.1	0.78	0.03
Programming	451	2.4	1.05	0.05
System analysis and evaluation	467	2.6	0.94	0.04
Time management	512	2.5	0.85	0.04
Understanding how we do business	515	2.7	0.87	0.04
TOTAL	6,552	2.8	0.91	0.01

Plot of the Standard Error of the Means (95% CI)

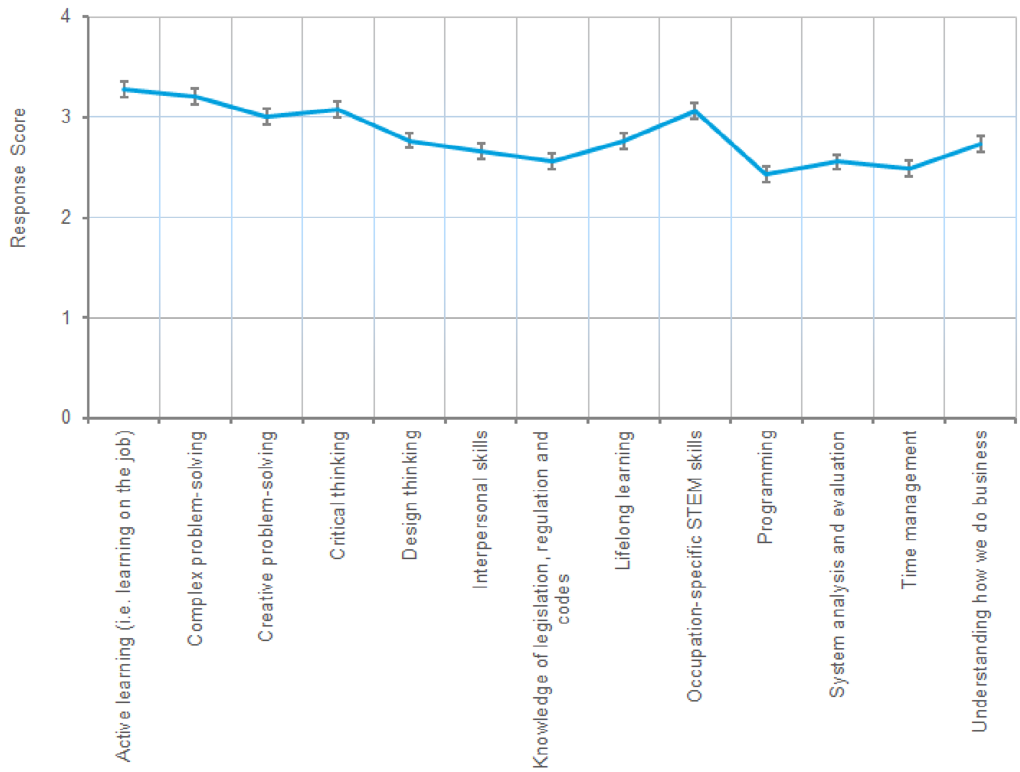
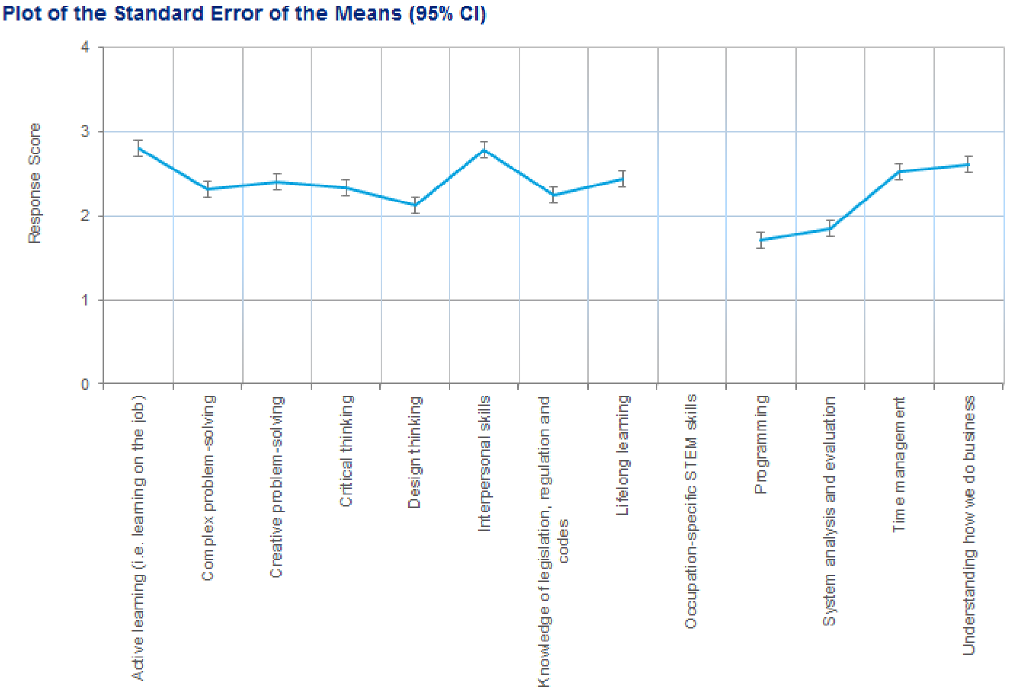


Chart 10.3 – Question 22: Overall, how would you rate the skill level of those in your workplace who have qualifications in non-STEM fields for the following skills and attributes?

STEM Skill	N	Mean of Total	Std. Dev. of Total	Std. Error of Total
Active learning (i.e. learning on the job)	410	2.8	0.80	0.04
Complex problem-solving	403	2.3	0.97	0.05
Creative problem-solving	401	2.4	0.94	0.05
Critical thinking	403	2.3	0.94	0.05
Design thinking	371	2.1	0.90	0.05
Interpersonal skills	413	2.8	0.82	0.04
Knowledge of legislation, regulation and codes	394	2.3	0.94	0.05
Lifelong learning	399	2.4	0.87	0.04
Occupation-specific STEM skills			n/a	
Programming	316	1.7	1.04	0.06
System analysis and evaluation	339	1.9	0.99	0.05
Time management	413	2.5	0.85	0.04
Understanding how we do business	401	2.6	0.87	0.04
TOTAL	4,663	2.4	0.96	0.01

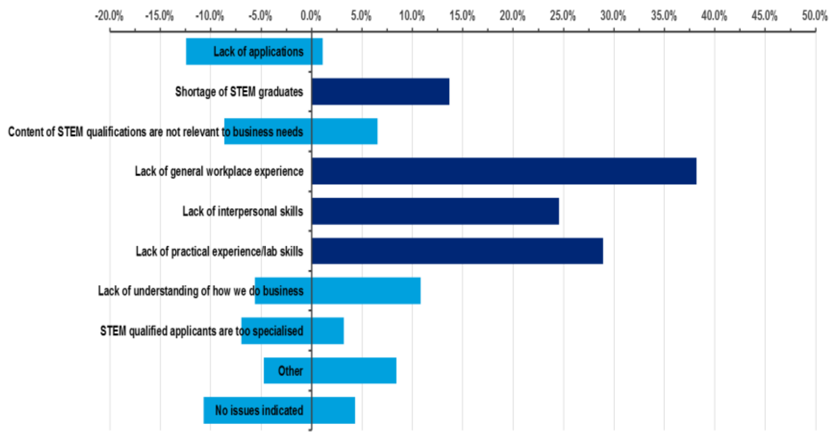


For the following table:

*** denotes a statistically significant difference at α = 0.05.

Chart 10.4 – Question 30 and 35: Thinking about your experiences in recruiting STEM qualified people with less (more) than 5 years' experience, did you encounter any of the following issues? (tick all that apply)

		Less than 5yrs experience		More than 5yrs experience					
	Number of distinct respondents	280		239					
Issue Category	Issue	No. of respondents	Proportion	No. of respondents	Proportion	z-value	lower confidence limit (CL)	upper confidence limit (CU)	
Quantity	Lack of applications	45	16.1%	52	21.8%	-1.7	-12.5%	1.1%	
	Shortage of STEM graduates	59	21.1%	34	14.2%	2.0	0.3%	13.4%	***
Quality	Content of STEM qualifications are not relevant to business needs	72	25.7%	64	26.8%	-0.3	-8.7%	6.5%	
	Lack of general workplace experience	98	35.0%	38	15.9%	4.9	11.8%	26.4%	***
	Lack of interpersonal skills	107	38.2%	62	25.9%	3.0	4.3%	20.2%	***
	Lack of practical experience/lab skills	92	32.9%	44	18.4%	3.7	7.1%	21.8%	***
	Lack of understanding of how we do business	101	36.1%	80	33.5%	0.6	-5.6%	10.8%	
	STEM qualified applicants are too specialised	24	8.6%	25	10.5%	-0.7	-7.0%	3.2%	
Other	Other	52	18.6%	40	16.7%	0.5	-4.7%	8.4%	
None	No issues indicated	66	23.6%	64	26.8%	-0.8	-10.7%	4.3%	



Appendix C: Terms of reference

Terms of Reference

1. Carry out and write a user-friendly and comprehensive literature review of employer surveys (both national and international) related specifically to STEM graduates.

2. Segment into meaningful fields both the workforce and education sectors.

3. Consult (through interviews and round-tables) with a representative sample of employers to develop a deeper understanding of the key attitudes, issues and barriers to employment of STEM graduates. Note: There is consideration being given to including a subset of Enterprise Connect clients who have engaged in the department's 'Researchers in Business' program. Access to this group will be explored with support from the National Adviser Science and Mathematics, Education and Industry.

4. Determine the most suitable respondent/s for different company size. E.g. Head of HR, CEO, manager of a technical function.

5. Obtain permission from the Statistical Clearing House to implement the survey.

6. Use the results of 1-3 to develop and implement a detailed on line survey of past, current and future employer attitudes, needs and expectations of STEM graduates by industry sector, including:

   (a) **Company details** - size, sector, type of activity

   (b) **Recruitment process** - number and availability of STEM qualified graduates for each advertised position

   (c) **Graduate employment details** - define the level of recruitment of graduates, what disciplines and levels of award, the preferred institution, the recruitment criteria (specialist and generic skills) and the degree to which these skills are readily available among STEM versus other graduates in the labour market. Provide an importance ranking of recruitment criteria.

   (d) **Attitudes to employing graduates** - a detailed understanding of employer's attitudes and perceptions regarding willingness to employ STEM graduates, the challenges involved and the potential barriers to employment. In what roles are STEM graduates most valued and why – e.g. What specific technical roles versus general business roles? Has willingness to employ STEM graduates been changing - and if so in what ways?

   (e) **Satisfaction with graduate skills** - quantify employer satisfaction with quality of technical skills and job readiness of graduates in the first year (against ranked criteria in b) and the application of these skills to their performance and progression of STEM graduates within employment over time. To what extent/ on which criteria do post graduates outperform graduates or otherwise?

   (f) **Projected skill gaps** - determine field and skill gaps that employers expect in the next 5-10 years. Will the need for STEM graduates increase or decrease in the future? What factors are driving this outlook?

   (g) **Business - Higher Education engagement** - define and describe employer engagement with tertiary education institutions and what form it took (e.g. cadetships, other work placement opportunities, cooperation on curriculum design).

   (h) **International Comparisons** - How do responses to a-g compare with those from two with two countries which score high on the Innovation Scale?

   (i) As a part of the survey the Researchers in Business subset of Enterprise Connect will also be interviewed.

7. Analyse the results of the survey to provide synthesised and statistically significant responses to the questions raised in Term 6 (a) - 6 (i).

Appendix D: Survey instrument

Welcome

Thank you for taking the time to complete this survey. We appreciate your cooperation in helping us to understand employer demand for Science, Technology, Engineering and Mathematics (STEM) skills in Australian workplaces.

This survey is being undertaken by Deloitte Access Economics on behalf of the Office of the Chief Scientist, Australia (www.chiefscientist.gov.au).

The survey will take approximately 20 minutes to complete.

Your privacy is very important to us, and we will keep all your answers and input confidential. Your organisation's name will never be included in any reports and none of your answers will be linked to you, or your organisation, in any way. The information you provide will be combined with information from all participants who take part in this survey culminating in a final report.

To progress through the survey, please click the 'Next' button. Any questions marked with an asterisk (*) require an answer in order to progress through the survey. If you do not know the answer, please select 'don't know' or if the question does not apply to your organisation select the 'not applicable' option. If at any time you would like to revise your answers to previous questions, please use the 'Prev' button.

If you have any questions about the survey, please email them to STEMresearch@deloitte.com.au.

This survey has been approved by the Australian Government Statistical Clearing House. The approval number is 02354-01. You may phone the Statistical Clearing House on (02) 6252 5285 to verify the approval number.

Page 1

About your organisation

*** 1. Before starting the survey, could you please provide the name of your organisation?**

This information will be kept confidential at all times and is only collected in order to monitor responses to the survey. It will not be linked with any of the information you provide as part of the survey, or used for any other purpose.

Page 2

About your organisation

Thank you again for taking the time to complete this survey.

The first section of the survey includes questions about the size of your organisation, and the industry that it operates in.

*** 2. Approximately how many people does [Q1] employ in the following occupations?**

If you are unsure, please provide an approximate number for the total number of employees.

Managers	
Professionals	
Technicians and Trades Workers	
Other	
TOTAL	

For this question, and all future questions, please include all permanent full-time and part-time staff, as well as people working on contracts more than six months in length. Please do not include casual or other temporary staff.

MANAGERS plan, organise, direct, control, coordinate and review the operations of government, commercial, agricultural, industrial, non-profit and other organisations, and departments.

PROFESSIONALS perform analytical, conceptual and creative tasks through the application of theoretical knowledge and experience in the fields of the arts, media, business, design, engineering, the physical and life sciences, transport, education, health, information and communication technology, the law, social sciences and social welfare.

TECHNICIANS AND TRADES WORKERS perform a variety of skilled tasks, applying broad or in-depth technical, trade or industry specific knowledge, often in support of scientific, engineering, building and manufacturing activities.

OTHER includes Community and Personal Service Workers, Clerical and Administrative Workers, Sales Workers (excluding ICT and Technical Sales Representatives who should be classified as PROFESSIONALS), Machinery Operators and Drivers and Labourers.

For further information, see Australian Bureau of Statistics publication 'Australian and New Zealand Standard Classification of Occupations' (ANZSCO) (cat. no. 1220.0) at www.abs.gov.au.

Page 3

About your organisation

*** 3. What is the main sector in which [Q1] operates?**

- Private
- Public/Government
- Not for profit
- Don't know
- Other (please specify)

4. Does [Q1] also operate outside Australia?

- Yes
- No
- Don't know

Page 4

About your organisation

5. What is your position within [Q1]?

- CEO/Managing Director/Owner
- Other Senior Executive Role
- Human Resources Director/Manager
- Manager
- Other (please specify your position)

*** 6. Will you be answering the survey on behalf of the whole of [Q1]?**

- Yes, all of [Q1]
- No, only a specific department, division or location within [Q1] (please specify the name of the department/division/location in the box below)

For the remainder of the survey, 'Your Workplace' refers to your answer to the previous question (i.e. whether you are answering the survey on behalf of your whole organisation, or a specific department, division or location).

Page 5

About your workplace

*** 7. What is the main industry in which [Q1] operates?**

- Agriculture, Forestry and Fishing
- Mining
- Manufacturing
- Electricity, Gas, Water and Waste Services
- Construction
- Wholesale Trade
- Retail Trade
- Accommodation and Food Services
- Transport, Postal and Warehousing
- Information Media and Telecommunications
- Financial and Insurance Services
- Rental, Hiring and Real Estate Services
- Professional, Scientific and Technical Services
- Administrative and Support Services
- Public Administration and Safety
- Education and Training
- Health Care and Social Assistance
- Arts and Recreation Services
- Don't Know
- Other Services (please specify)

Page 6

About your workplace

*** 8. Approximately how many people does [Q6] employ in the following occupations?**

If you are unsure, please provide an approximate TOTAL number.

Managers

Professionals

Technicians and Trades Workers

Other

TOTAL

Remember, please include all permanent full-time and part-time staff, as well as people working on contracts more than six months in length. Please do not include casual or other temporary staff.

*** 9. What is the main industry in which [Q6] operates?**

- Agriculture, Forestry and Fishing
- Mining
- Manufacturing
- Electricity, Gas, Water and Waste Services
- Construction
- Wholesale Trade
- Retail Trade
- Accommodation and Food Services
- Transport, Postal and Warehousing
- Information Media and Telecommunications
- Financial and Insurance Services
- Rental, Hiring and Real Estate Services
- Professional, Scientific and Technical Services
- Administrative and Support Services
- Public Administration and Safety
- Education and Training
- Health Care and Social Assistance
- Arts and Recreation Services
- Don't Know
- Other Services (please specify)

Page 7

Understanding STEM

The purpose of this survey is to assist the Office of the Chief Scientist in understanding how science, technology, engineering and mathematics (STEM) are used in Australian businesses.

The research aims to understand what skills are required by Australian businesses, and whether or not these skills are readily available in the marketplace.

For the purposes of this survey, we are interested in knowing about the people with STEM qualifications who are employed in your workplace. This includes the following qualifications:

* Vocational Education and Training (VET) (awarded Certificate III, Certificate IV, Diploma or Advanced Diploma; including via traineeship or apprenticeship)
* Undergraduate (awarded Bachelor or Honours Degree)
* Postgraduate (awarded Graduate Certificate, Graduate Diploma, Masters or PhD/Doctorate)

Disciplines of study included as part of STEM are outlined below.

SCIENCE

Includes Physics and Astronomy, Chemical Sciences, Earth Sciences, Biological Sciences, Agriculture, Horticulture and Viticulture, Forestry Studies, Fisheries Studies, Environmental Studies and related studies.

TECHNOLOGY

Includes Computer Science, Information Systems and related studies.

ENGINEERING

Includes Manufacturing Engineering, Process and Resources Engineering, Automotive Engineering, Mechanical and Industrial Engineering, Civil Engineering, Geomatic Engineering, Electrical and Electrical Engineering, Aerospace and Maritime Engineering and related studies. This includes Mechanics, Processing and Technology, Fitting and Turning, etc

MATHEMATICS

Includes Mathematics, Statistics and related studies.

*** 10. Does your workplace currently employ anybody with any qualifications in any of the above STEM fields?**

- Yes
- No
- Don't know

Page 8

Science

* 11. Does your workplace currently employ anyone with a qualification in Science?

- Yes
- No
- Don't know

Page 9

SCIENCE

Includes Physics and Astronomy, Chemical Sciences, Earth Sciences, Biological Sciences, Agriculture, Horticulture and Viticulture, Forestry Studies, Fisheries Studies, Environmental Studies and related studies.

Page 10

Science

SCIENCE

12. For each of the occupations listed below, approximately how many staff have Science qualifications? If you are unsure, please provide a TOTAL number.

Managers	
Professionals	
Technicians and Trades Workers	
Other	
TOTAL	

Please enter '0' if your workplace does not employ anyone in that occupation with a qualification in Science.

Page 11

Technology

*** 13. Does your workplace currently employ anyone with a qualification in Technology?**

- ○ Yes
- ○ No
- ○ Don't know

Page 12

TECHNOLOGY

Includes Computer Science, Information Systems and related studies.

Page 13

Technology

TECHNOLOGY

14. For each of the occupations listed below, approximately how many staff have Technology qualifications? If you are unsure, please provide a TOTAL number.

Managers	
Professionals	
Technicians and Trades Workers	
Other	
TOTAL	

Please enter '0' of your workplace does not employ anyone in that occupation with a qualification in Technology.

Engineering

*** 15. Does your workplace currently employ anyone with a qualification in Engineering?**

- Yes
- No
- Don't know

Page 15

ENGINEERING

Includes Manufacturing Engineering, Process and Resources Engineering, Automotive Engineering, Mechanical and Industrial Engineering, Civil Engineering, Geomatic Engineering, Electrical and Electrical Engineering, Aerospace and Maritime Engineering and related studies. This includes Mechanics, Processing and Technology, Fitting and Turning, etc

Page 16

Engineering

ENGINEERING

16. For each of the occupations listed below, approximately how many staff have Engineering qualifications? If you are unsure, please provide a TOTAL number.

Managers	
Professionals	
Technicians and Trades Workers	
Other	
TOTAL	

Please enter '0' if your workplace does not employ anyone in that occupation with a qualification in Engineering.

Page 17

MATHEMATICS

Includes Mathematics, Statistics and related studies.

Mathematics

*17. Does your workplace currently employ anyone with a qualification in Mathematics?

- Yes
- No
- Don't know

Page 18

Mathematics

MATHEMATICS

18. For each of the occupations listed below, approximately how many staff have Mathematics qualifications? If you are unsure, please provide a TOTAL number.

Managers	
Professionals	
Technicians and Trades Workers	
Other	
TOTAL	

Please enter '0' if your workplace does not employ anyone in that occupation with a qualification in Mathematics.

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Skills and attributes: importance to your workplace

This question asks you to consider the importance of a variety of skills to your workplace.

19. To what extent are the following skills and attributes important to your workplace?

	Very important	Important	Moderately important	A little important	Not important	Don't know	Not applicable
Active learning (i.e. learning on the job)							
Complex problem-solving							
Creative problem-solving							
Critical thinking							
Design thinking							
Interpersonal skills							
Knowledge of legislation, regulation and codes							
Lifelong learning							
Occupation-specific STEM skills							
Programming							
System analysis and evaluation							
Time management							
Understanding how we do business							

20. Are there any other skills which are considered to be very important in your workplace which have not been listed above?

Page 21

Skills and attributes: people with STEM qualifications

This question asks you to consider the skill level of those in your workplace with qualifications in STEM disciplines.

21. Overall, how would you rate the skill level of those in your workplace who have STEM qualifications for the following skills and attributes?

	Very good	Good	Acceptable	Poor	Very poor	Don't know	Not applicable
Active learning (i.e. learning on the job)	○	○	○	○	○	○	○
Complex problem-solving	○	○	○	○	○	○	○
Creative problem-solving	○	○	○	○	○	○	○
Critical thinking	○	○	○	○	○	○	○
Design thinking	○	○	○	○	○	○	○
Interpersonal skills	○	○	○	○	○	○	○
Knowledge of legislation, regulation and codes	○	○	○	○	○	○	○
Lifelong learning	○	○	○	○	○	○	○
Occupation-specific STEM skills	○	○	○	○	○	○	○
Programming	○	○	○	○	○	○	○
System analysis and evaluation	○	○	○	○	○	○	○
Time management	○	○	○	○	○	○	○
Understanding how we do business	○	○	○	○	○	○	○

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Skills and attributes: people with non-STEM qualifications

This question asks you to consider the skill levels of those in your workplace with qualifications in NON-STEM disciplines. If your workplace does not employ any people with NON-STEM qualifications, select 'not applicable'.

22. Overall, how would you rate the skill level of those in your workplace who have qualifications in non-STEM fields for the following skills and attributes?

	Very good	Good	Acceptable	Poor	Very poor	Don't know	Not applicable
Active learning (i.e. learning on the job)							
Complex problem-solving							
Creative problem-solving							
Critical thinking							
Design thinking							
Interpersonal skills							
Knowledge of legislation, regulation and codes							
Lifelong learning							
Programming							
System analysis and evaluation							
Time management							
Understanding how we do business							

Page 23

STEM qualified people in your workplace

Below are a series of general statements about people with STEM qualifications.

23. Based on your experiences of employing and/or recruiting people with STEM qualifications, how much do you agree or disagree with each of the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know	Not applicable
STEM qualified people are becoming increasingly valuable to my workplace	○	○	○	○	○	○	○
STEM qualified people are among our most innovative staff	○	○	○	○	○	○	○
STEM qualifications are valuable in my workplace even when their STEM qualification is not a prerequisite for their role	○	○	○	○	○	○	○
My workplace has difficulty recruiting people with STEM qualifications for technician and trade worker roles	○	○	○	○	○	○	○
My workplace has difficulty recruiting STEM graduates	○	○	○	○	○	○	○
STEM qualified people do not have good interpersonal skills	○	○	○	○	○	○	○
People with STEM qualifications are too specialised	○	○	○	○	○	○	○
People with STEM qualifications are able to adapt to changes in my business	○	○	○	○	○	○	○

Page 24

Recruitment of STEM qualified people

This section of the survey asks you about your workplace's general recruitment practices.

***24. Do you actively seek to employ people with STEM qualifications in your workforce?**

- Yes
- No
- Don't know

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Recruitment of STEM qualified people

25. When assessing the suitability of STEM qualified applicants for your workplace, how important are the following candidate attributes?

	Very important	Important	Moderately important	A little important	Not important	Don't know	Not applicable
Unpaid work experience							
Paid work experience							
Work experience of 12 weeks duration or less							
Work experience of a period longer than 12 weeks							
Work experience in this organisation							
Work experience in relevant industry							
Work experience in any industry							
Level of qualification (e.g. Certificate IV, Bachelors, Masters)							
Academic results							
Specific subject selection as part of education qualification							
Extracurricular activities (e.g. club membership, sporting teams)							
Interpersonal skills							
Understanding how we do business							
Occupation-specific STEM qualification							

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Recruiting recently qualified STEM people

This section of the survey will ask you about your recent experiences in recruiting, or attempting to recruit, people with STEM qualifications.

***26. In the past 12 months, has your workplace recruited, or attempted to recruit, any STEM qualified people with less than 5 years of experience?**

- Yes
- No
- Don't know

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Recruiting recently qualified STEM people

27. In the past 12 months, approximately how many positions has your workplace attempted to recruit STEM qualified people with less than 5 years experience into?

This includes positions where a STEM qualification was either a mandatory requirment, or a preferred qualification.

Managers	
Professionals	
Technicians and Trade Workers	
Other	
TOTAL	

28. For each occupation, approximately how many applications did your workplace receive for these positions in total?

Managers	
Professionals	
Technicians and Trade Workers	
Other	
TOTAL	

29. For each occupation, approximately how many of these positions did your workplace successfully fill?

Managers	
Professionals	
Technicians and Trade Workers	
Other	
TOTAL	

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30. Thinking about your experiences in recruiting STEM qualified people with less than 5 years experience, did you encounter any of the following issues? (tick all that apply)

- ☐ Lack of applications
- ☐ Shortage of STEM graduates
- ☐ Content of STEM qualifications are not relevant to business needs
- ☐ STEM qualified applicants are too specialised
- ☐ Lack of interpersonal skills
- ☐ Lack of understanding of how we do business
- ☐ Lack of general workplace experience
- ☐ Lack of practical experience/lab skills
- ☐ Other (please specify)

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Recruiting experienced STEM qualified people

This section of the survey will ask you about your recent experiences in recruiting, or attempting to recruit, experienced people with STEM qualifications (i.e. people with 5 or more years experience)

*** 31. In the past 12 months, has your workplace recruited, or attempted to recruit, any STEM qualified people with 5 or more years experience?**

- Yes
- No
- Don't know

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Recruiting experienced STEM qualified people

32. In the past 12 months, approximately how many positions has your workplace attempted to recruit STEM qualified people with more 5 years or more experience into?

This includes positions where a STEM qualification was either a mandatory requirement, or a preferred qualification.

Managers	
Professionals	
Technicians and Trade Workers	
Other	
TOTAL	

33. For each occupation, approximately how many applications did your workplace receive for these positions in total?

Managers	
Professionals	
Technicians and Trade Workers	
Other	
TOTAL	

34. For each occupation, approximately how many of these positions did your workplace successfully fill?

Managers	
Professionals	
Technicians and Trade Workers	
Other	
TOTAL	

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35. Thinking about your experiences in recruiting STEM qualified people with 5 or more years experience, did you encounter any of the following issues? (tick all that apply)

- ☐ Lack of applications
- ☐ Shortage of STEM graduates
- ☐ Content of STEM qualifications are not relevant to business needs
- ☐ STEM qualified applicants are too specialised
- ☐ Lack of interpersonal skills
- ☐ Lack of understanding of how we do business
- ☐ Lack of general workplace experience
- ☐ Lack of practical experience/lab skills
- ☐ Other (please specify)

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Future demand for STEM in your workplace

This section of the survey asks you to consider your future workforce demand for people with STEM qualifications.

36. Do you expect your workplace's requirements for people with STEM qualifications to increase, decrease, or remain about the same over the next 5-10 years?

	Increase	Decrease	About the same	Don't know	Not applicable/don't employ
Managers	○	○	○	○	○
Professionals	○	○	○	○	○
Technicians and Trades Workers	○	○	○	○	○
Other	○	○	○	○	○
TOTAL	○	○	○	○	○

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Future demand for STEM in your workplace

37. Do you expect your workplace's requirements for the following skills to increase, decrease or remain about the same over the next 5-10 years?

	Increase substantially	Increase	About the same	Decrease	Decrease substantially	Don't know	Not applicable
Active learning (i.e. learning on the job)	○	○	○	○	○	○	○
Complex problem-solving	○	○	○	○	○	○	○
Creative problem-solving	○	○	○	○	○	○	○
Critical thinking	○	○	○	○	○	○	○
Design thinking	○	○	○	○	○	○	○
Interpersonal skills	○	○	○	○	○	○	○
Knowledge of legislation, regulation and codes	○	○	○	○	○	○	○
Lifelong learning	○	○	○	○	○	○	○
Occupation-specific STEM skills	○	○	○	○	○	○	○
Programming	○	○	○	○	○	○	○
System analysis and evaluation	○	○	○	○	○	○	○
Time management	○	○	○	○	○	○	○
Understanding how we do business	○	○	○	○	○	○	○

Other (please specify)

Links with post-secondary educational institutions

This section of the survey asks about any links between your workplace and the post-secondary educational institution sector.

*** 38. Does your workplace currently have any links with post-secondary educational institutions?**

- Yes
- No
- Don't know

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Links with post-secondary educational institutions

39. Overall, how would you rate your workplace's level of involvement with post-secondary educational institutions against each of the following activities?

	Very high	High	Moderate	Low	Very low/nil	Don't know	Not applicable
Provision of work placements	○	○	○	○	○	○	○
Provision of work placements for academic credit	○	○	○	○	○	○	○
Provision of STEM apprenticeships	○	○	○	○	○	○	○
Provision of financial incentives, e.g. sponsorship for work placements	○	○	○	○	○	○	○
Engagement with post-secondary educational institutions to develop business-relevant STEM courses	○	○	○	○	○	○	○
Encouragement of employees to present seminars at educational institutions	○	○	○	○	○	○	○
Encouragement of employees to teach at educational institutions	○	○	○	○	○	○	○
Partnership with universities for research and innovation	○	○	○	○	○	○	○
Membership of subject or faculty level advisory board (e.g. engineering faculty board)	○	○	○	○	○	○	○
Membership of institution-wide advisory board	○	○	○	○	○	○	○
Development of research projects	○	○	○	○	○	○	○
Employment of students after completion	○	○	○	○	○	○	○

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Links with post-secondary educational institutions

40. How long have your relationships with post-secondary educational institution/s been in place?

	Less than 1 year	1 year to less than 3 years	3 years to less than 5 years	5 years to less than 10 years	10 years or more	Don't know	Not applicable
Provision of work placements	○	○	○	○	○	○	○
Provision of work placements for academic credit	○	○	○	○	○	○	○
Provision of STEM apprenticeships	○	○	○	○	○	○	○
Provision of financial incentives, e.g. sponsorship for work placements	○	○	○	○	○	○	○
Engagement with post-secondary educational institutions to develop business-relevant STEM courses	○	○	○	○	○	○	○
Encouragement of employees to present seminars at educational institutions	○	○	○	○	○	○	○
Encouragement of employees to teach at educational institutions	○	○	○	○	○	○	○
Partnership with universities for research and innovation	○	○	○	○	○	○	○
Membership of subject or faculty level advisory board (e.g. engineering faculty board)	○	○	○	○	○	○	○
Membership of institution-wide advisory board	○	○	○	○	○	○	○
Development of research projects	○	○	○	○	○	○	○
Employment of students after completion	○	○	○	○	○	○	○

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Links with post-secondary educational institutions

41. Overall, how satisfied are you with your relationships with post-secondary educational institution/s?

	Very Satisfied	Satisfied	Neither satisfied nor unsatisfied	Not satisfied	Very unsatisfied	Don't know	Not applicable
Provision of work placements							
Provision of work placements for academic credit							
Provision of STEM apprenticeships							
Provision of financial incentives, e.g. sponsorship for work placements							
Engagement with post-secondary educational institutions to develop business-relevant STEM courses							
Encouragement of employees to present seminars at educational institutions							
Encouragement of employees to teach at educational institutions							
Partnership with universities for research and innovation							
Membership of subject or faculty level advisory board (e.g. engineering faculty board)							
Membership of institution-wide advisory board							
Development of research projects							
Employment of students after completion							

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Links with post-secondary educational institutions

42. Are there any reasons why your workplace does not have links with post-secondary educational institutions? (tick all that apply)

- ☐ We haven't been approached by post-secondary educational institutions
- ☐ Our approaches to post-secondary educational institutions have not been successful
- ☐ It would take too much of our time to develop these relationships
- ☐ We are satisfied with the quality of education being provided by the post-secondary educational institutions sector
- ☐ We don't hire graduates
- ☐ We don't know how to approach post-secondary educational institutions
- ☐ We have never considered approaching post-secondary educational institutions
- ☐ Other (please specify)

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Work placements

Structured work placements of post-secondary educational institution students allow them to gain experience with an employer while gaining credit towards their qualification.

*** 43. Does your workplace participate in structured work placements?**

- Yes
- No
- Don't know

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Work placements

44. Could you please specify approximately how many work placement students you take each year?

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Work placements

45. If a grant were available to cover some of the costs of structured work placements, how many students would you take per year? Please enter '0' if you would not take any students.

Higher degree by research

We are interested in how higher degrees by research are delivered in Australia.

*** 46. Do you have any views on STEM Research Masters and/or PhDs Doctorates?**

- Yes
- No
- Don't know

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PhDs/Doctorates

*** 47. Do you employ people with PhDs/Doctorates in Science, Technology, Engineering or Mathematics?**

- Yes
- No
- Don't know

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PhDs/Doctorates

48. What are some of the reasons your workplace does not employ people with PhD/Doctorate qualifications in STEM fields? (tick all that apply)

- ☐ PhD/Doctorate qualification is not required for the role
- ☐ PhD/Doctorate holders don't have the skills we are looking for
- ☐ PhD/Doctorate holders have limited practical experience
- ☐ PhD/Doctorate holders have higher turnover rates than staff with lower level qualifications
- ☐ PhD/Doctorate holders don't have interpersonal skills that we require
- ☐ PhD/Doctorate holders don't have the attitude we require
- ☐ PhD/Doctorate holders don't have the business knowledge that we require
- ☐ PhD/Doctorate holders focus is too narrow
- ☐ PhD/Doctorate holders wage expectations are too high
- ☐ Don't know
- ☐ Other (please specify)

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PhDs/Doctorates

49. What roles do people with PhD/Doctorate qualifications in STEM fields undertake in your workplace? (tick all that apply)

- [ ] Administration
- [ ] Clinical trials/Experiments
- [ ] Commercialisation/Innovation
- [ ] Leadership/Management
- [ ] Professional services
- [ ] Research and development
- [ ] Sales
- [ ] Technical roles
- [ ] Don't know
- [ ] Other (please specify)

50. What skills and capabilities would you expect from people with STEM PhDs/Doctorates? Are those expectations currently being met?

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Research Masters

***51. Do you employ people with Research Masters in Science, Technology, Engineering or Mathematics?**

- Yes
- No
- Don't know

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Research Masters

52. What are some of the reasons your workplace does not employ people with Research Masters in STEM fields? (tick all that apply)

- ☐ Research Masters level qualification is not required for the role
- ☐ Research Masters holders don't have the skills we are looking for
- ☐ Research Masters holders have limited practical experience
- ☐ Research Masters holders have higher turnover rates than staff with lower level qualifications
- ☐ Research Masters holders don't have interpersonal skills that we require
- ☐ Research Mastersholders don't have the attitude we require
- ☐ Research Masters holders don't have the business knowledge that we require
- ☐ Research Masters holders focus is too narrow
- ☐ Research Masters holders wage expectations are too high
- ☐ Don't know
- ☐ Other (please specify)

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Research Masters

53. What roles do people with Research Masters qualifications in STEM fields undertake in your workplace? (tick all that apply)

- ☐ Administration
- ☐ Clinical trials/Experiments
- ☐ Commercialisation/Innovation
- ☐ Leadership/Management
- ☐ Professional services
- ☐ Research and development
- ☐ Sales
- ☐ Technical roles
- ☐ Don't know
- ☐ Other (please specify)

54. What skills and capabilities would you expect from people with STEM Research Masters? Are those expectations currently being met?

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Method of teaching

55. Based on your experience employing STEM qualified people, what teaching methods do you think are most effective and why?

For example, face to face, tutorials, online, lectures, field work, practicals, work placement.

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Future research

Thank you for all of your responses so far.

These final questions are about our future contact with you, and any final comments that you may have.

*** 56. Do you give consent for the Office of the Chief Scientist to contact you in the future for further input into this project?**

- No, thanks
- Yes, you can reach me on the following details (please provide your name, email and phone number)

Please note that your contact details will not be linked in any way to the responses that you have provided as part of this survey.

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Final comments

57. Would you like to make any other comments about the topics covered in this survey, and do you have any suggestions for future research or ideas to promote STEM in Australia?

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Thank you

Chief Scientist

Thank you very much for providing us with a valuable insight into what your organisation's needs are in relation to the hiring and utilisation of people with STEM qualifications.

If you feel that this research would be of any interest to your industry colleagues, please direct them to https://surveymonkey.com/s/STEMsurveylink. We would greatly appreciate their input.

Results from this research will be published on the Office of the Chief Scientist website (www.chiefscientist.gov.au) in early 2014.

In the meantime, if you have any questions please email STEMresearch@deloitte.com.au.

Thank you.

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