Lifting our Science, Technology, Engineering and Maths (STEM) Skills

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EXECUTIVE SUMMARY

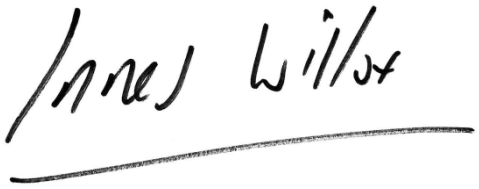
Australia's productivity and competitiveness is under immense pressure. A key way to meet the emerging challenge of developing an economy for the 21st century is to grow our national skills base - particularly the Science, Technology, Engineering and Mathematics (STEM) skills of our school leavers. Our relative decline of STEM skills is holding back our national economy and causing real frustration for employers.

It has been estimated that 75% of the fastest growing occupations require STEM skills and knowledge. Yet this Australian Industry Group research report reveals a disturbing picture in this area. Young people in schools and universities are not acquiring the STEM skills we need for our future prosperity. International studies such as the Trends in Mathematics and Science Study (TIMSS) also highlight stagnation in Australia's performance.

We asked employers about this and they have reported significant difficulty recruiting people for occupations with STEM skills. There is particular difficulty recruiting technicians and trades workers (41%), professionals (27%) and managers (26%) with these skills across different industries. While this was experienced by enterprises of all sizes, it was most keenly felt by large enterprises.

Employers identified barriers experienced in recruiting people with STEM skills. Chief among these were applicants without STEM skills (25%) and a lack of workplace experience (24%). Employers promote STEM skills in the community by providing high quality work placements, internships, financial incentives for university recruits and engaging with schools to motivate students about STEM. However, more can be done to increase employer commitment and engagement.

It is time for a major re-think by Australian education at all levels and in all sectors to address this situation. There are several examples of partnership programs operating effectively but often in isolation. Ai Group calls for the establishment of an industry-led working group, in conjunction with the Office of the Chief Scientist, to develop a national framework and strategies to implement 'school-industry" STEM skills initiatives and to support increased university and industry participation.



Innes Willox

Chief Executive
Australian Industry Group

KEY POINTS

- STEM skills are essential for the future economic and social well-being for the nation;
- Australia's participation in STEM skills at secondary school and university are unacceptably low;
- Ai Group survey results indicate industry experiences difficulty recruiting employees with STEM skills especially technicians and trade workers (41%), professionals (27%) and managers (26%) across many industry areas;
- Industry needs to become more engaged in the promotion of STEM skills at all levels of education and training; and
- There is an urgent need to introduce a number of strategies across the various sectors to lift participation in STEM-related activity.

Why are STEM skills important?

The importance of STEM disciplines for the future economic and social well-being of Australia cannot be underestimated. International research indicates that 75% of the fastest growing occupations require STEM skills and knowledge.[1] Employment in STEM occupations is projected to grow at almost twice the pace of other occupations.[2]These skills are critical for Australia's national productivity and global competitiveness. The combination of Science, Technology, Engineering and Mathematics as STEM is a recent initiative that is growing across all sectors of education and gaining international credence.[3] For example, STEM skills are essential in the following occupations:[4]

- electrical engineers
- agricultural and forestry scientists
- environmental scientists
- software and applications programmers
- architectural, building and surveying technicians
- metal casting, forging and finishing trades workers
- electricians
- mining engineers
- chemists, and food and wine scientists
- ICT business and systems analysts
- database and systems administrators
- mechanical engineering draftspersons and technicians
- toolmakers and engineering patternmakers
- telecommunications trades workers

[1] Becker, K. and Park, K.; Effects of integrative approaches among STEM subjects on students' learning, Journal of STEM Education 12, July – September 2011.

[2] Elizabeth Craig et al., No Shortage of Talent: How the global market is producing the STEM Skills needed for growth, September 2011, Accenture Institute for High Performance.

[3] Dr Mike Brown, Analysing some STEM-like programs in secondary schools across Australia, La Trobe University.

[4] Training and the Arts and A STEM Skills Strategy for South Australia, Department of Further Education, Employment, Skills and Training.

The OECD *Over-Qualified or Under-Skilled: A review of Existing Literature* report published in 2011 notes that increasing demand for STEM graduates in the workforce is a result of:

- Growing use and impact of information and communication technologies;
- Rapid application of scientific advances in new products and processes;
- High rates of innovation required of business to stay competitive;
- Declines in student enrolments in STEM particularly at secondary school; and
- Shifts to more knowledge-intensive industries and services. [5]

"In Australia you tend to get people that are experts in their field, but they can't see left and they can't see right of what they've actually done and the skills…in engineering you have to be able to look to the left and to the right to be able to put things together….And I think it's that part that's missing in the education sector."[6]

"If Australia is to be a productive and progressive economy in the future, a workforce of scientifically and technologically literate is required."[7]

What is the current situation?

The same OECD report indicated that Australia is lagging in the number of STEM graduates from its tertiary institutions. A recent report noted that the number of students enrolled in a mathematics major in Australian universities declined by 15% between 2001 and 2007.[8] Commencements in tertiary ICT courses have declined by 53% between 2001 and 2011, while completions declined by 58% in the same period.[9]

The current number of Australian engineering graduates provides less than 40% of the engineers employed each year in Australia.[10] Whilst the numbers of undergraduates in engineering programs have been slowly rising the shortfall has had to be addressed through migration and less than suitably qualified and experienced individuals.

In addition, there are also grounds for concern in secondary education. The number of students undertaking advanced mathematics in secondary school fell by 27% between 1995 and 2007. The impact of this decline is compounded by the lack of qualified teachers.[11]

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.[12] The Australian Workforce and Productivity Agency has noted that despite attempts by governments over the

[5] OECD; *Over-Qualified or Under-Skilled: A review of Existing Literature*, OECD Social, Employment and Migration Working Papers, No 121, Paris, 2011.

[6] Australian Industry Group focus group comment.

[7] Reid J. et al; Establishing STEM Educational Leadership, 2nd International STEM in Education Conference.

[8] http://www.theaustralian.com.au/news/nation/mathematics-students-in-serious-decline, March 10, 2010.

[9] Australian Workpforce and Productivity Agency, ICT Skills Forum presentation, November 2012.

[10] Beanland, D.; How Engineers Australia can support the transformation of engineering education in Australian universities, 30.10.2012.

[11] http://www.theaustralian.com.au/news/nation/mathematics-students-in-serious-decline, March 10, 2010.

[12] Sue Thompson et al*., Highlights from TIMSS and PIRLS 2011 from Australia's perspective*, Australian Council for Educational Research, 2012.

last decade to increase school student participation in STEM the proportion of students commencing in STEM has flat-lined at around 10% or less.[13]

In addition, research is indicating that girls are opting out of mathematics and science. In NSW for example, the percentage of girls not studying any maths in the HSC increased from 9.5% in 2001 to 21.8% in 2011. Only 13.8% of girls studied one maths and one science subject for their HSC in 2011.[14] The gender disparity in maths and science participation is now greater than it was in the 1980s.

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[15]

> *"The state of maths and science at Australian schools and universities has deteriorated to a dangerous level."[16](Vice-Chancellor Gavin Brown, University of Sydney)*

The declining enrolments and reduced numbers of graduates in STEM disciplines / courses / qualifications is of significant concern to Ai Group.

There are also concerns about STEM skills and apprenticeships. Ai Group research has indicated that 25% of apprentices are affected by low levels of literacy and numeracy issues which impacts on their capacity to acquire STEM skills.[17] This has a significant impact on the Australian economy as technicians and trade workers is the group most reported as experiencing skills shortages. The Department of Education, Employment and Workplace Relations (DEEWR) has recently assessed 18 occupations within the technicians and trades area as having national skill shortages far exceeding any other occupation category.[18]

[13] *Australia's skills and workforce development needs*, Discussion Paper, Australian Workforce and Productivity Agency, July 2012.

[14] *Study finds more girls opting out of maths and science*, The Conversation, 14 February 2013.

[15] Universities Australia, *STEM and non-STEM First Year Students*, January 2012.

[16] http://www.theaustralian.com.au/news/nation/mathematics-students-in-serious-decline, March 10, 2010.

[17] *National Workforce Literacy Project, Final Report*, January 2012, Australian Industry Group.

[18] *Skill Shortages – Summary*, Australian Government Department of Education, Employment and Workplace Relations.

What are employers saying?

These developments have not gone unnoticed by industry. This report conveys employer views from our *Survey of Workforce Development Needs 2012*. The survey addressed the issue of recruiting individuals with STEM skills, specifically, the survey asked employers to indicate if they had experienced difficulties recruiting specific occupations with STEM skills.

The most prominent difficulties of recruiting people with STEM skills are in the following occupations across all industries:

- Technicians and trade workers (41%)
- Professionals (26.6%)
- Managers (26.3%)

Changing nature of work

The demand for technicians in part reflects the changing nature of the Australian workplace over the last decade. This has been characterised by increasing adoption of technologies and a consequent need for a higher level of skills across the workforce.

This was a common theme in focus group research into technology investment and productivity in Australian businesses conducted by Ai Group in 2013.

One participant noted that:

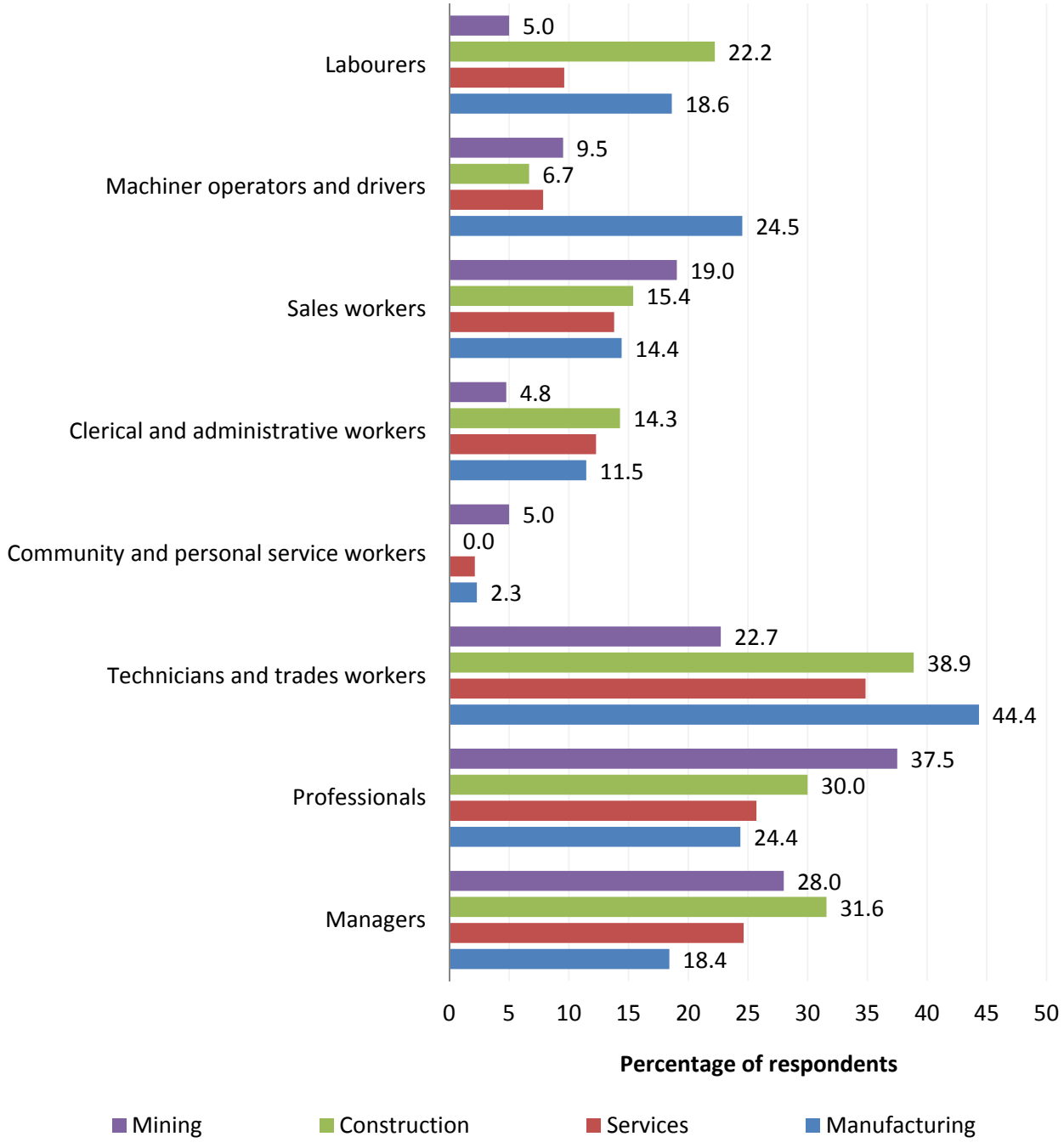
"the old-fashioned manufacturing manager basically is gone. Now he needs to know how to…manipulate a database and do all that sort of thing that they never heard of 10 years ago."

Another commented:

"Five years ago, my labour force was the guy with the fluoro shirt who came into work at 6 o'clock in the morning and left at 2 o'clock in the afternoon, and that was his eight hours of work…. He was happy with his life. [Then] My labour force changes from a fluoro shirt guy to a warehouse technician. His job now is he comes in at 6.30 and he looks at knobs and switches and PLCs. He doesn't pick on the line. The whole mindset of my skill set is gone. It's no longer a manual labour perspective."

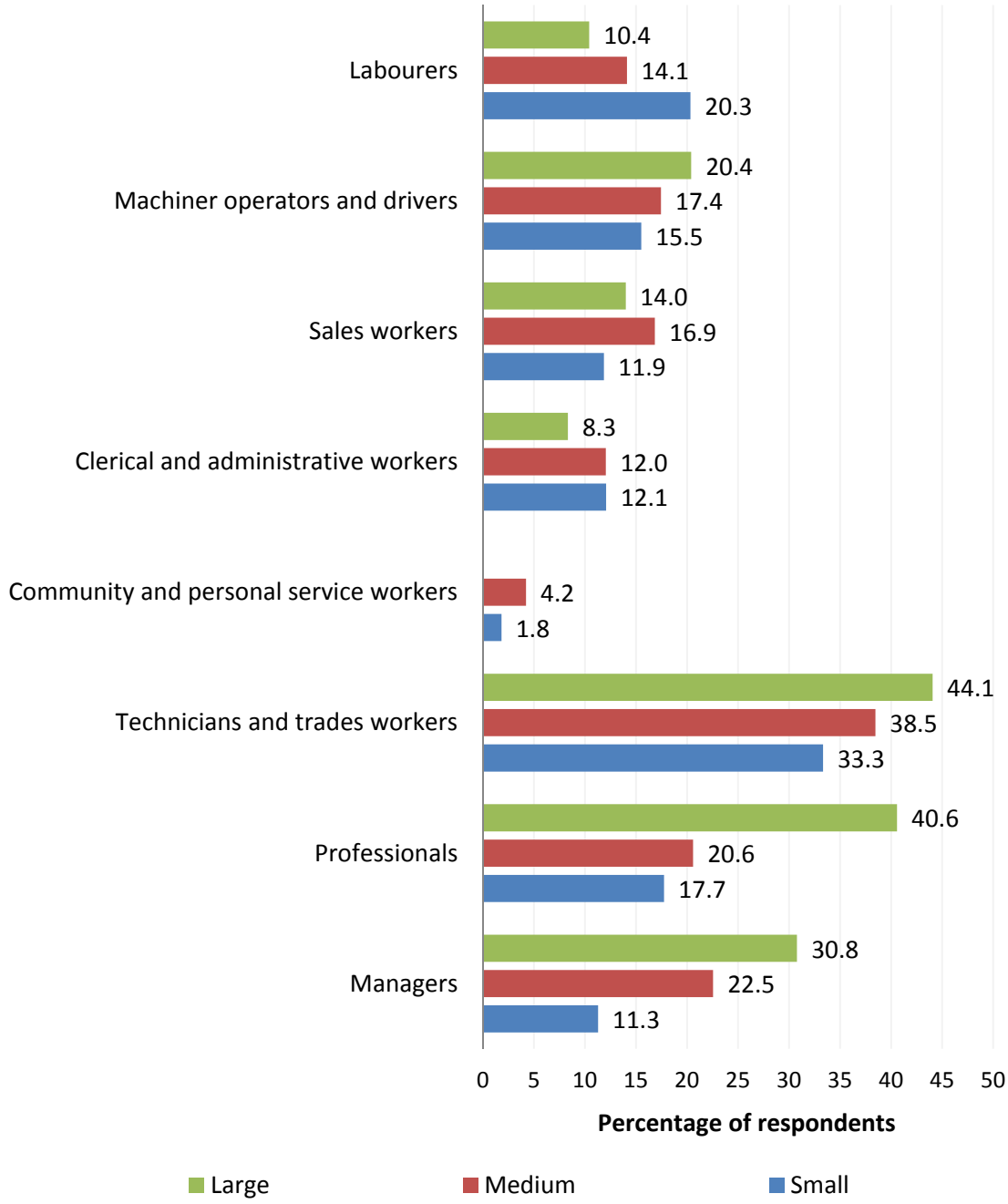
The difficulty in recruiting individuals with STEM skills was consistently encountered by the respondents from different industry areas. The highest response was for technicians and trade workers in the manufacturing sector (44%). This was also the case for the construction industry with almost 39% in this category and the services sector at almost 35%. The most prominent difficulty for the mining sector was in professional occupations (37.5%). All of these occupations with STEM skills shortages are at the higher end of the qualifications spectrum.

Chart 1: Business experiencing difficulty recruiting individuals with STEM skills by industry area



A further consideration is to examine how this issue affected different sized businesses. The *Survey of Workforce Development Needs 2012* revealed that large enterprises experienced the greatest difficulties in technicians and trade workers (44%), professionals (41%) and managers (31%) compared to medium and small enterprises.

Chart 2: Business experiencing difficulty recruiting individuals with STEM skills by Enterprise size



Respondents to the *Survey of Workforce Development Needs 2012* were also asked to comment on barriers they had experienced in this area. Of the employers who had experienced difficulties recruiting staff with STEM skills, 24.9% found a lack of applicants with STEM skills to be the greatest barrier. Other key barriers included a lack of workplace experience (24.4%) and the content of qualifications not being relevant to business needs (18.3%).

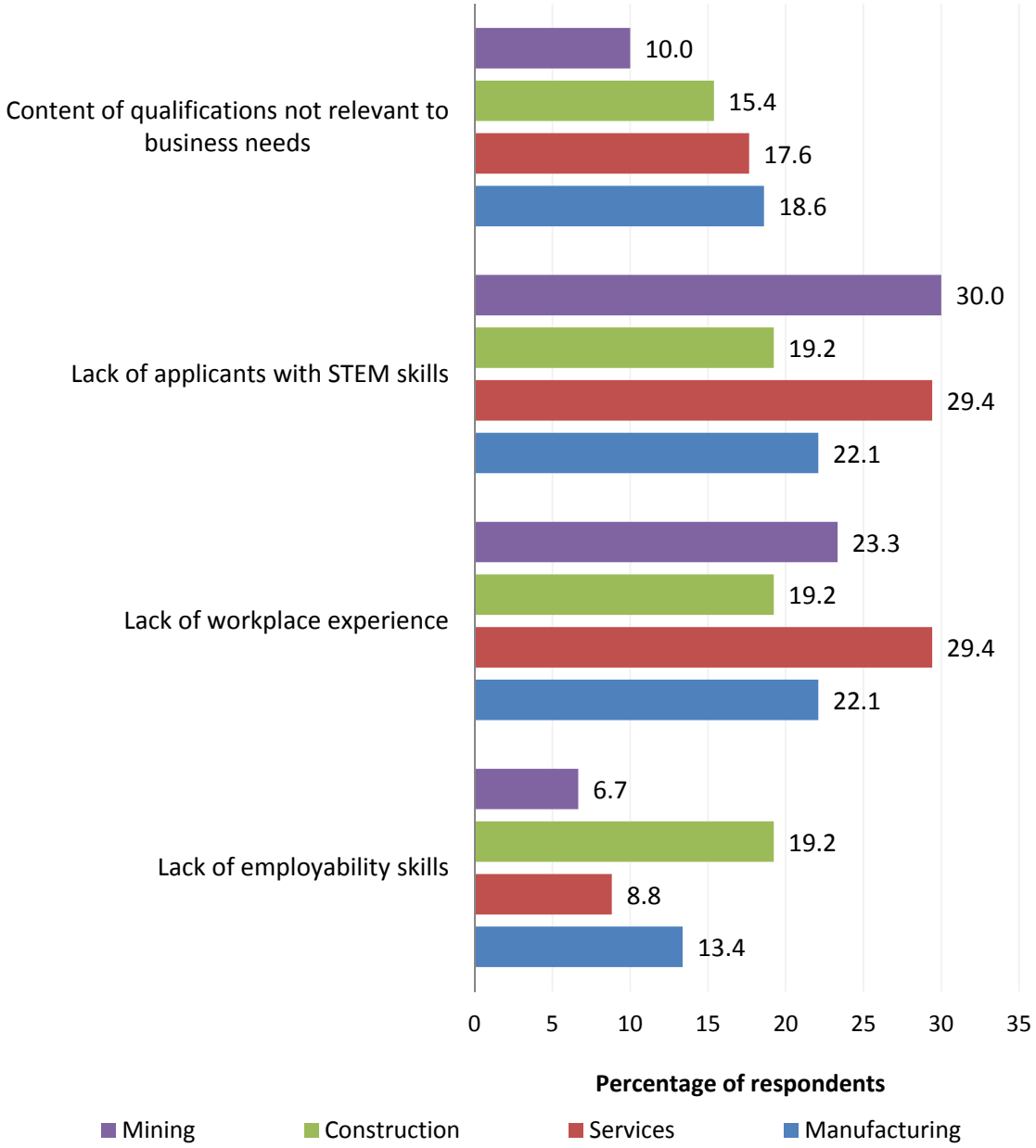
The issue of graduates not being 'work ready' was a common theme in the Ai Group focus groups mentioned earlier. A number of contributors made comments to the effect that the Australian education and training system was good at producing specialist engineers but not at producing graduates with the skills to look at problems from a systems perspective.

Table 1: Barriers for Recruiting STEM Skills

Barriers for Recruiting STEM Skills	Percentage
Lack of employability skills	**11.8**
Lack of workplace experience	**24.4**
Lack of applicants with STEM skills	**24.9**
Content of qualifications not relevant to business needs	**18.3**
Not applicable	**20.5**
Total	**100**

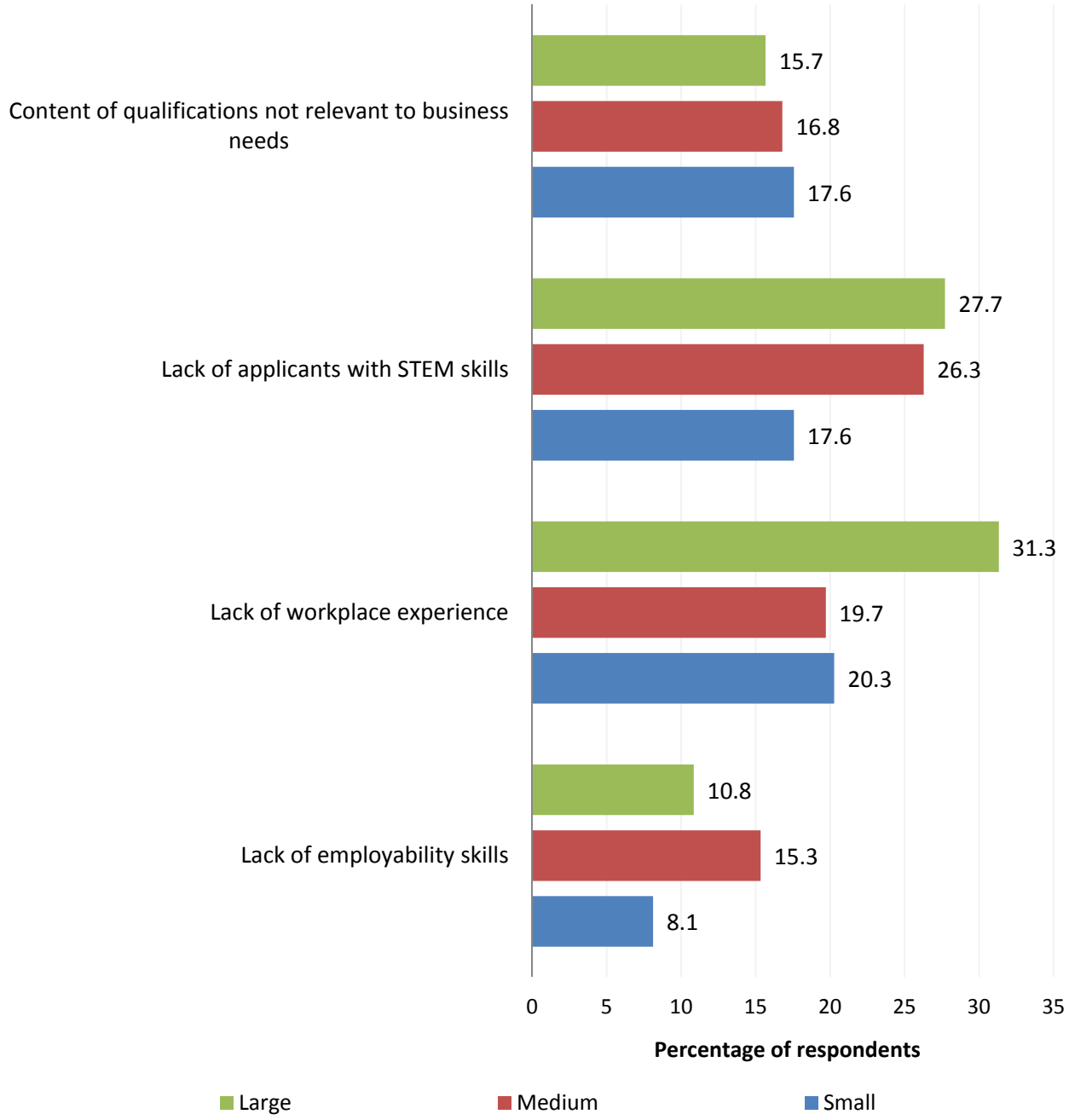
In terms of industry responses both the mining (30%) and the services sector (29.4%) reported the lack of applicants with STEM skills to be greatest barrier. The services sector also reported that a lack of workplace experience was a significant barrier (29.4%).

Chart 3: Barriers to Recruiting Staff with STEM Skills by Industry



An analysis of these responses by business size revealed that large businesses experienced the greatest barriers. Large businesses reported the lack of workplace experience as the greatest barrier (31.3%) followed by a lack of applicants with STEM skills (27.7%). The next largest response was by medium sized businesses reporting a lack of applicants with STEM skills (26.3%).

Chart 4: Barriers to Recruiting Staff with STEM Skills by Company Size



Employers were asked about what measures they adopt to promote STEM skills to the community. A large number either did not respond or indicated "not applicable". This suggests that industry has a low-level of engagement with this issue. Of those employers that did respond to the issue the following were the most common means of promotion:

- Providing high quality work placements
- Providing financial incentives for higher education recruits
- Internships
- Engaging with schools to motivate students about STEM
- Developing business related STEM courses with higher education

These results demonstrate a range of industry responses with some preference for work-based solutions.

What needs to be done?

A promising beginning was made in the 2012 Australian Government budget when a $54 million package of measures was announced in response to the recommendations of the Chief Scientist. These measures included the establishment of a new post within the Office of the Chief Scientist to promote greater STEM awareness, to improve high quality teaching in mathematics and science and national initiatives to set new benchmarks for raising the engagement of school students.[19]

Ai Group believes that this approach now needs to be further developed. Australian education at all levels and in all sectors requires a major re-think leading to a transformation in STEM to increase participation in STEM-related education and training. This has been recognised in reports from some of the jurisdictions.[20]

This issue is particularly important in school education as STEM subjects provide critical underpinning skills in the workforce and society. Further, without these underpinnings, students may not have the pre-requisites to progress to tertiary study or specific vocational programs.

There have been some encouraging initiatives. Quantum Victoria, for example, is a statewide facility co-located with Charles La Trobe P – 12 College dedicated to improving Victorian students' outcomes in science and mathematics. Their programs can be accessed by students, teachers, laboratory technicians and members of the wider community.[21] John Monash Senior Secondary College, co-located at Monash University, is a specialist maths – science school with a rich science-based curriculum.

A further example concerns the Northern Advanced Manufacturing Industry Group (NAMIG). It was formed as a consortium of local industries, government and education providers to

[19] http://www.chiefscientist.gov.au/2012/05/54-million-committment-to-mathematics-engineering-and-science-2/

[20] For example *Towards a 10-year plan for STEM education and skills in Queensland*, Discussion Paper, Queensland Department of Education, Training and the Arts and *A STEM Skills Strategy for South Australia*, Department of Further Education, Employment, Skills and Training.

[21] *Quantum Victoria: supporting science and mathematics education*, Curriculum Leadership Journal, 2 September 2011.

introduce Advanced Manufacturing pathways to students. It is currently funded by the South Australian government with some additional funding from industry partners.

NAMIG developed the C2C Program to provide a way for schools and industry in Northern Adelaide to work together to provide students with industry experience and assistance as they create their own C2C projects. Recent years have seen the expansion of the program making the C2C model available to schools outside of the northern suburbs of Adelaide. The program has been in operation since 2005 and there are currently some 3000 students from 27 schools currently undertaking C2C projects.

The Re-Engineering Australia Foundation with its highly successful F1 in Schools national competition is a further example of a highly innovative program.[22] In the field of mathematics Hawker College in the A.C.T. has replaced formal maths classes with a flexible student-led study program which integrates online learning with specially created work spaces. A special Hawker maths website, YouTube videos and interactive software have been used to engage students. The initiative has increased student engagement and introduced fun into maths.[23]

All of these programs demonstrate what is possible but are isolated examples. There would be benefit placing these within a national framework of STEM related initiatives. They also address the issue of innovative pedagogy which is essential if young people are to be engaged in this area.

The Chief Scientist recently found that real life science from within a student's field of experience is one of the most powerful ways to spark their interest. This highlights the importance of industry involvement in engaging students to think about STEM careers and skills and the opportunities they open up. New initiatives could include collaboration with educators to produce digital resources.

There is also a need to address higher level specialist skills for entry into STEM courses, qualifications and apprenticeships which are required for technician and trade worker occupations.

The Office of the Chief Scientist has referred to workplace opportunities for higher education STEM students being in place but on too small a scale. This has led to the call for a semester-long work-related placement or project as part of the course for 50% of the 56,000 incoming STEM undergraduates.[24] This has been identified as one the key breakthrough actions by the OCS. Ai Group supports this initiative to strengthen work placements in undergraduate STEM courses.

There are opportunities as well for increased collaboration between industry and higher education in regard to STEM research projects especially for post-graduate students.

Ai Group believes that governments need to urgently address the decline in STEM skills through the development and implementation of major initiatives across the sectors to lift STEM discipline participation.

[22] www.rea.org.au

[23] School subtracts maths classes, The Sydney Morning Herald, 13 March 2013.

[24] *Top Breakthrough Actions for Innovation*, Office of the Chief Scientist, December 2012.

RECOMMENDATIONS

SCHOOLING

1. Given the importance of the early experience of STEM skills for young people, it is imperative to support a range of strategies in the schooling sectors that lead to increase participation by students in STEM skills. These strategies include:

   - measures to lift teacher quality, capability and qualifications in STEM and related disciplines;
   - the adoption of a more innovative pedagogy which teaches STEM skills in an engaging and integrated way;
   - the development of measures that encourage girls to remain engaged in STEM skills;
   - the development of career advice in schools that advances the importance of STEM subjects required by many occupations and careers;
   - the need to commence an expanded engagement with STEM skills at primary school where students first encounter these areas; and
   - to support the recommendation by the Office of the Chief Scientist for the establishment of a National Centre for Mathematics and Science Teachers.

2. Ensure that future negotiations between all levels of government on new and improved resourcing for all Australian schools to prominently feature the development and implementation of Key Performance Indicators that measure increased participation and attainment in STEM-related disciplines.

TERTIARY EDUCATION

3. The introduction of semester-long work-related placements or projects for 50% of all incoming STEM undergraduates as recommended by the Office of the Chief Scientist; and

4. Universities and industry to collaborate on business-related research projects, especially with PhD students.

BUSINESS AND INDUSTRY

5. The Australian Government establish, in conjunction with the Office of the Chief Scientist, an industry-led working group, also comprising STEM experts:

    a. to develop a national framework and strategies to promote and implement 'school-industry' STEM skills initiatives with Australian primary and secondary schools including consideration of the range of successful school – industry initiatives as well as create a road map for expanded funding support;

    b. to develop a project bank of real work-based research projects for use by undergraduate and post-graduate students; and

    c. to develop models to support internships and work placements in conjunction with industry as well as strategies designed to encourage industry to engage with them

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