The Australian Industry Group

Progressing STEM Skills in Australia

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AiGROUP

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Executive Summary

The imperative for the growth of STEM skills in the economy is even greater today than when the Ai Group first drew attention to this issue two years ago. Fresh data has arrived, including for Australia, which strengthens the case for action.

The Australian Bureau of Statistics has reported that STEM skills jobs grew at about 1.5 times the rate of other jobs in recent years – by 14% compared to 9% between 2006 and 2011. About 18% of the Australian workforce has STEM qualifications with design, engineering, science and transport professionals and ICT professionals the fastest growing occupations.

Despite this need, Australia's performance internationally lags behind many other comparable countries which are improving their provision, participation and performance more rapidly than us.

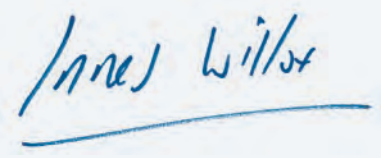
Our own Survey of Workforce Development Needs 2014 updates what employers are saying to us. As was the case two years ago, almost 44% of employers continue to experience difficulties recruiting STEM qualified technicians and trade workers. The main barriers are a lack of qualifications relevant to the business (36%) and a lack of employability skills and workplace experience (34%).

The pipeline of STEM skills to the workforce remains perilous. In the school system participation in science and advanced mathematics is in decline and our students underperform in all the major international studies.

In the tertiary education sector, participation in STEM-related disciplines is in decline in absolute terms and in comparison with other comparable nations. Participation is also low in the VET sector in all STEM areas except engineering.

Now is the time for action. At the centre of this is a need for a national STEM strategy – a key feature of all STEM-strong economies. We need co-ordinated efforts to increase education participation in concert with industry. Ai Group with support from the Office of the Chief Scientist has commenced a strategic school – industry STEM partnership to assist in this area. We need a greater focus on developing engaging and integrating curriculum as well significantly expanding our STEM-qualified teaching workforce. The data is in. We have the knowledge. Now it is time to act for Australia to become a strong STEM economy.

Innes Willox



Chief Executive
Australian Industry Group

KEY POINTS

- STEM skills are increasingly important for the competitiveness of the Australian economy.
- Australia is under-performing internationally compared to STEM strong countries.
- STEM skills are increasingly important to the Australian workforce.
- Participation by primary and secondary school students in STEM related subjects is decreasing and performance is below many countries in terms of international comparisons.
- Participation by university students in STEM related disciplines is not keeping pace with the needs of the economy and is low compared to other like-economies.
- Employers report significant difficulties recruiting technicians and trades workers with STEM skills.
- Those employers that promote STEM skills most commonly do so through work placements, work experience and internships.
- Australia, unlike many other comparable countries, still lacks a national STEM skills strategy driven in concert with industry.
- School – industry STEM initiatives are characterised by un-coordinated and non-systemic activity.
- University – industry collaboration, including STEM fields, is low by international comparison.
- Commonwealth financial assistance to STEM is thinly dispersed, non-systemic and does not contribute to a national approach.
- There is a need to develop more engaging school curriculum and pedagogy to attract students to STEM.
- There is a need to increase the qualified STEM teaching workforce.

Recommendations

National Strategy

1 There is an urgent need to develop a national STEM skills strategy to lift the level of STEM qualified employees in the workforce to enable the Australian economy and be more competitive and prosperous.

STEM in the Schooling Sector

2 A range of strategies are required to raise the participation of school students and industry in STEM related programs and activities.

- The expansion of school-based STEM activity needs to occur in a co-ordinated manner and in conjunction with increased industry participation.
- Schools need to be provided with co-ordinated assistance to enable STEM elements to be taught in an integrated manner utilising practical teaching pedagogies and programs.
- There needs to be an extension of support in relation to the recruitment, pre-service training and in-service professional development to raise the qualifications of the STEM teaching profession to enable them to more effectively deliver STEM curriculum and programs.
- Examine the Pathways in Technology Early College High School (P-TECH) model developed in the United States for its applicability in the Australian schools context.

STEM in the Higher Education Sector

3 Implement strategies that encourage expanded participation by undergraduates in STEM related disciplines.

4 Implement a nationally co-ordinated expansion of Work Integrated Learning in STEM disciplines in conjunction with employers through peak industry bodies and Universities Australia.

STEM in the Vocational Education and Training Sector

5 Develop strategies to build numeracy skills to support STEM fields of study in the VET sector.

Resourcing

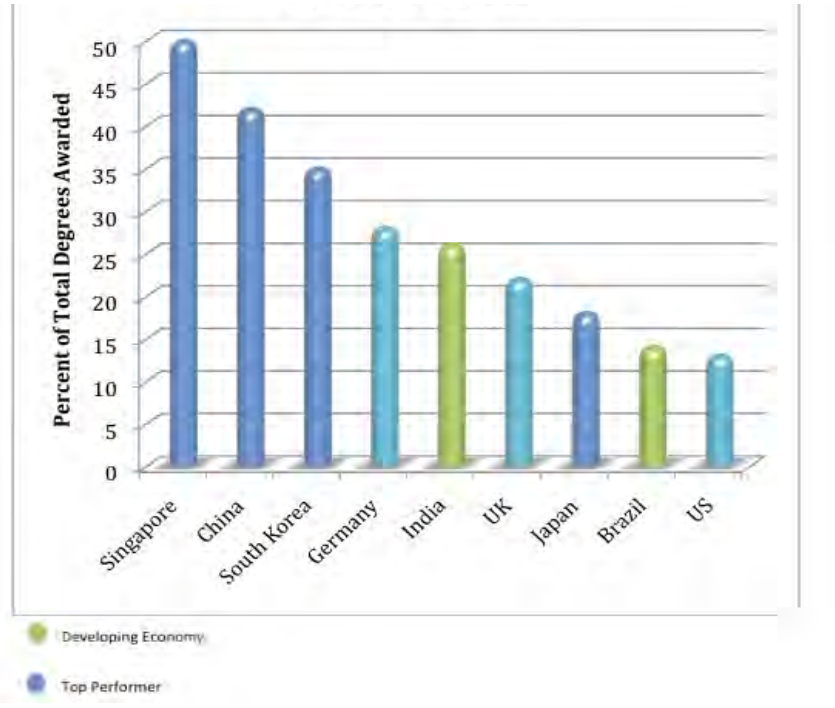
6 Australian Government financial support for STEM related activity needs to maximise opportunities to contribute to a co-ordinated national approach.

The imperative of STEM skills

STEM refers to science, technology, engineering and mathematics. The basic contributors to healthy STEM are research, international engagement and education. Specifically, education prepares a skilled and dynamic STEM workforce and sets the foundation for lifelong STEM literacy in the community.[1]

The importance of STEM disciplines for the future economic and social well-being of Australia cannot be underestimated. International research indicates that 75 per cent of the fastest growing occupations require STEM skills and knowledge.[2] In the US STEM employment grew three times more than non-STEM employment over the past twelve years and is expected to grow twice as fast by 2018.[3] In Europe there are predictions of a shortage of between 380,000 and 700,000 ICT workers.[4]

Chart 1: STEM degrees as a percentage of all degrees (selected countries) 2011*



Singapore has nearly 50 per cent of STEM degrees as a percentage of the total and China has significantly expanded its investment in STEM so that it has become the second largest Research and Development investor in the world. 41 per cent of all degrees awarded by Chinese institutions in 2011 were in a STEM subject, almost twice the proportion in the UK and three times the rate in America.[5]

India and Brazil are pursuing the same goal. Accenture has predicted that Brazil will increase its engineering graduates by 68 per cent by 2015 and produce more PhD engineers than the US by 2016.[6]

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* "Statistic of the Month: Investigating the Skills Mismatch, Center on International Education Benchmarking, July 31, 2012.
1 Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, November 2014.
2 Becker, K. and Park, K.; Effects of integrative approaches among STEM subjects on students' learning, Journal of STEM Education 12, July – September 2011.
3 The global race for STEM skills, The Observatory on Borderless Higher Education, January 2013.
4 The global race for STEM skills, The Observatory on Borderless Higher Education, January 2013.
5 No Shortage of Talent: How the Global Market is Producing the STEM Skills Needed for Growth, Accenture Institute for High Performance, September 2011.
6 No Shortage of Talent: How the Global Market is Producing the STEM Skills Needed for Growth, Accenture Institute for High Performance, September 2011.

The Office of the Chief Scientist has estimated that 65 per cent of economic growth per capita from 1964 to 2005 is due to improvements in the use of capital, labour and technological innovation made possible in large part by STEM.[7] The Australian Bureau of Statistics (ABS) released a report Perspectives on education and training: Australians with qualifications in science, technology, engineering and mathematics (STEM), 2010-11 demonstrating that STEM skills jobs such as scientists, ICT professionals and engineers, grew about 1.5 times the rate of other jobs in recent years.

"The number of people in jobs commonly held by workers with science, technology, engineering and mathematics (STEM) qualifications grew by 14 per cent between 2006 and 2011. This compares with only nine per cent growth for other jobs. Many people have caught on with the trend, with around 2.1 million workers in Australia having STEM qualifications in 2010-11."[8]

This represents about 18 per cent of the Australian workforce and the occupations that showed the highest growth between 2006 and 2011 were design, engineering, science and transport professionals (23 per cent) and ICT professionals (19 per cent).

Of those employees with university level STEM qualifications, 75 per cent were employed in higher skill jobs such as Professionals or Managers. However, those with vocational level STEM qualifications fared differently, with 41 per cent working as Technicians and trades workers and 25 per cent working as Managers or Professionals.

To recognise and take full advantage of the opportunities which STEM provides, Australia will benefit most if there is widespread and general STEM literacy throughout the community, complementing the deep expertise of STEM practitioners.[9]

What is the current situation?

… in international comparisons

Investment in STEM disciplines is increasingly seen in the US and Europe as a means to increase innovation. Countries strong in STEM have certain common features:

- School teachers enjoy high esteem, are better paid and work within meritocratic career structures, eg, Finland and China;
- Countries have unbreakable commitment to disciplinary contents – focus on STEM knowledge, teachers are expected to be fully qualified;
- Active reform programs in curriculum and pedagogy focussed on making science and maths more engaging and practical, eg, Korea and Japan;
- Developed innovative programs to lift STEM participation among formerly excluded groups eg Finland focus on low-achievers, indigenous STEM education in Canada;
- Developed strategic national STEM policy frameworks with centrally driven and funded programs, world class university programs, partnerships and engagement that link schools, vocational and higher education with industry.[10]

7 Science, Technology, Engineering and Mathematics: Australia's Future, Office of the Chief Scientist, September 2014, page 7.
8 Media Release, Qualifications paying off in science, technology, engineering and maths, Australian Bureau of Statistics, 24 February 2014.
9 Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach, Office of the Chief Scientist, July 2013.
10 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 15.

Notwithstanding the rapidly growing importance of STEM skills, Australia has under-performed in this area as reported in the major ACOLA international study:

" … the news is good but not great. Australia has travelled fairly well until now, but there are holes in capacity and performance. Further, many other countries are improving STEM provision, participation and performance more rapidly than us."[11]

These skills are critical for Australia's national productivity and global competitiveness.

… in the workplace

The gap between the knowledge generated in the education system and the skills demanded by employers and individuals is widening. A recent research report about the readiness of five growth industries to meet their demand for skills concluded:

"Australia's science, technology, engineering and mathematics capability must improve, not only at entry level in these industries but through continuing professional education. The current emphasis in public funding on entry-level training can work against the need to refresh STEM skills and potentially inhibits readiness to meet demand for growth in all industries."[12]

The most recent ACOLA report has urged education providers to engage with business to gain a better understanding of trends in STEM skill needs.[13]

The Office of the Chief Scientist has also highlighted that over 70 per cent of employers considered their STEM staff as among their most innovative and with 82 per cent agreeing that employees with STEM skills are valuable to the workforce.[14] Further, 45 per cent of employers expect that their workforce requirements for STEM-qualified employees will increase over the next five to ten years. The same report indicated that 40 per cent of employers had difficulty filling technician and trade worker roles in STEM fields and 32 per cent had difficulty recruiting professionals and managers.

Ai Group research through the Survey of Workforce Development Needs 2014 has produced similar results.

There is a further issue in relation to women in the workforce.

"Women and girls are under-represented in STEM fields throughout their education and career."[15]

The participation of women in STEM employment in 2008 was 45.1 per cent, only a small increase of 2.8 per cent from 1992 especially in relation to other areas of employment. Accordingly, women are an under-utilised resource in the workforce and could provide a larger talent pool from which to draw STEM employees.[16]

… in the schools

As well as difficulties within the workforce there are problems in the pipeline from schools and tertiary education institutions into the workforce. Despite attempts by governments over the last decade to increase school student participation in STEM the proportion of students commencing in STEM has flat-lined at around 10 per cent or less.[17] A decreasing number of students are participating in mathematics. This can be a feature of education systems like Australia's where mathematics is not compulsory until the end of school unlike China, Russia and some European countries.[18]

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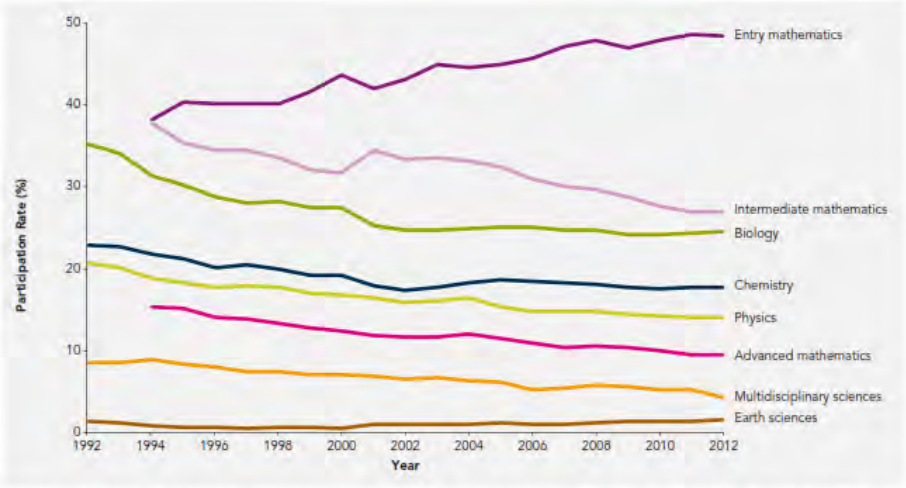
11 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 15.
12 Francesca Beddie et al., Readiness to meet demand for skills: a study of five growth industries, NCVER Research Report, 2014, page 27. The growth industries in question are food and agriculture, biotechnology and pharmaceuticals, advanced manufacturing, mining equipment and oil and gas.
13 The role of science, research and technology in lifting Australia's productivity, Australian Council of Learned Academies, June 2014.
14 STEM skills in the workforce, Office of the Chief Scientist, forthcoming.
15 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 134.
16 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, pages 137 -140.
17 Australia's skills and workforce development needs, Discussion Paper, Australian Workforce and Productivity Agency, July 2012.
18 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 14.

The state of mathematics and science in schools has deteriorated to a 'dangerous level' according to a review commissioned by the Vice-Chancellors of Australia's eight research-intensive universities. The number of students undertaking intermediate and advanced mathematics in secondary school fell by 34 per cent over the past 18 years[19]. Students may select the easier option of General Mathematics in the belief that this will contribute to a higher ATAR for university entrance. In response to this the ACOLA report makes a series of recommendations about mathematics advocating consideration of some element of compulsion.[20]

Ai Group has drawn attention to the unacceptably low level of participation by secondary school students in STEM related areas of knowledge and skills.[21] The Office of the Chief Scientist has documented the decline in the proportion of Year 12 students undertaking mathematics and science since 1992.

Chart 2: Year 12 Mathematics and Science Participation Rates 1992 - 2012[22]



Note: Figure shows the number of students taking a course in science or mathematics as a proportion of the total year 12 population (Kennedy et al. 2014). Students can elect to take one or more science subjects and in some jurisdictions one or more mathematics levels and so may be counted more than once.

Despite increasing levels of Year 12 enrolments, the participation rates in physics, chemistry and biology have all declined. Participation in mathematics has been divided into different categories. Participation in entry mathematics (including subjects not designed to lead to further tertiary study) has increased over the period. However, participation rates in intermediate mathematics and advanced mathematics have both declined.

There are particular concerns in regard to school student performance in mathematics. The 2011 Trends in Mathematics and Science Study (TIMSS) indicates that Australia's performance in mathematics and science has stagnated over the past 16 years.[23] Within this international research 17 countries recorded significantly higher results than Australia in mathematics for Year 4 students including most of the Asian countries, England and the United States. Of particular concern is the result that 30 per cent of Australian Year 4 students were achieving at the low international benchmark or not achieving at least at this level.[24]

The latest PISA results also present a bleak picture. The mathematics skills of 15 year olds have slipped back and 16 countries achieved significantly higher results than Australia. Australia's mean

19 Dealing with Australia's Mathematical Deficit, Australian Mathematical Sciences Institute, May 2014.
20 Ibid, page 20.
21 Lifting our Science, Technology, Engineering and Maths (STEM) Skills, Australian Industry Group, 2013.
22 Mathematics, Engineering and Science in the National Interest, Office of the Chief Scientist, May 2012, page 19. Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, November 2014, page 100.
23 Sue Thompson et al., Highlights from TIMSS and PIRLS 2011 from Australia's perspective, Australian Council for Educational Research, 2012.
24 Sue Thompson et al., Highlights from TIMSS and PIRLS 2011 from Australia's perspective, Australian Council for Educational Research, 2012.

mathematical literacy performance declined significantly between PISA 2003 and PISA 2012 by the equivalent of more than a half year of schooling.[25] The results indicate that 42 per cent of the students failed to reach the national baseline proficiency level in mathematical literacy.[26] In relation to scientific literacy Australia's mean score changed little in absolute and relative terms between 2006 and 2012.[27]

There are particular concerns about the low levels of participation by girls in STEM-related subjects. The Australian Mathematical Sciences Institute has drawn attention to the low female enrolments in Year 11 and 12 mathematics and the 30 per cent undergraduate and post-graduate enrolment level.[28]

In addition to concern about the levels of participation, there are further concerns about pedagogy. A report from Universities Australia highlighted a number of concerns in relation to secondary education including:

- "in too many schools STEM is still mostly science and mathematics taught separately with little or no attention to technology and engineering"
- "Students need to be made aware of the career opportunities afforded to STEM graduates at an earlier age rather than just years 11 and 12.[29]

The impact of this decline is compounded by the lack of qualified teachers.[30] This was also reported in the TIMSS study where more than 20 per cent of Year 8 students were being taught mathematics by teachers who were only 'somewhat' confident about teaching the subject.[31] A 2011 study by the Australian Council for Education Research found that for years 7 – 10 mathematics teaching, only 62 per cent of teachers had two or more years of tertiary mathematics (the minimum requirement). More than a third were teaching out of field and 23 per cent had no tertiary mathematics at all.[32] This is related to the low ATAR scores required for entry into teaching.

The ACOLA report recommends the reintroduction of more comprehensive prerequisite requirements for university entrance to encourage greater secondary school student participation in STEM subjects.[33] Further,

"despite the plethora of government policies and reviews focused on education, and science and innovation and the relatively recent emergence of the STEM agenda in Australia, the 'pipeline' is decreasing and there are serious questions about performance in the foundation skills of literacy and numeracy, and the enabling sciences, mathematics and scientific literacy."[34]

However, as the Chief Scientist has recently reported:

"State and territory governments all design and fund a patchwork of programmes relevant to STEM – from school through to vocational and tertiary institutions, and in business and industry. They may, or may not, align with the effort of federal investment in education, innovation or research and development."[35]

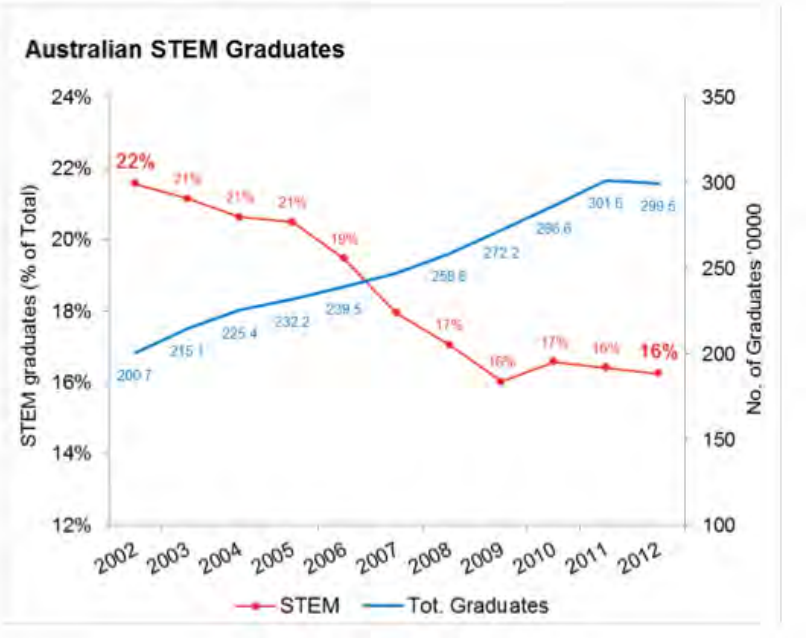
25 MEDIA RELEASE, 3rd December 2013, Latest PISA results 'cause for concern', says ACER.
26 ACER FACT SHEET, Selected results from PISA 2012, 3 December 2013
27 As reported in Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, November 2014, page 93.
28 Media release, Dealing with Australia's mathematical deficit, Australian Mathematical Sciences Institute, 7 August 2014.
29 Universities Australia, STEM and non-STEM First Year Students, January 2012.
30 http://www.theaustralian.com.au/news/nation/mathematics-students-in-serious-decline, March 10, 2010.
31 MEDIA RELEASE, 13th December 2012, ACER releases results from latest international studies of student achievement.
32 As reported in STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 17.
33 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 20.
34 Ibid, page 51.
35 Science, Technology, Engineering and Mathematics: Australia's Future, Office of the Chief Scientist, September 2014, page 10.

… in the tertiary education sector

Higher education plays a crucial role in the provision of STEM qualifications as an entrance to workforce roles.

"Without the training, research and development role of the higher education sector, it would be difficult to develop a workforce capable of STEM-based innovation."[36]

Chart 3: Australian STEM Graduates

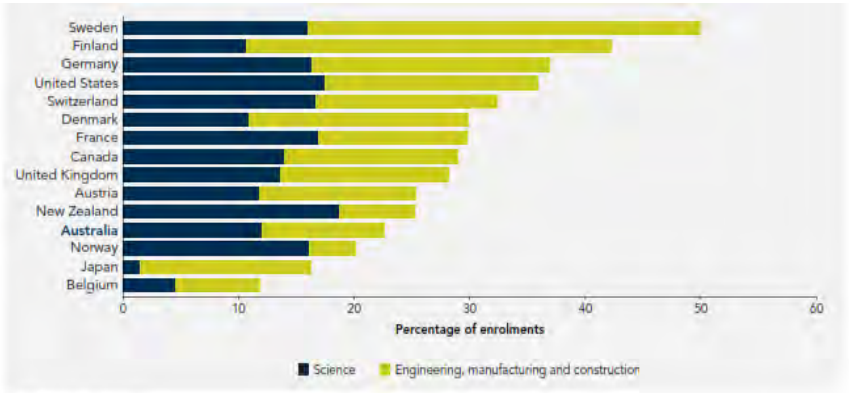


However, Australia has a declining rate of STEM-related course completions which have decreased over the past 10 years from 22 per cent to 16 per cent. The situation is similar for doctoral graduates with eight comparator countries performing better than Australia.[37] The most recent report from the Office of the Chief Scientist indicates that the proportion of tertiary students with first degrees in STEM is only 10.6 per cent. As an international comparison with 11 Western European countries, the United States and Canada (that is, like-economies) there are 11 countries above Australia in this regard.[38] So while Australia has a relatively high rate of per capita enrolments in higher education there is less emphasis on STEM. Australia sits in the middle of comparator countries for undergraduate degrees (see Chart 4).

In the earlier ACOLA report student participation in STEM-related study in the Vocational Education and Training sector was measured.[39] Results indicate that 195,000 effective full time VET students were enrolled in STEM disciplines which represents 29.9 per cent of all VET EFT enrolments.[40] Over half of these were in the engineering and related technologies area (16.9 per cent), whereas agriculture, environmental and related studies (4.8 per cent), information technology (2.7 per cent) and natural and physical sciences (0.7 per cent) have much lower levels of participation.[41]

36 Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, November 2014, page 76.
37 Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, November 2014, pages 84 – 85.
38 Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, November 2014.
39 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, pages 42 – 45.
40 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 44.
41 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, pages 44 – 45.

Chart 4: Distribution of student enrolments in first degrees in tertiary education: science and engineering, manufacturing and construction, selected countries 2009



Source: OECD (2011).

What are employers saying?

Employers have expressed their views via the Ai Group's Survey of Workforce Development Needs 2014. Employers were asked whether they had experienced difficulty recruiting individuals with STEM skills in the past 12 months and also what is expected in the next 12 months. The results are summarised in Chart 5.

Chart 5: Difficulties recruiting staff with STEM skills

The largest category by far where difficulties were experienced was technicians and trade workers. Almost 44 per cent experienced difficulty in the past year and over 45 per cent expected difficulties in the next 12 months. This was also the largest area in the previous 2012 survey.

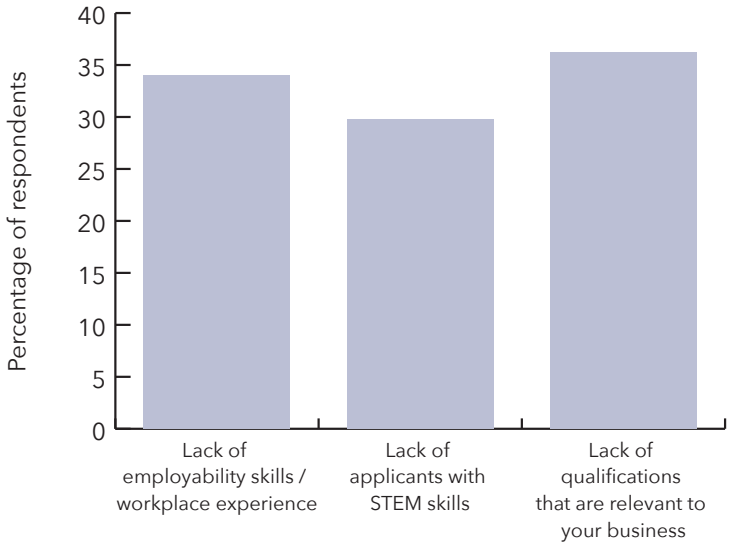
In terms of the past 12 months machinery operators and drivers (24.5 per cent), sales workers (24.1 per cent), labourers (20.3 per cent) comprise the next largest groupings experiencing difficulties. These difficulties are expected to decrease slightly in the next 12 months for sales workers (20.5 per cent) and machinery operators and drivers (19.8 per cent), whereas labourers (22.1 per cent) expect a slight increase.

The results for professionals and managers were very similar. The difficulty experienced concerning professionals in the past 12 months was 21.3 per cent and for managers 19.4 per cent. Both expect a small decrease to 17.1 per cent in the next 12 months. These results represent a decrease on the 2012 survey results where the difficulty for professionals was 26.6 per cent and for managers 26.3 per cent.

Clerical and administrative workers (12.1 per cent) and especially community and personal service workers (2.9 per cent) experienced the lowest levels of difficulties.

Employers were also asked for the reasons they had experiencing difficulty. These results are reported in Chart 6.

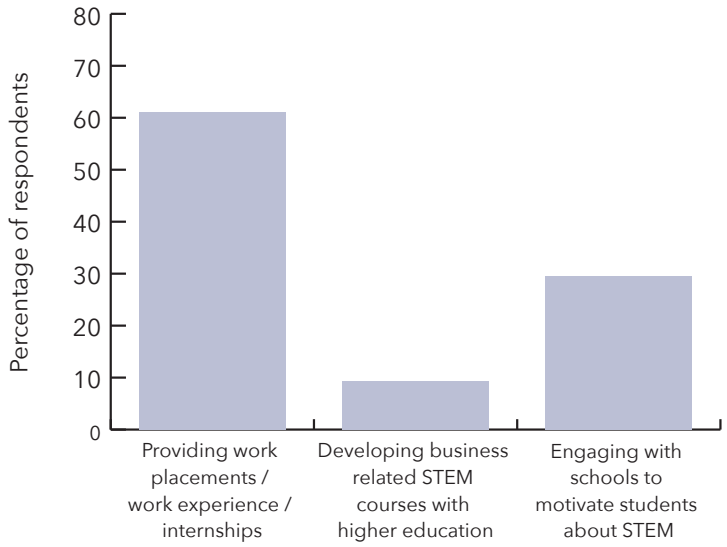
Chart 6: Barriers to recruiting staff with STEM skills



All three of the provided options received significant responses. A lack of qualifications relevant to the business (36.2 percent) was the largest response. Lack of employability skills and workplace experience (34 per cent) and a lack of applicants with STEM skills (29.7 per cent) were the other results. A lack of relevant qualifications has doubled since the 2012 employer survey, a lack of employability skills and workplace experience have also increased in size and a lack of applicant with STEM skills has remained about the same.

Finally employers were asked to what extent STEM skills were promoted by undertaking a series of actions. Of those employers who responded to this question the results are reported in Chart 7.

Chart 7: Business promotion of STEM skills



By far the largest response was through the provision of work placements, work experience and internships (61.1 percent). Engaging with schools to motivate students was also a significant response (29.5 per cent) but developing business related STEM courses with higher education was a relatively small response (9.3 per cent).

What needs to be done?

The urgent need for a national STEM strategy

A key national response to the emergence of STEM skills related issues is the need for a national strategy in this policy area. Engineers Australia has noted:

"Industry groups, professional bodies and the chief scientist have all called for a national STEM strategy that will encourage children's interest in engineering and ultimately ensure a vibrant and economic future for this country."[42]

The Chief Scientist called for the establishment of national strategy in July 2013 with the release of Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach. This was further supported with the release of Science, Technology, Engineering and Mathematics: Australia's Future in September 2014. This later publication reiterates the need for a national strategy and advocates a strategic approach to STEM.

Among the key arguments is a comparison of Australia's performance with other like-countries. The Chief Scientist has on a number of occasions drawn attention to the fact that Australia is the only country among the members of the OECD without a science or technology strategy.[43] Beyond this a number of countries including the United Kingdom, the European Union, Canada, the United States, China and South Korea have prioritised investment in science as an important foundation for future sustained growth.[44]

42 Desi Corbett, Where is Australia's national STEM strategy?, Engineers Australia, April 2014.
43 See for example Ian Chubb, Australia needs a strategy, science.org, 29 August 2014.
44 Media Release, Chief Scientist, Science – the platform to build sustained growth, 13 May 2014.

As well as this there is a distinct lack of urgency in Australia to address this problem. The Chief Scientist has reported:

"Around the world there is a sense of urgency – a need to improve a nation's capacity and a commitment not to take the future for granted or to presume that past practice will be good enough."[45]

The Confederation of Business and Industry in the UK also makes the case for increased urgency:

"We have made real progress on STEM uptake in the last decade – but there is much more to do. These skills are central to the sectors that must be the anchors of our economy. A new urgency is required – in terms of both the existing and future workforce."[46]

To date the response of the Australian Government has been minimal. In relatively recent times the Commonwealth Science Council has been established with terms of reference that include the provision of advice to the Government on:

"a strategic and whole-of-government approach to all aspects of science, technology, engineering, mathematics and innovation."[47]

This provides the opportunity to advance a national strategy although the Council is only scheduled to meet twice a year. This does little to contribute to the urgency of the strategy development. In the interim, work will be referred to the National Science, Technology and Research Committee which will report to the Council.

Given the importance of STEM skills to the economy and our future prosperity together with increasing concerns from industry about the state of STEM skills in the workforce, it is time for the urgent development of a national STEM skills strategy. As already noted strong STEM countries have strategic national policy frameworks with centrally driven and funded programs.[48]

Co-ordinated school education – industry STEM initiatives

Given the deteriorating participation by students in schools and universities in STEM-related study and the state of STEM skills in the workforce, there is a need for a co-ordinated expansion of activity in this area. Australia does not want from a number of initiatives or programs; the issue is rather that these programs are often ad hoc and do not contribute to a national strategy. There may well be a need for a common platform for all programs.

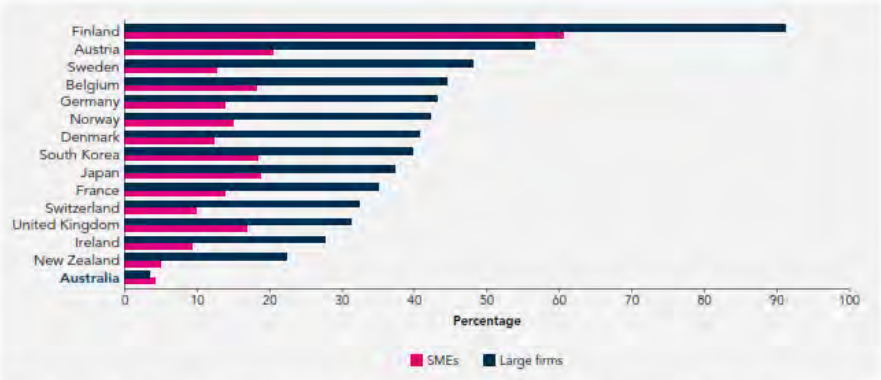
In relation to school-based STEM programs the Ai Group and the Office of the Chief Scientist are working together in a new initiative – Strengthening School – Industry STEM Skills Partnerships.[49] This project has a number of aims including the mapping and documentation of existing school – industry partnerships in this area with a view to developing transferable model(s) of this practice. This will form the basis of expanding this activity on a number of levels through a pilot program on a nationally co-ordinated basis. The program will focus on sustainability and develop approaches to long-term funding of this activity.

45 Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach, Office of the Chief Scientist, July 2013, page 9.
46 Engineering our future: Stepping up the urgency on STEM, CBI, March 2014.
47 www.chiefscientist.gov.au/2014/11/commonwealth-science-council
48 STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 15.
49 This project will be conducted throughout 2015 and 2016.

Co-ordinated tertiary education – industry STEM initiatives

What is also required is a similar approach to tertiary education and industry partnerships in the STEM area. This is required to assist with the expansion of STEM-related courses in both higher education and VET providers in conjunction with industry. Related to this is the relatively low level of university – industry collaboration in Australia. Australia has the lowest level of business to research collaboration among comparator countries. Australia ranks 32nd out of 33 OECD countries for SMEs and last for large enterprises; this is about 4 per cent of large firms. This compares, for example, with Sweden (5th) where the figure is 50 per cent of large firms and the UK (19th) where it is about 30 per cent.[50]

Chart 8: Industry – Higher Education and Research Institutions Collaboration on Innovation 2008 - 2010



Notes: By OECD classifications, firms with 10–250 employees are considered SMEs, and firms with more than 250 employees are large firms. Where no data were available for 2008–2010, other years are displayed: Australia 2010–2011, New Zealand 2009–2011, Ireland 2006–2008, Switzerland 2009–2011, Japan 2009–2010 and South Korea 2005–2007.

Source: OECD 2011b.

Further, some 60 per cent of all researchers in Australia are based in higher education and a further 10 per cent in research agencies. Only 30 per cent of Australian researchers are in industry compared with 80 per cent in the United States, 70 per cent in Japan and 64 per cent in Switzerland.[51] Further industry – higher education collaboration in STEM skills is a powerful mechanism for increasing industry – university collaboration overall.

In a related policy area greater collaboration would be enhanced by an expansion of work placement opportunities in industry for undergraduates. This could be achieved through more effective communication of Work Integrated Learning to industry and its subsequent expansion of implementation as highlighted in a number of recent reports.[52]

Further consideration also needs to be given to STEM skills emerging from the VET sector. The largest area of STEM skill shortages identified by employers occurs in technicians and trade workers and strategies need to be developed to address this. One such measure worthy of investigation is the provision of incentives to employers and students participating in apprenticeships and traineeships (especially ICT skills) in STEM sills areas.

50 Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, November 2014, page 30.
51 Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach, Office of the Chief Scientist, July 2013, page 8.
52 See for example Engaging Employers in Work Integrated Learning: Current State and Future Priorities, PhillipsKPA report to the Department of Industry, September 2014; Work Integrated Learning in STEM in Australian Universities, Australian Council for Educational Research, December 2014; and Work Integrated Learning in STEM disciplines: employer perspectives, NCVER, December 2014.

Increased Strategic Commonwealth Budget support

At the time of the announcement of the formation of the Commonwealth Science Council there was a $12 million investment in STEM education through the Government's Industry Innovation and Competitiveness Agenda.[53] This was part of the earlier Budget allocation of $9.2 billion in 2014 – 15 as an investment in science, research and innovation across 115 line items and across 15 different portfolios.[54] The investment is characterised by expenditure of less than $10 million per year on a line item. Some 87 per cent of the total funding is invested in less than 20 line items.[55] So there is considerable activity but investment of public funding requires a systematic approach to maximise return.[56] There is now an opportunity to maximise the benefits of any STEM skills investment to advance a national approach in this area.

Development of engaging STEM curriculum

A further key area of action is the pedagogy or way that STEM curricula is taught. There is a need to give priority to inquiry-based learning and the development of problem-solving and higher order thinking skills. Applied learning is a more appropriate pedagogy in this area. A report by Engineers Australia quotes Re-engineering Australia:

"Conventional education has struggled to deliver subjects in a way that links the learning process to the relevant application of that learning."[57]

There is the potential for technology and engineering to provide the application for the teaching of science and mathematics. The introduction of new subjects into the national curriculum by ACARA in design and technologies and digital technologies is helpful in this regard.

There is effective good practice from some programs about how to engage students and provide clear pathways for them to STEM careers. Action-learning and problem-solving strategies are prominent in these. In secondary education programs like the F1 in Schools confirmed it was:

"able to have a significant impact on the career motivations of the children who participated with 64% of boys and 35% of girls indicating that F 1 in Schools had influenced a change in their career motivations toward engineering."[58]

In primary education Engineers Australia's EngQuest is a national primary school outreach program designed to equip teachers with the tools and resources to teach science, technology and engineering. There were over 100,000 student participants in 2013.

STEM programs can be promoted differently to male and female students; there are different sets of motivators in play. Programs that emphasised interaction between students had an impact on boys whereas an understanding of the processes involved in the profession and how they relate to career decisions had a greater impact on girls. Communicating the why of projects and the difference an individual can make can be a powerful student motivator.

There needs to be greater emphasis on linking the teaching of STEM elements together, using inquiry-based and action-learning programs and pedagogies and adopting different and appropriate motivational factors to persuade students to expand their interest in STEM programs.

53 Media Release, Strategy, Science and a National Innovation Agenda, Office of the Chief Scientist, 14 October, 2014.
54 Media Release, Commonwealth Science Council, Office of the Chief Scientist, 27 November 2014.
55 Record of First Commonwealth Science Council meeting, 27 November 2014.
56 Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach, Office of the Chief Scientist, July 2013, page 10.
57 Desi Corbett, Where is Australia's national STEM strategy, Engineers Australia, April 2014, page 49.
58 Desi Corbett, Where is Australia's national STEM strategy?, Engineers Australia, April 2014, page 49.

Support for expansion of teachers in STEM disciplines

A key to success in this area is an expansion of STEM qualified teachers. In terms of teacher preparation the TIMSS data indicates Australian mathematics teachers are under-qualified in terms of comparator countries. High performing nations in mathematics and science such as Korea, Japan and Singapore, have a high proportion of teachers majoring in these disciplines at university. While this is not the complete picture, it is nevertheless an important factor to ensure that our STEM teachers are better qualified.

A further factor is the required average teaching time in STEM subjects. The required average teaching time for mathematics in Australian primary schools is the same as the OECD average of 17 per cent of weekly teaching time. However, the required average teaching time for science in primary schools is 5.7 per cent of weekly teaching time which is below the OECD average of 7.4 per cent. This is an area that needs greater attention.

The overall aim is for the recruitment, pre-service preparation and in-service support for all teachers to be improved to ensure teachers are well versed in STEM disciplines.

"Australia's STEM teachers at all levels, from primary to tertiary, need to be equipped to deliver inspirational course content and develop all students to their full potential."[59]

There are some useful examples of good practice from which we can learn. The Warren Centre for Advanced Engineering at the University of Sydney has noted that investment in STEM qualified teachers is a key plank in a STEM national strategy.[60] Indeed, three faculties within this university have been combined to form a STEM Teacher Enrichment Academy "aimed at inspiring and building the confidence of teachers across Australia responsible for the delivery of mathematics, science and technology education."[61]

59 Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, November 2014, page 90.
60 Desi Corbett, Where is Australia's national STEM strategy?, Engineers Australia, April 2014, pages 47 – 48.
61 Desi Corbett, Where is Australia's national STEM strategy?, Engineers Australia, April 2014, page 48.

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