Developing the Workforce for a Digital Future

Addressing critical issues and planning for action

Contents

Key Points

- Digital transformation is changing the global economy
- Automation, robotics, machine learning and computerisation are advancing rapidly
- Changing work arrangements are emerging across some sectors where businesses are taking advantage of lower transaction costs
- Some jobs will be lost and new jobs created
- Demand is increasing for higher skilled workers as routine work declines
- Not just more but new skills are required for the workforce
- These include digital literacy skills, STEM skills, skills for Industry 4.0, enterprise and entrepreneurial skills and new management capabilities
- Education and training sectors need to develop new workforce capabilities
- School systems need to focus on digital and ICT skills, STEM education and general literacy and numeracy proficiency
- The VET sector provides some coverage of digital skills but needs a sharper focus on higher order skills
- Higher education needs to focus on cooperation with industry, leadership and management development and the expansion of micro-credentialing
- Industry needs to concentrate on workforce development and upskilling

Company Action Plan

- Develop a strategy plan
- Review work organisation
- Develop leaders and managers
- Form partnerships with education sectors
- Re-skill existing workforce
- Invest in research and development
- Utilise government support

1. How is digital transformation changing the global economy?

1.1 Introduction

The fourth industrial age rolling out across the globe is creating a digitally-enabled environment that will affect every company. Digital innovation has the capacity to transform practices, raise performance and increase growth across all industry sectors. The pace of change in digital technologies continues to increase and become more embedded in the economy.

Figure 1: Top threats to growth according to Australian CEOs

Advancements in artificial intelligence, unprecedented computer power, the Internet of Things (IoT) and big data, among other technological progressions, are changing the nature of the link between technology and employment.[1] There is the potential that these changes will bring benefits beyond labour substitution, including higher levels of output, better quality, and fewer errors that are achievable through automation. The increasing introduction of machine technology means computers are progressively substituting for workers in performing routine, codifiable tasks while at the same time amplifying the comparative advantage of workers in supplying problem solving skills, adaptability, and creativity.[2] In a landmark report PwC calculated that 5.1 million jobs, or 44 per cent, were at risk of digital disruption. In the same report, the pace of technological change is a concern for growth according to Australian CEOs.[3]

Global value chains have now become a dominant part of the world economy. Each stage can occur in different countries and under different regulatory conditions and be implemented wherever the necessary skills and materials are available at competitive cost and quality.[4]

Digital transformation itself should not be seen as a negative to the workforce. If adopted successfully and combined with successful organisational change and change management practices, a business will be able to achieve, and remain competitive, in an increasingly global marketplace.

[1] Frey, C and Osborne, M: Technology at Work: The Future of Innovation and Employment, Oxford Martin School and Citi, 2015 http://www.oxformartin.ox.ac.uk/downloads/reports/Citi GPS Technology Work.pdf

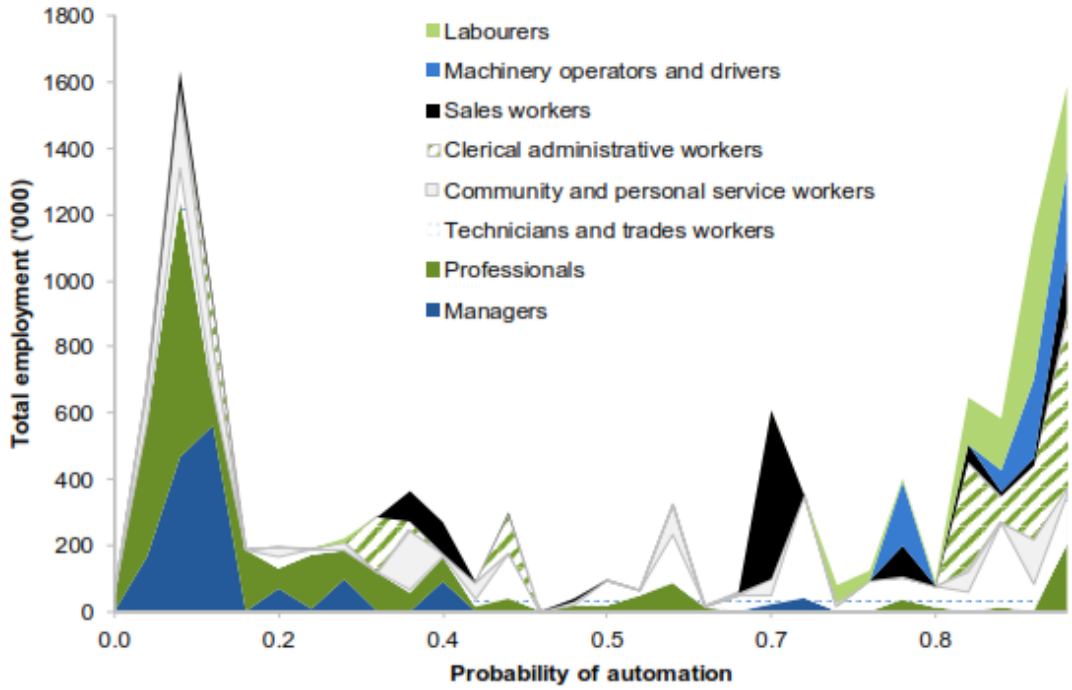
[2] Chui, M, Manyika J, Meremadi M, 2016, 'Where machines could replace humans—and where they can't (yet)', McKinsey Quarterly, <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet?cid=other-eml-ttn-mkq-mck-oth-1612

[3] PwC, A smart move, April 2015.

[4] Beitz, S 'Developing the capacity to adapt to industry transformation' in Australia's future workforce', Committee for Economic Development of Australia, June 2015.

The risk remains though of digitalisation increasing the pace of the 'hollowing-out' of certain occupation roles. Those jobs relying on a high level of automatable tasks are at high risk of being substituted by new technologies. Computers and algorithms mainly substitute for easily codifiable, conceptual jobs on the highly skilled end of the skill distribution, or manual jobs at the bottom end of the skill distribution. The Productivity Commission has estimated which occupations are likely to be automated. The occupations more likely to be disrupted include labourers, machinery operators and drivers and clerical workers. Personal service workers and professionals are more likely to remain unaffected.[5]

Chart 1: Which occupations are likely to be automated?



[a] The number of jobs by profession group likely to be automated at each level of probability.

Source: Durrant-Whyte et al. (2015).

Digital transformation requires that individuals need the necessary skills to adapt. This will require changes to educational systems and an increased need for on the job training to realise the benefits of digital change. The aim needs to be increasing the number of people able to be involved in the digital economy.[6]

[5] Digital Disruption: what do governments need to do?, Productivity Commission Research Paper, June 2016.

[6] Gabriel, S & Gurría, A 2017, 'Policy 4.0: Bringing the People on Board in a Digital World', The World Post, <http://www.huffingtonpost.com/oecd/policy-40-bringing-the-pe_b_14114510.html

1.2 Automation

The international flows of capital, information, products, skills and technology are important aspects of globalisation. Having immediate access to information around the world and at lower cost has affected the rate of diffusion of technology and innovation, leading to automation.

While automation from digitalisation will eliminate very few occupations completely, it will affect parts of nearly all jobs to a greater or lesser degree. There are strong complementarities though between automation and labour that increase productivity, raise earnings, and augment demand for labour. In the last few decades, one noticeable change has been the 'polarisation' of labour, in which wage increases have been gained disproportionately to those at the top and at the bottom of the income and skill distribution levels, and not to those in the middle.[7]

Figure 2: Jobs likely to be automated in the next 20 years

Predictable physical activities, prominent in industries such as manufacturing, food service and accommodation, and retailing are the most susceptible to automation if considering technical dimensions alone. The potential varies among companies from those with little or inconsistent use of automation to those with strong elements of automation.[8]

The collection and processing of data is also an element of the workplace which has potential for automation. Activities in areas such as procurement, payroll, invoicing and logistics involve the management of data which can be automated.

With the automation of many tasks, the personal service industry will remain an important employment growth area. Human services are often preferred in this area of the economy. In the healthcare sector workers with greater expertise and interaction with patients will experience less automation. While there is a greater move to online learning, education involves complex interactions with teachers and fellow students which are not necessarily able to be automated.[9]

For business, the challenge will be on how to maximise the value of automation given the current potentially high costs.[10] The combination of smart machines and

[7] Autor, D, 'Why Are There Still So Many Jobs? The History and Future of Workplace Automation', Journal of Economic Perspectives, 2015, Vol. 29, No. 3.
[8] Chui, M, Manyika J, Meremadi M, 2016, 'Where machines could replace humans—and where they can't (yet)', McKinsey Quarterly, <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet?cid=other-eml-ttn-mkq-mck-oth-1612>
[9] Coppola, F, 2014, 'Automation and Jobs: Competition or Cooperation?' in Our Work Here is Done: Visions of a Robot Economy, Nesta, London.
[10] Chui, M, Manyika J, Meremadi M, 2016, 'Where machines could replace humans—and where they can't (yet)', McKinsey Quarterly, <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet?cid=other-eml-ttn-mkq-mck-oth-1612>.

big data is expected to allow companies to do more with less, potentially even displacing certain professional jobs in areas such as legal services, medical diagnosis and financial analytics.[11]

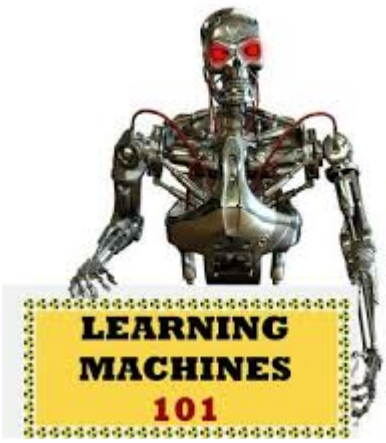
Only a small percentage of occupations can be fully automated by adapting current technologies, but some work activities of almost all occupations could be automated. For workers, automation will change many work processes and require a closer collaboration with technology.[12]

1.3 Robotics and Machine Learning

As technology develops, robotics and machine learning will take greater precedence in activities that currently have low potential for automation.

> *"The expansion of the digital economy is accelerating the presence of a new kind of productive entity, somewhere between human capital and physical capital – robots and intelligent algorithms."*[13]

For example, if machines are eventually designed to understand natural language to a reasonable level, and were able to undertake regular communication with people, there will be greater potential for automation to take the role of workers. This kind of automation could transform the workplace for everyone, including senior management. People though are better at dealing with the unexpected and developing innovative solutions to problems than machines are, which offers potential capacity for people to work with robots for greater productivity and innovation.



The attraction and challenge of adopting robots is similar to that of computers in general. It can be difficult to repurpose a business activity to suit automation and it requires a significant upfront investment in capital. Once that is done it can drive efficiency improvements and avoid human errors.

Where there is potential for increased productivity in jobs through the application of robotics and machine-learning algorithms there will be relatively less employment for the same output. Health is an especially significant area likely to be impacted – through automation in clinical data and predictive diagnostics (analysis roles), to robotics assisting in areas from surgery to nursing and from hospital logistics to pharmaceutical dispensary.

The application of robots will produce mixed results for the workforce. Employment will decrease where tasks can be automated and increase in occupations where human labour is more complementary to robots. This balance between these effects depends specifically on the areas of such applications. For example, welding robots can replace workers performing the same operation whereas assembling robots increase the need for technicians to supervise the production flows.[14]

[11] Beitz, S., 'Developing the capacity to adapt to industry transformation', in Australia's future workforce, Committee for Economic Development of Australia, June 2015.
[12] McKinsey Global Institute; A Future That Works: Automation, Employment, and Productivity, 2017.
[13] The Global Human Capital Report 2017, World Economic Forum, 2017, page 35.
[14] Key issues for Digital Transformation in the G20, OECD, 2017, pages 109 – 110.

This increasing trend will contribute to the loss, change and creation of occupations. The nature of the impact will depend on the pace and extent of the implementation of these kinds of technological innovation.

1.4 Computerisation

Automating routine tasks through mechanisms such as the use of computers, has led to the development of more high-skilled roles involving critical thinking and problem solving. This has resulted in a more 'hollowed-out' employment market with growing employment in high-income, highly skilled jobs and low-income manual ones, accompanied by a decrease in middle-income routine jobs.

There have been considerable gains in the storage, processing and transmission of data to significantly expand the information available to businesses. The use of Big Data and Advanced Analytics potentially allows less routine tasks to become programmable. Combined with other technological advances such as machine learning, the increasing abilities of robots and the use of sensor technology further computerisation of tasks will be possible.[15]

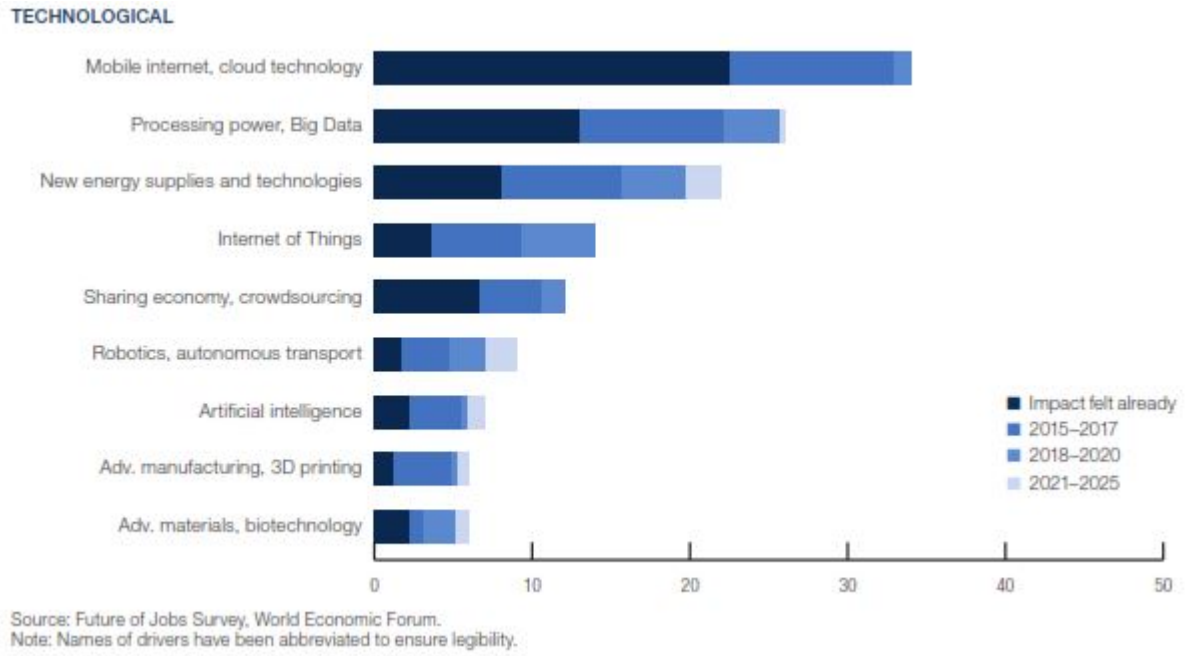
A range of impacts is likely. The first relates to the expanded role of machine intelligence and robotics to replace many routine occupations. A second impact will be on routine office jobs by computers and machine-learning algorithms. These include occupations such as legal clerks, market research and sales, predictive analytics and many others. Finally, there will the impact of robotics and machine-learning algorithms on occupations that are not necessarily routine. This would include banking and legal advice that involve data and analysis where most of the tasks are routine, but not all of them.[16]

[15] Bhalla V. et al; Twelve forces that will radically change how organisations work, The New Way of Working Series, www.bcg.com/publications/2017/people-organisation-strategy

[16] Durrant-Whyte, H, McCalman, L, O'Callaghan, S, Reid, A and Steinberg, D, 'The impact of computerisation and automation on future employment', in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

The World Economic Forum has analysed the technological drivers of change and timed impact on employee skills. This data includes a significant number of computerisation advances that have already had an impact on employee skills as well as having an impact up to 2025.[17]

Chart 2: Drivers of change and time to impact on employee skills



Source: Future of Jobs Survey, World Economic Forum.
Note: Names of drivers have been abbreviated to ensure legibility.

1.5 Technology and the Organisation of Work

Technology is also changing the way work and businesses are organised, which itself has implications for employment. As data collection and analysis tools improve, less hierarchy is required, with online networks instead playing a greater role. 'Platform' or 'gig' work arrangements have emerged across some sectors where businesses can take advantage of lower transaction costs and access a larger pool of potential workers and suppliers.

Companies may become smaller in terms of their core staff, and rely on networks of freelancers and service providers to deliver a greater proportion of their work. Such flexible employment is in theory attractive to companies. It allows them to respond rapidly to changes in their markets, for example large orders or the need for new products, without needing to maintain a large inventory of staff on the payroll.

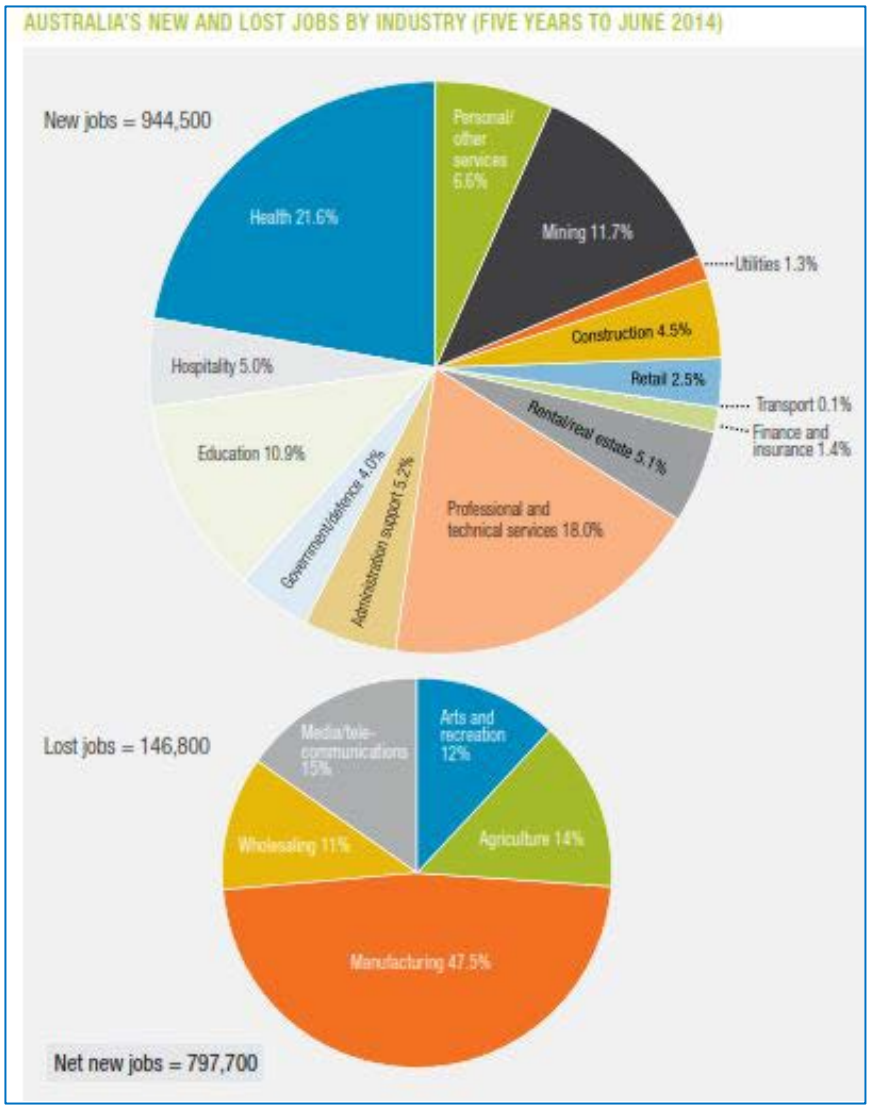
Freelance workers are more likely to seek jobs in which they can develop and use skills that are easily transferable, as they must be continually looking to future jobs. They will be less willing though to invest time and effort into developing less transferable skills or knowledge without an ongoing employment relationship. Where such specific skills are important, employers may benefit by offering ongoing employment to attract good workers. Similarly, where relationships with customers are important, the company is also likely to benefit from building long term relationships with their employees.

[17] The Future of Jobs: Employment, Skills and Workforce Strategy for the fourth Industrial Revolution, Executive Summary, World Economic Forum, January 2016.

2. What do these changes mean for the future economy and the future worker?

The Australian economy transitioned from an agricultural base to one dominated by the manufacturing sector through to an economy where services and management occupations are the largest employers. The economy successfully embraced technological advancement by adapting and adopting new skills gained through education and training and new job creation. Each major technological wave in modern economic history, after a period of disruption, has generated enough jobs for the workforce.[18]

Chart 3: Australia's New and Lost Jobs by Industry



While innovation may reduce labour demand and lead to unemployment, it also triggers a number of automatic market adjustments that can compensate for the direct decrease in labour demand.

Indeed, the *Australia's future workforce* report noted that the number of jobs created was over six times the number lost in the five years to June 2014.[19]

While new technologies make some jobs redundant, they also raise the demand for others. In the 1920s, passenger cars displaced equestrian travel and the related occupations, but the roadside motel and fast food industries rose up to serve the 'motoring public'. Higher income generated in high-tech industries may also result in higher demand and employment in low-tech services, such as restaurants, cleaning and other personal services.[20]

[18] Autor, D, 'Why Are There Still So Many Jobs? The History and Future of Workplace Automation', Journal of Economic Perspectives, 2015, Vol. 29, No. 3.

[19] Ruthven P., 'Where the jobs are', in in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

[20] OECD 2016, ICTs and jobs: complements or substitutes? The effects of ICT investment on labour demand by skills and by industry in selected OECD countries , Organisation for Economic Co-operation and Development <http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/IIS(2016)1/FINAL&docLanguage=En>

Success in the newer digital environment will result from ensuring workers are equipped with the right skills and environments to flourish. The nature of employment will change dramatically in the coming decades with a decrease in demand for some traditional skills.[21]

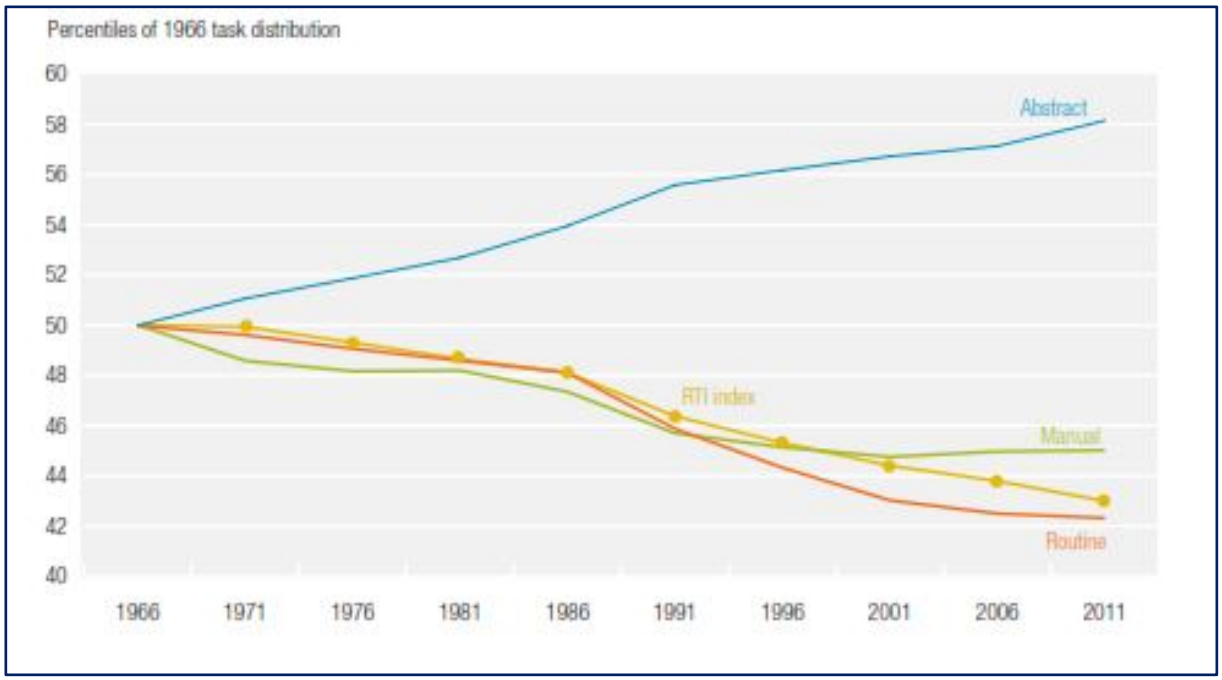
The jobs of the future are likely to be created as individuals, businesses and even nations continue to specialise in the production of certain goods and services. This specialisation will in turn generate the need for more support services. This trend will benefit:

- businesses that bring more specialised employees to perform increasingly niche activities in the global value chain that is emerging,
- individuals who can command higher remuneration for their services, and
- nations that are able to develop value adding specialist goods and services. [22]

Regardless of the longer-term implications, in the short to medium term workers will need to engage more comprehensively with machines as part of their everyday activities. Tighter integration with technology will free up time for workers including managers to focus more fully on activities to which they bring skills that machines have yet to master. This could make work more complex and harder to organise.

The impact will be different for various kinds of workers. Higher-skill workers who either work closely with technology or undertake tasks that complement automation, will be more favourably positioned. The reverse is more likely for lower-skill workers, especially where they are in larger supply.[23]

Chart 4: Measures of the Average Demand for Labour to Complete Tasks 1966 to 2011

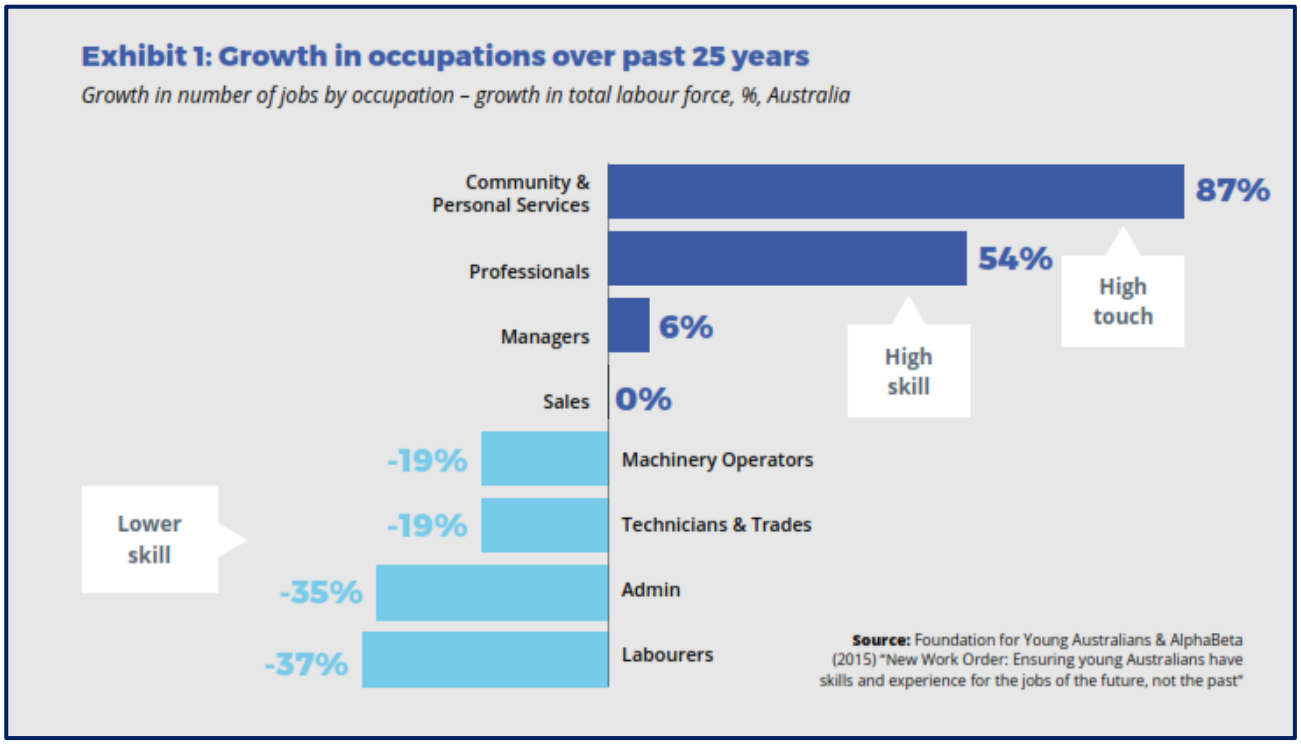


[21] Bradlow, H: 'The impact of emerging technologies in the workforce of the future' in Australia's future workforce, Committee for Economic Development of Australia, June 2015.
[22] Taylor N., 'The industrial revolution's next wave' in Australia's future workforce, Committee for the Economic Development of Australia, June 2015.
[23] McKinsey Global Institute 2017, A Future That Works: Automation, Employment, and Productivity, Executive Summary, January 2017.

The chart highlights the rapid expansion of workplace tasks considered to be 'abstract' and the long-term decrease of tasks that are 'manual' and 'routine'.[24] Automation though, will create an opportunity for those in work to make use of the innate people skills that machines are not able to readily replicate, such as social and emotional capabilities, providing expertise, coaching and developing others and creativity.[25]

The Foundation For Young Australians research has characterised this as growth in 'high skill' and 'high touch' occupations and a decline in lower skill occupations.[26]

Chart 5: Growth in Occupations over the Past 25 Years



While factories increasingly employ the latest smart, connected technologies, human workers remain central to factory performance. Efficiently delivering information to machines that enhances their performance is essential. Some efforts to this end have involved installing stationary PCs or tablets at workstations that, for example provide warehouse workers with inventory data or allow repair technicians to check off completed steps during a maintenance call.

International evidence suggests that labour markets are polarising, with more workers moving into higher and lower skilled jobs than mid-level jobs.[27] Workers that perform manual or cognitive tasks that lend themselves to automation or codification (e.g. book-keeping, monitoring processes, processing information) are, in turn, concentrated in the middle of the wage distribution. Provided that routine and

[24] Borland J. and Coelli M., 'Information Technology and the Australian labour market', in Australia's future workforce, Committee for Economic Development of Australia, June 2015.
[25] McKinsey Global Institute 2017; A Future That Works: Automation, Employment, and Productivity, Executive Summary, January 2017.
[26] The New Basics: Big data reveals the skills that young people need for the New Work Order, Foundation For Young Australians, 2016.
[27] McKinsey Global Institute; Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation, Executive Summary, December 2017.

non-routine tasks are imperfect substitutes, the diffusion of digital technologies increases the demand for jobs with non-routine tasks at the expense of jobs with routine tasks.[28]

High and low-skilled jobs involve tasks that are non-routine, requiring either cognitive capacity or manual labour to complete them. At the high end, these include jobs in managerial and professional occupations, such as those in law, architecture and design, and finance; at the low end, jobs requiring manual labour are found in the construction sector, in installation and maintenance, and in the transportation and shipping sectors.[29]

With the productivity gains and the adoption of technology, new and complementary jobs are likely to be created. Overall, however, the share of middle wage jobs, characterised by routine tasks, has declined and the wage share of the middle-skilled has also contracted. Evidence of temporary job polarisation is also supported by OECD findings which suggest that in periods where labour demand decreases due to ICT, the decrease is stronger for medium-skilled workers than for their high- and low-skilled counterparts.

Workers will need different skills, not just more skills.

Regardless of the precise number of jobs at risk of automation, continued hollowing-out will continue to disrupt the labour market.

[28] OECD 2016, ICTs and jobs: complements or substitutes? The effects of ICT investment on labour demand by skills and by industry in selected OECD countries, Organisation for Economic Co-operation and Development <http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/IIS(2016)1/FINAL&docLanguage=En>

[29] Frey, C and Osborne, M: Technology at Work: The Future of Innovation and Employment, Oxford Martin School and Citi, 2015 http://www.oxformartin.ox.ac.uk/downloads/reports/Citi GPS Technology Work.pdf

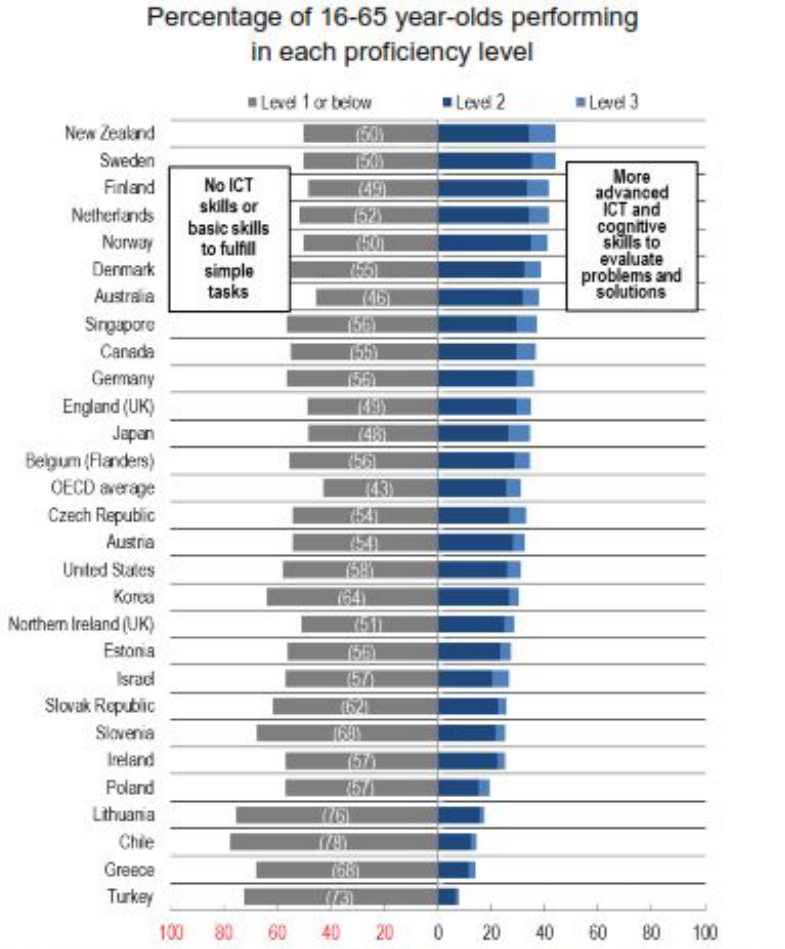
3. What skills are needed for the workplace?

These significant changes in the nature of work are demanding a new range of skills for the modern workforce.

3.1 Digital Literacy Skills

Skills are clearly a fundamental factor in the uptake of digitalisation. Evidence suggests that despite an increasing diffusion of digital technologies in business, a large proportion of people do not effectively use digital technologies at work or do not have adequate ICT skills. The OECD's Survey of Adult Skills indicates that on average more than half of the adult population can only perform the simplest set of computer tasks, or have no ICT skills at all. Only about one third of workers have the skills to evaluate problems and find solutions. Australia's performance is higher than the OECD average in this regard.[30]

Chart 6: Percentage of 16 - 65 year-olds proficiency performance



Notes: Individuals in Level 2 or Level 3 have more advanced ICT and cognitive skills to evaluate problems and solutions than those in Level 1 or below.
Source: OECD (2015c), Survey of Adult Skills (PIAAC) 2015.

To enter the labour market of the future all Australians will need to be literate, numerate and digitally literate. These capabilities will be threshold requirements for most jobs. While numeracy and literacy have long been on the radar for education providers, digital literacy is relatively new.

A challenge is the rapid change in computer software and hardware, which can make learned skills redundant. However, there are likely to be fundamental and enduring concepts of digital literacy which will be important for future job seekers to have mastered.[31]

Increasing use of digital technologies at work is raising the demand for new skills. Workers across an increasing range of occupations need to acquire generic ICT skills to be able to use such technologies in their daily work. The production of ICT products and services – software, web pages, e-commerce, cloud and big data – requires ICT specialist skills to

[30] Skills for a Digital World, OECD, December 2016.
[31] Hajkowicz, S, Reeson, A, Rudd, L, Bratanova, A, Hodgers, L, Mason, C, & Boughen, N, Tomorrow's Digitally Enabled Workforce, Commonwealth Scientific and Industrial Research Organisation, 2016.

programme, develop applications and manage networks.

The former Australian Workforce and Productivity Agency reported that ICT skills and capabilities are important for the whole workforce and not just those engaged in specialist ICT roles. The UK Digital Skills Taskforce developed a framework to address ICT skills required in the workforce. This analysis revealed that almost all of the 30 million members of the workforce will need the ability to use technology. The Taskforce recommended that digital literacy should be a core component of the school curriculum together with English and mathematics.[32]

Table 1: Digital Skill Level Categories

DIGITAL SKILL LEVEL CATEGORIES

Skill level	Definition	Population
Digital muggle	"no digital skills required – digital technology may as well be magic."	2.2 million people (seven per cent of the workforce)
Digital citizen	"the ability to use digital technology purposefully and confidently to communicate, find information and purchase goods/services."	10.8 million people (37 per cent of the workforce)
Digital worker	"at the higher end, the ability to evaluate, configure and use complex digital systems. Elementary programming skills such as scripting are often required for these tasks."	13.6 million people (46 per cent of the workforce)
Digital maker	"skills sufficient to build digital technology (typically software development)."	2.9 million people (10 per cent of the workforce)

Source: UK Parliament Select Committee on Digital Skills – Report of Session 2014–15.

The use of ICT is also changing the way work is carried out and raising the demand for ICT-complementary skills, including the capability to process complex information, communicate with co-workers and clients, solve problems, plan in advance and adjust quickly.

OECD research shows that higher use of ICT at work is associated with tasks that require more interaction with co-workers and clients, more problem solving and less physical work. As ICT is reshaping business models and firms' organisation, the skills required to perform these tasks become more important. Changes in the task set associated with increasing use of ICT tend to be larger for people in low-skilled occupations than for those in middle-skill and high-skill occupations. The need for re-skilling is likely to be larger for those people that educational and training systems have more trouble reaching.

Future jobs will require a focus on generic or employability skills; skills that build a broader set of 'capabilities' that can be rapidly applied to other work environments. A greater focus on skills that are

[32] Beitz, S., 'Developing the capacity to adapt to industry transformation', in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

transferable – and that enable the development of high levels of technical capability underpinned by a strong foundation of broad based vocational knowledge - is critical.[33]

The World Economic Forum's 2016 Human Capital Report discusses the need for skills diversity in the new world of work, and suggests that the dichotomy between humanities and sciences is becoming obsolete, instead focussing on the breadth of skills needed to be developed in higher education systems. [34] It is interesting to note that in the 2017 report, while Australia ranked 20th overall, the ranking for the skill diversity of graduates in the 15 – 24 age group was 75th.[35]

One of the challenges faced by employers is the ways in which some disciplines are coming together. While businesses often look for employees based on specific knowledge and skill sets, many of the required skills can be generic: the skills required to perform in a particular role can be possessed by graduates from a range of different disciplines.

By recognising this, and being prepared to recruit new employees from disciplines that may not traditionally be perceived as being aligned to a given occupation, businesses can bring in new knowledge and ideas that can be applied creatively to problems in innovative ways. Even traditionally labour intensive occupations such as nursing or aged care are likely to require an ability to work with computers and operate complex machines. Similarly, an electrician will need to understand, and be able to connect, the multiple devices and smart systems of future homes.

Full or partial automation will result in labour displacement, and it will be important to support workers as they transition from one set of activities to another. As work evolves at higher rates of change between sectors, locations, activities, and skill requirements, many workers will need retraining in adjusting to the new age. Up-skilling will be part of the solution to job polarisation, but workers will also need different sorts of skill-sets.[36]

The remaining middle-skill jobs in the future will combine routine technical tasks with the set of non-routine tasks in which workers hold comparative advantage: interpersonal interaction, flexibility, adaptability, and problem solving.[37] Those whose skill sets are entirely oriented towards the jobs that are disappearing may find themselves both unemployed and unemployable. As we have seen in the past when large dominant industries have died, for example the Australian automotive industry, it can be difficult for people to retrain for work that is unfamiliar.

It is uncertain if wages will accelerate at both ends of the skill distribution. The reason is that while it may be possible for workers to quickly 'skill down' by giving up an automated middle-skill job to take a lower-

[33] CEEMET Position Paper on the New Skills Agenda for Europe, 27 February 2017. http://www.ceemet.org/sites/default/files/ceemet_-_position_paper_on_the_new_skills_agenda_for_europe.pdf
[34] The Human Capital Report 2016, World Economic Forum.
[35] The Global Human Capital Report 2017, preparing people for the future of work, World Economic Forum, 2017, page 62.
[36] OECD 2017, Key Issues for Digital Transformation in the G20, G20 German Presidency/ OECD, <https://www.oecd.org/g20/key-issues-for-digital-transformation-in-the-g20.pdf>
[37] Autor, D, 'Why Are There Still So Many Jobs? The History and Future of Workplace Automation', Journal of Economic Perspectives, 2015, Vol. 29, No. 3.

skilled job which is more heavily in demand in the labour market – it may not be as easy for them to 'skill up' to take higher-skilled jobs for which wages are accelerating.

To skill up requires cognitive capacity, which tends to come about from education and job training that can be a slow-moving process. These changes have been described as a 'race between technology and education.' The former occurs rapidly and disruptively; the latter very slowly. The end result is that additional labour supply keeps wage growth relatively muted at the bottom, while its absence causes wages to accelerate quickly at the top.[38]

Although the effects on job polarisation remain unclear, there is broad recognition that the shift from routine to non-routine tasks is likely to remain a long-term feature of labour demand in the digital economy.[39]

3.2 Management Capabilities

Businesses that prepare managers as leaders and decision-makers adept at dealing with uncertainty and constantly changing landscapes are more likely to succeed in a networked-knowledge economy.[40] Strong leadership committed to change and to adopting digital transformation is needed to lead an organisation's workforce through change. To understand and recognise the upcoming changes in digitalisation and automation, leaders of businesses need to identify where their own organisations will be transformed and then put in place plans to migrate to new business processes enabled by digitalisation. A digital strategy needs to be developed, with a key component the digital skills capability and development of the company's workforce.

Leadership and management capability is the driver that enables companies to steer the interconnectivity between systems, machines and people – across companies, countries and value networks. Managers need to develop the digital strategies required, develop workforces with proficiency in problem solving in technology rich environments and ensure workers continue to utilise their information processing skills.

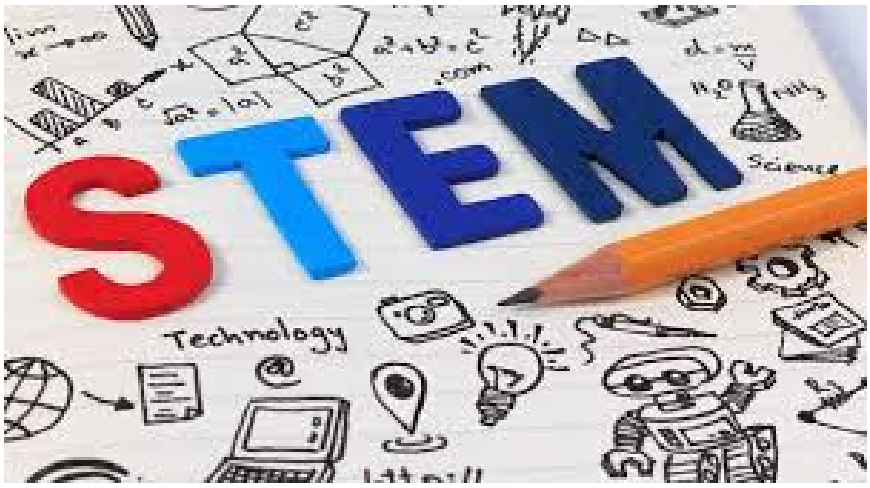
The key workplace dynamics needed to ensure any skills are utilised include effective leadership and management, advanced HR practices, communication and consultation, and employee commitment and motivation.[41] Team work, autonomy, task direction, mentoring, job rotation and applying new learning all play a part.

[38] Frey, C and Osborne, M: Technology at Work: The Future of Innovation and Employment, Oxford Martin School and Citi, 2015 http://www.oxformartin.ox.ac.uk/downloads/reports/Citi GPS Technology Work.pdf
[39] Key issues for Digital Transformation in the G20, OECD, 2017.
[40] The Future of Management Education, Final Report, Australian Business Deans Council, 2014.
[41] Chui, M, Manyika J, Meremadi M, 2016, 'Where machines could replace humans—and where they can't (yet)', McKinsey Quarterly, <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet?cid=other-eml-ttn-mkq-mck-oth-1612>

The greater challenges for leaders are the workforce and organisational changes that will have to be put in place as automation upends entire business processes, as well as the cultures of organisations. The digital economy requires a change in the way work is done and managed. In the past, much of the role of a senior manager called on their expertise and knowledge. The role increasingly focuses on the ability to locate knowledge, assess its validity and apply it in collaboration with other people.

Being aware of the activities that are most likely to change from a technical perspective allows managers to rethink how workers engage with their jobs and how digital platforms can better connect workplaces. This will also assist managers to understand how many of their own activities could be more efficiently undertaken by machines so they can focus on the core competencies that new technology is yet to master. Leadership in the digital economy is leadership for learning; it is collective leadership.[42]

Another new management challenge in a world where knowledge is dispersed across companies, industries and countries is the globalisation of innovation. The increasing geographic dispersion of knowledge, research and development also requires new forms of collaboration and levels of coordination by managers.



3.3 STEM Skills

STEM (Science, Technology, Engineering and Mathematics) skills will be required in many of the higher-skilled jobs of the future. As technology becomes more advanced and more complex, STEM capabilities will increasingly become an entry level requirement. 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.[43] International research indicates that 75 per cent of the fastest growing occupations require STEM skills and knowledge.[44] Employment in STEM occupations is projected to grow at almost twice the pace of other occupations.[45] Despite these findings, the Australian Council of Learned Academies (ACOLA) reports that:

> *" … 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."*[46]

[42] Tapscott, D, The Digital Economy – Promise and Peril in the Age of Networked Intelligence, 1997.
[43] Science, Technology, Engineering and Mathematics: Australia's Future, Office of the Chief Scientist, September 2014, page 7.
[44] Becker, K. and Park, K.; Effects of integrative approaches among STEM subjects on students' learning, Journal of STEM Education 12, July – September 2011.
[45] 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.
[46] STEM: Country Comparisons, Final Report, Australian Council of Learned Academies, May 2013, page 15.

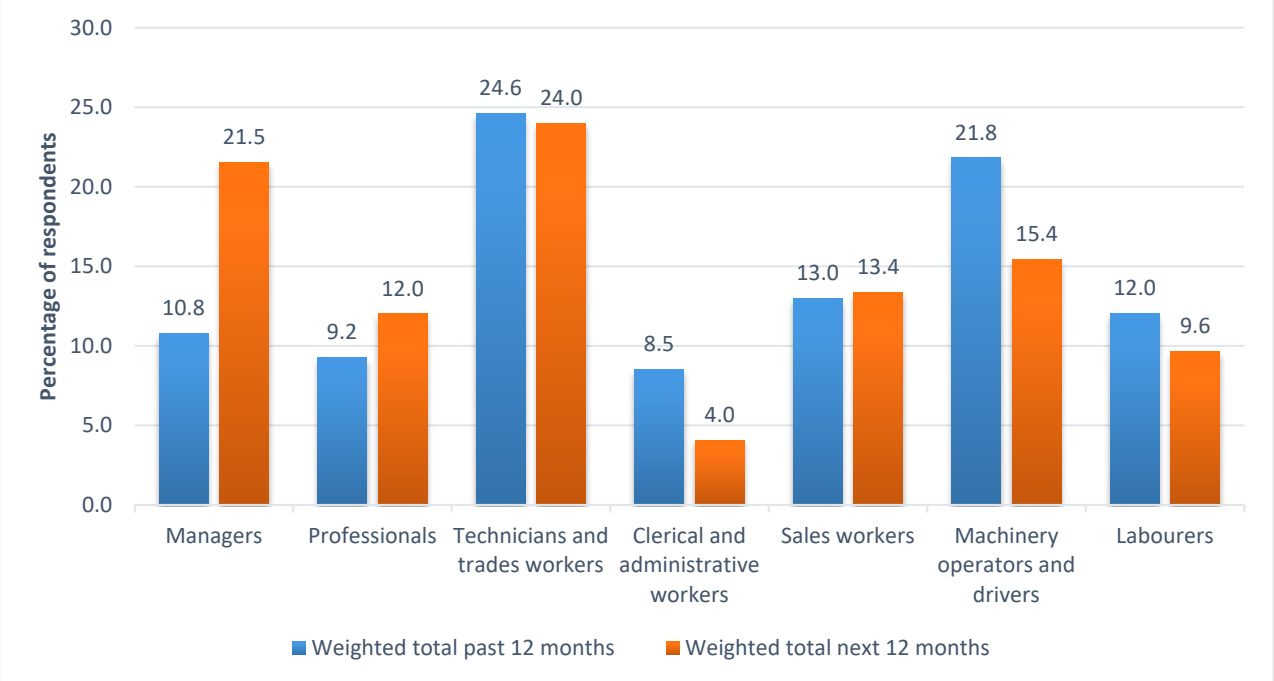
The Australian Bureau of Statistics (ABS) released a report *Perspectives on education and training: Australians with qualifications in science, technology, engineering and mathematics (STEM), 2010-11* demonstrating that STEM skills jobs such as scientists, ICT professionals and engineers, grew about 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."* [47]

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.

Chart 7: Difficulties recruiting people with STEM skills



In terms of occupation groups, in 2016 Technicians and Trade Workers were the most difficult to recruit over the previous 12 months (24.6 per cent) and were expected to be the most difficult for the next 12 months (24 per cent). Machinery Operators and Drivers as an occupation category were difficult to recruit over the past 12 months (21.8 per cent) although this was expected to ease in the following year (15.4 per

[47] Media Release, Qualifications paying off in science, technology, engineering and maths, Australian Bureau of Statistics, 24 February 2014.

cent). The largest anticipated increase in recruiting difficulty for the next 12 months was Managers (21.5 per cent) up from 10.8 per cent.[48]

When consideration is given to individual sectors the anticipated difficulty of recruiting Technicians and Trade Workers increases significantly. The level of expected difficulty was 30.2 per cent in manufacturing and 29 per cent in construction.

These results are similar to those found by Deloitte Access Economics in a report to the Commonwealth Office of the Chief Scientist.[49] In this instance employers were required to agree or disagree with the provided statements. Overall, 40.4 per cent of respondents had difficulty recruiting people with STEM qualifications for technician and trade worker roles and 31.5 per cent had difficulty recruiting STEM graduates.

3.4 Skills for Industry 4.0

The term Industry 4.0 encompasses the digitalisation of production processes based on devices autonomously communicating with each other along a value chain. This means that skills requirements for Industry 4.0 are more interdisciplinary than those for basic digital literacy. So significantly higher demands are placed on all members of the workforce in terms of managing complexity and higher levels of abstraction and problem solving .[50]

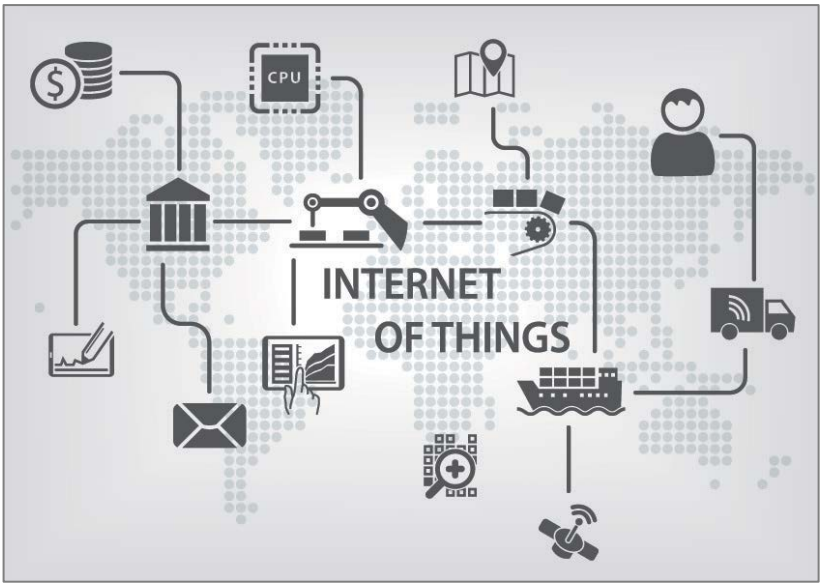
A PwC 2016 Global Industry 4.0 Survey revealed that half of the companies identified a lack of digital culture and training as a major challenge.

"Therefore, the main issue for most firms today turns out to be the recruitment, tenure and training of people with the appropriate skills rather than the adoption of a particular technology."[51]

Australian companies require a workforce which combines disciplinary and/or technological expertise with the ability to effectively and efficiently integrate various knowledge bases and skill sets including team building capacity, emotional intelligence, strategic visioning, market analysis and cultural sensitivity.[52]

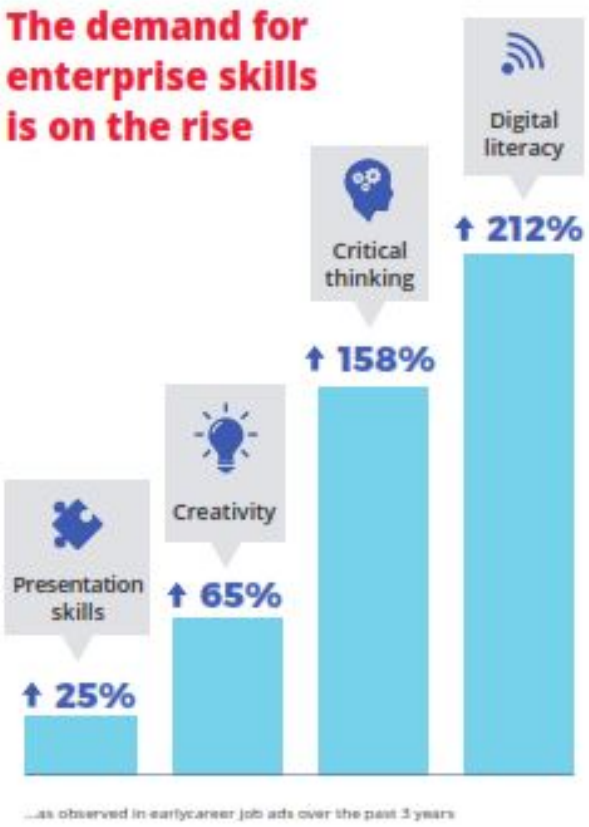
[48] Workforce Development Needs Survey Report, Australian Industry Group, December 2016.
[49] Australia's STEM workforce: a survey of employers, Office of the Chief Scientist and Deloitte Access Economics, Deloitte Access Economics Pty Ltd, 2014, page 36.
[50] OECD, 2017, Key Issues for Digital Transformation in the G20, G20 German Presidency/ OECD, <https://www.oecd.org/g20/key-issues-for-digital-transformation-in-the-g20.pdf
[51] OECD, 2017, Key Issues for Digital Transformation in the G20, G20 German Presidency/ OECD, <https://www.oecd.org/g20/key-issues-for-digital-transformation-in-the-g20.pdf
[52] OECD, 2017, Key Issues for Digital Transformation in the G20, G20 German Presidency/ OECD, <https://www.oecd.org/g20/key-issues-for-digital-transformation-in-the-g20.pdf

The Ai Group is leading a nationally significant pilot to introduce Industry 4.0 higher apprenticeships into Australia. In partnership with Siemens Ltd and Swinburne University of Technology the project is utilising the apprenticeship mode to deliver new qualifications in a Diploma and Associate Degree in Applied Technologies. The qualification meets the particular needs of industry with a focus on the adoption of high-level technology skills and the tools required for the future workforce.[53]



3.5 Enterprise and Entrepreneurial Skills

Enterprise and entrepreneurs are the driving force behind a significant portion of the innovation, productivity growth and new employment opportunities in today's business environment, and are key factors in economic growth. It follows that workers with these capabilities are needed in the digital economy. Enterprise skills are transferable skills that enable people to engage with a complex world and navigate the challenges they will inherit. These essential skills have had a number of descriptions over the years including 21st century skills. Regardless of what they are called, they are skills that are required in many jobs. The Foundation For Young Australians in their research of job vacancies has found that employers are increasingly looking for digital literacy, critical thinking and creativity in the workplace. They have been found to be a powerful predictor of long-term job success.[54]



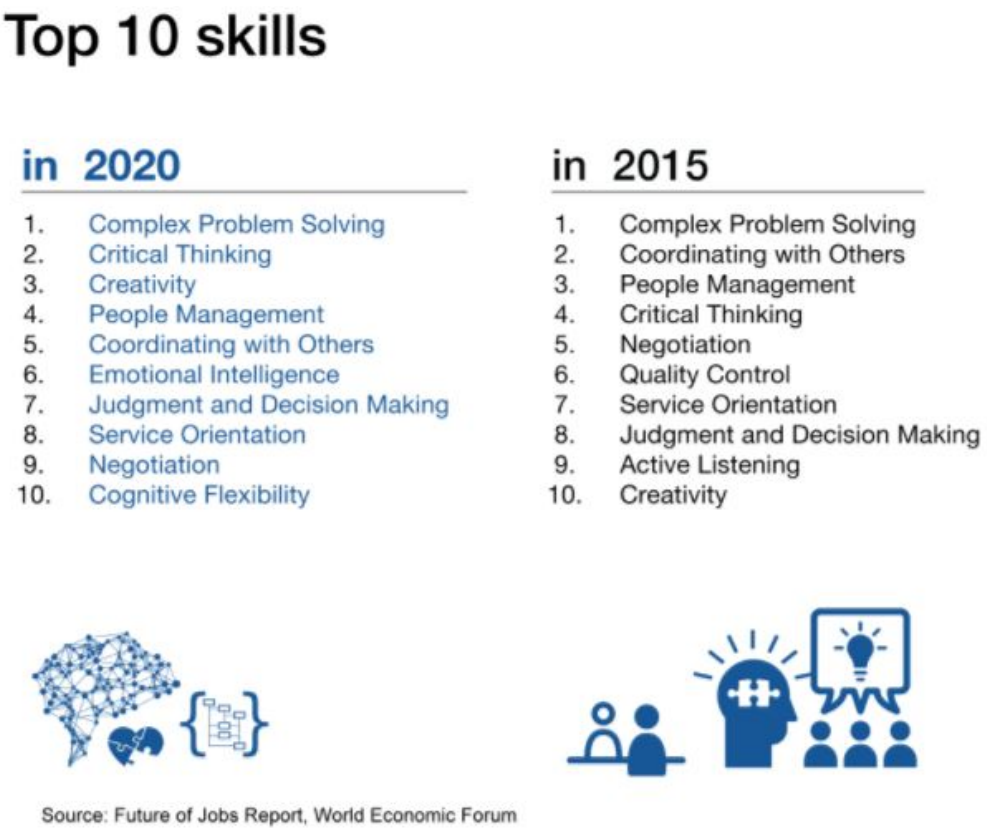
Skills classified as enterprise skills include: problem solving, communication skills, digital literacy, teamwork, presentation skills, critical

[53] Lilly, M.: The Future of Australian Apprenticeships, Australian Industry Group, October 2016.
[54] The New Basics: Big data reveals the skills young people need for the New Work Order, The Foundation for Young Australians, Melbourne, Australia, 2016.

thinking, creativity, financial literacy. They represent higher level thinking skills.[55]

Workers with entrepreneurial skills have the initiative to take predicted current and future needs and combine them with good ideas that lead to innovation in an organisation. Through their characteristics of self-reliance, optimism and risk appetite they can help contribute to 'start-up' cultures within their own organisations, or as consultants to organisations.

It has been estimated that five years from now over one third of the workforce skills considered important will have changed.[56] In particular, the rapid advancement of the Fourth Industrial Revolution with its associated technologies will transform the nature of work. The 'Top 10 skills' listed by the World Economic Forum in 2015 are anticipated to change by 2020. While 'Complex Problem Solving' remains at the top, "Critical Thinking', 'Creativity', 'Emotional Intelligence' and 'Cognitive Flexibility' will become increasingly important.



[55] The New Basics: Big data reveals the skills young people need for the New Work Order, The Foundation for Young Australians, Melbourne, Australia, 2016.
[56] www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/

4. How can education and training develop the capability that industry needs?

4.1 What new approaches to skills development are needed in the new economy?

Education and training has been identified as one of the most critical factors shaping workforce outcomes in the future. Future employment requires high levels of knowledge and skills and continual investment in education is required in order to deal with the rate of change brought about by developments in digital technology. Accordingly, new approaches to education, training, re-skilling and skills use throughout the economy will be key to maximising the benefits of a digital and inclusive economy [57]

The skill composition of the workforce has a direct impact on the performance of companies, including the competitiveness of industries and economies in global value chains. The comparative advantage of an economy does not depend on a specific set of skills but rather on the way these skills are distributed among workers.[58]

In addition, the demands of the digital economy are leading to a renewed focus on workplace learning and lifelong learning.

> *In order to enable this kind of flexibility, the workforce needs to be prepared for life-long learning, both through workplace training and other forms of education. As the labour force and economy evolve over time, people must be able to continuously undertake training and development activities to enable further innovation.*[59]

Some employment will require the acquisition of a new skill set and the skill sets of many occupations must be transferable to other occupations. These transferable skill sets required to be successful in the changing workplace include skills in problem solving and critical thinking, communicating and engaging, science, maths and technology knowledge.[60]

Changes in the demand for skills driven by the digital economy present two major challenges to skills development. Whilst there is awareness that the skills profile of the population will be very different from the past, the skills of the future are difficult to identify with certainty due to fast technological change in the digital economy. The challenge is to ensure that once changes in skills have been identified, skills development systems adjust sufficiently fast to match new skill demands.[61]

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[57] Hajkowicz, S, Reeson, A, Rudd, L, Bratanova, A, Hodgers, L, Mason, C, & Boughen, N, Tomorrow's Digitally Enabled Workforce, Commonwealth Scientific and Industrial Research Organisation, 2016.
[58] OECD, 2017, Key Issues for Digital Transformation in the G20, G20 German Presidency/ OECD, <https://www.oecd.org/g20/key-issues-for-digital-transformation-in-the-g20.pdf
[59] Hajkowicz, S, Reeson, A, Rudd, L, Bratanova, A, Hodgers, L, Mason, C, & Boughen, N, Tomorrow's Digitally Enabled Workforce, Commonwealth Scientific and Industrial Research Organisation, 2016.
[60] The New Work Smarts: Thriving in the New Work Order, The Foundation for Young Australians, Melbourne, Australia, 2017.
[61] The New Work Smarts: Thriving in the New Work Order, The Foundation for Young Australians, Melbourne, Australia, July2017.

The high demand for enterprise skills underscores the importance of general capabilities being retained and elevated in the curriculum. A number of countries around the world have taken steps to redesign their curriculum and explicitly embed 21st Century competencies and enterprise skills like problem solving, collaboration, global awareness and communication skills into the curriculum. Greater efforts are needed to raise the skills of those adults with weak literacy, numeracy and digital skills to enable them to fully participate in the digital economy and society. At the same time, digital technologies are creating new opportunities for skills development.

Education and training that involves work-based learning in the VET sector and work-integrated learning in the higher education sector enables students to engage with employers as part of their studies, and can help improve employment outcomes by ensuring that new entrants to the workforce are gaining skills and experience that are work relevant.[62]

These arrangements have a secondary benefit of creating closer links between employers and education providers, which can inform the relevance and currency of the education curriculum. To prepare workers for the digitalisation of the economy, businesses will benefit from working with educators and governments to assist education and training systems keep up with the needs of the labour market.[63]

4.2 School Education

In the school education sector attention is required in three key areas.

4.2.1 Digital and ICT Literacy

Digital competency will need to become a basic competency for all workers. Workers will require a deeper digital literacy, which will need to be a crucial element of school education, separate from subjects in ICT, technology and computer science.[64] It needs to be included as a core component of school education, both in terms of content and delivery, as distinct from the teaching of specialised ICT, technology and computer science subjects.

The World Economic Forum has noted:

> *"Many of today's education systems are already disconnected from the skills needed to function in today's labour markets and the exponential rate of technological and economic change is further increasing the gap between education and labour markets. Furthermore, the premise of current education systems is on developing cognitive skills, yet behavioural and non-cognitive skills that nurture an individual's capacity to collaborate, innovate, self-direct and problem-solve are increasingly important."*[65]

[62] The New Work Smarts: Thriving in the New Work Order, The Foundation for Young Australians, Melbourne, Australia, 2017.
[63] The Global Human Capital Report 2017, World Economic Forum, 2017.
[64] Taylor N., 'The industrial revolution's next wave' in Australia's future workforce, Committee for the Economic Development of Australia, June 2015.
[65] The Global Human Capital Report 2017, World Economic Forum, 2017, page 34.

The most recent National Assessment Program for ICT literacy in schools has produced some concerning results. Every three years since 2005 a national sample of Year 6 and Year 10 students have been tested to assess their ICT knowledge, understanding and skills. The 2014 report shows a significant decline in ICT literacy performance for both cohorts compared to previous cycles. ACARA itself has concluded:

> *"These declines in performance are concerning and warrant serious attention."*[66]

As demand for workers with ICT skills is expected to increase over the coming years, ICT education in Australian schools will be crucial, both for building the foundation ICT skills required of the future Australian workforce, and for increasing students' interest in studying ICT to ensure that the supply of ICT workers can keep pace with the rising demand.[67] The focus will also be on improving basic skills through the school system and putting a new emphasis on capabilities that are among the most difficult to automate, including creativity, understanding human emotions, and coaching others.

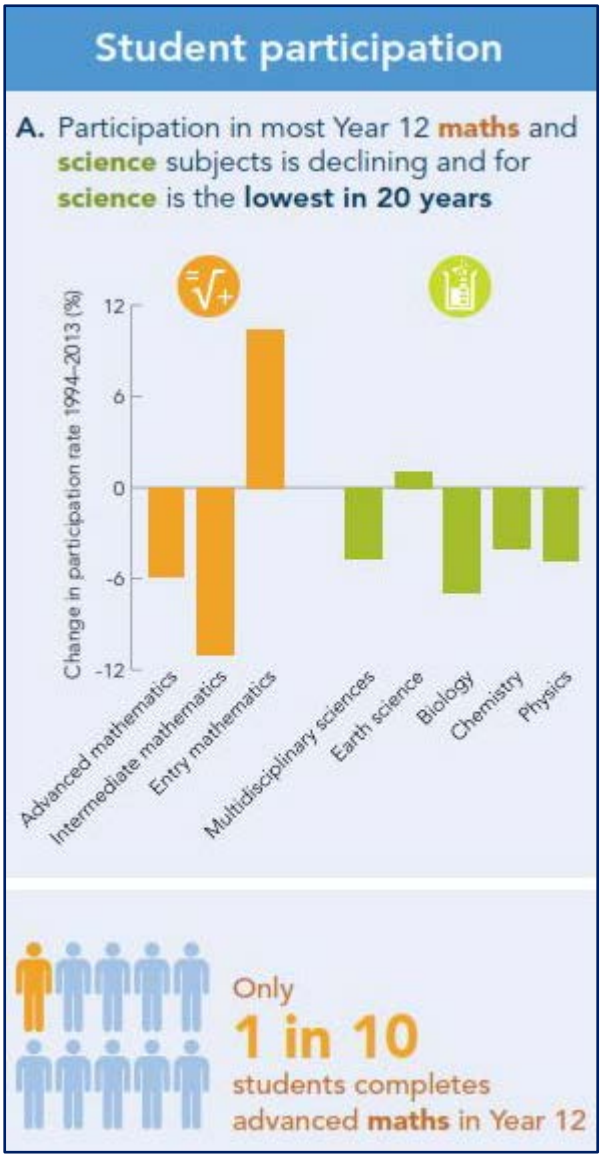
In its report into the future demand for ICT skills, the Australian Workforce and Productivity Agency noted that digital skills and capabilities are important for all workers, not just those engaged in specialist ICT roles. It found that digital literacy needs to be included as a core component of school education, both in terms of content and delivery, as distinct from the teaching of specialised ICT, technology and computer science subjects. The teaching of digital literacy skills must continue into tertiary education and be a core component of ongoing workplace skills development.[68]

4.2.2 STEM Education

Ai Group's long-standing concerns about the state of STEM skills and the impact on the economy are well documented.[69] The Office of the Chief Scientist has documented the decline in the proportion of Year 12 students undertaking STEM-related studies in science and mathematics.[70]

Despite increasing levels of Year 12 enrolments during this period the participation rates in physics, chemistry and biology all declined. Participation in entry mathematics increased however there have been steady decreases in both intermediate and advanced mathematics. This decreasing level of participation has flow on effects to both the VET and higher education sectors.

[66] National Assessment Program – ICT Literacy Years 6 & 10, report 2014, Australian Curriculum and Assessment Authority, 2015.
[67] Australia' Digital Pulse: Key Challenges for our nation - digital skills, jobs and education, Deloitte Access Economics, Sydney, 2015.
[68] Beitz, S., 'Developing the capacity to adapt to industry transformation', in Australia's future workforce, Committee for Economic Development of Australia, June 2015.
[69] Progressing STEM Skills in Australia, Australian Industry Group, February 2015.
[70] Science and Maths in Australian Secondary Schools, Datasheet 2, Office of the Chief Scientist, Australian Government, December 2017.



This is only one measure of concern about school-based STEM. A related concern is the poor performance by Australian school students in international tests of mathematics and science. The most recent Trends in Mathematics and Science Study (TIMSS) indicates that Australia's performance has stagnated over the last decade. Of particular concern is the result that 30 per cent of Australian Year 4 students were achieving only at the low international benchmark.[71] The results are no better in the Programme for International Student Assessment (PISA) of the mathematics skills of 15 year-olds. Australia's mean mathematical literacy performance declined significantly between PISA 2003 and PISA 2012 by the equivalent of more than a half year of schooling.[72]

Recent research by the Ai Group piloted a number of approaches for school – industry STEM partnerships. Models of partnership have been identified as well as the need for education systems to provide more professional development and support for teachers to implement school-based STEM initiatives in conjunction with employers.[73] Initiatives such as these need to be implemented to enable school students to prepare for the workforce with an increased emphasis on STEM skills.

4.2.3 Literacy and Numeracy

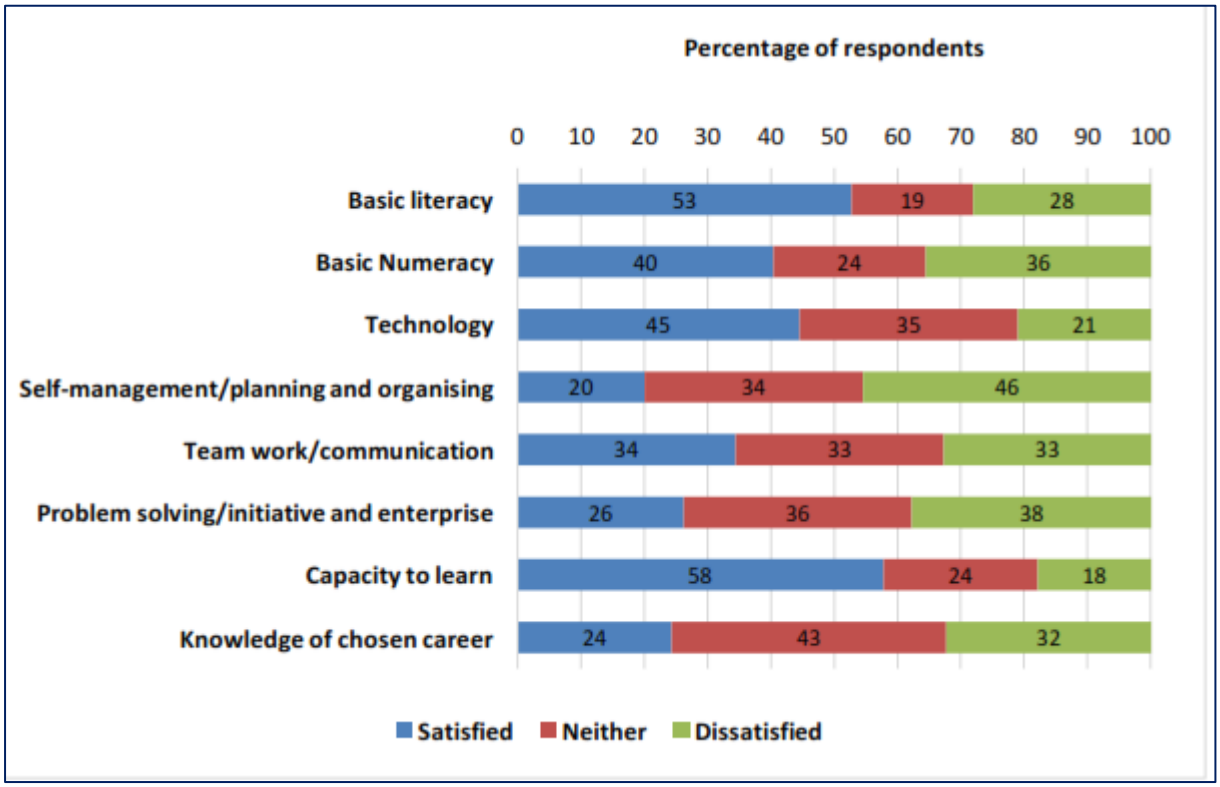
Ai Group regularly surveys employers about a range of skill issues including the literacy and numeracy levels of those seeking employment. In the most recent survey employers expressed dissatisfaction with the levels of literacy and numeracy of school leavers as well a number of broad employability skills.[74]

The levels of dissatisfaction are much higher across a wider range of skills compared to the Higher Education and VET sectors. The level of dissatisfaction is high with both basic numeracy (36 per cent) and basic literacy and the use of English (28 per cent).

[71] Sue Thompson et al., Highlights from TIMSS and PIRLS 2011 from Australia's perspective, Australian Council for Educational Research, 2012.
[72] Media Release, 3 December 2013, Latest PISA results 'cause for concern', says ACER.
[73] Strengthening School-Industry STEM Skills Partnerships, Australian Industry Group, June 2017.
[74] Workforce Development Needs Survey Report, Australian Industry Group, December 2016.

In addition, dissatisfaction was reported for a range of employability skills including self-management, planning and organising (46 per cent); problem solving, initiative and enterprise (38 per cent) and team work and communication (33 per cent).

Chart 8: Levels of satisfaction with school leavers



This concern is further highlighted through the release of the most recent results of the 2017 National Assessment Program – Literacy and Numeracy (NAPLAN) tests. This year's results are particularly interesting as they represent ten years of national testing. Overall there has been little improvement in the proportion of students meeting national minimum standards across the five domains of reading, writing, spelling, grammar and punctuation. Also, the performance in numeracy has either flatlined or declined across most year groups since last year.

Boys performed worse than girls in all domains across all year groups. Year 7 boys are performing poorly, with 17 per cent across the country not meeting the minimum standard in writing, compared to 7 per cent of Year 7 girls. The literacy results for Year 9 students are also in decline with 24.6 per cent of boys and 18.4 per cent of all students failing to meet the band 6 national minimum standard in this year's writing test. There has been no significant difference in achievement in any domain (reading, writing, language conventions, numeracy) or year level (3,5,7 and 9) in the last year.[75]

The trajectory of these results indicates concerns about the preparedness of our school students for the workforce when they complete their schooling. This is particularly so given our well documented poor performance in international tests such as PISA and TIMSS.

[75] http://www.nap.edu.au/results-and-reports/national-reports

4.3 Vocational Education and Training

Notwithstanding recent challenges of funding and quality, the VET sector has a large role to play in the training of workers for the digital economy. The impact of digital disruption requires that many workers will need to re-skill to continue to meet the needs of the economy. This will require a shift in the nature and level of skills that the VET sector will need to provide. In particular, growth is being experienced in more highly-skilled occupations and in the service sector.[76] It is clear that digital literacy will be increasingly important for all workers.

The VET sector, driven by industry standards has work-based learning at its core. Work-based learning occurs in a work environment, through participation in work practices and processes. This mode of learning must be strengthened in the new economy through closer connections between employers and training providers. Effective relationships between the sectors are reliant on clear information, ongoing communication, flexibility with approach, skilled trainers, engaged students and businesses committed to driving work-based learning within their organisations.[77]

The NCVER'S working paper, *Developing appropriate workforce skills for Australia's emerging digital economy*, indicates the VET system contains a significant amount of digital training content spread across different units of competence and training packages. This research considered a sample of eleven training packages.[78] This table shows the total number of units of competency in each training package and the number that contain some digital skills content. The Paper notes however that a large number of the units are elective rather than core to the qualifications. Given their growing importance, a shift to core status for many of these units could enable digital integration with other competency development.

Table 2: Distribution of digital skills containing unique units of competency across training packages

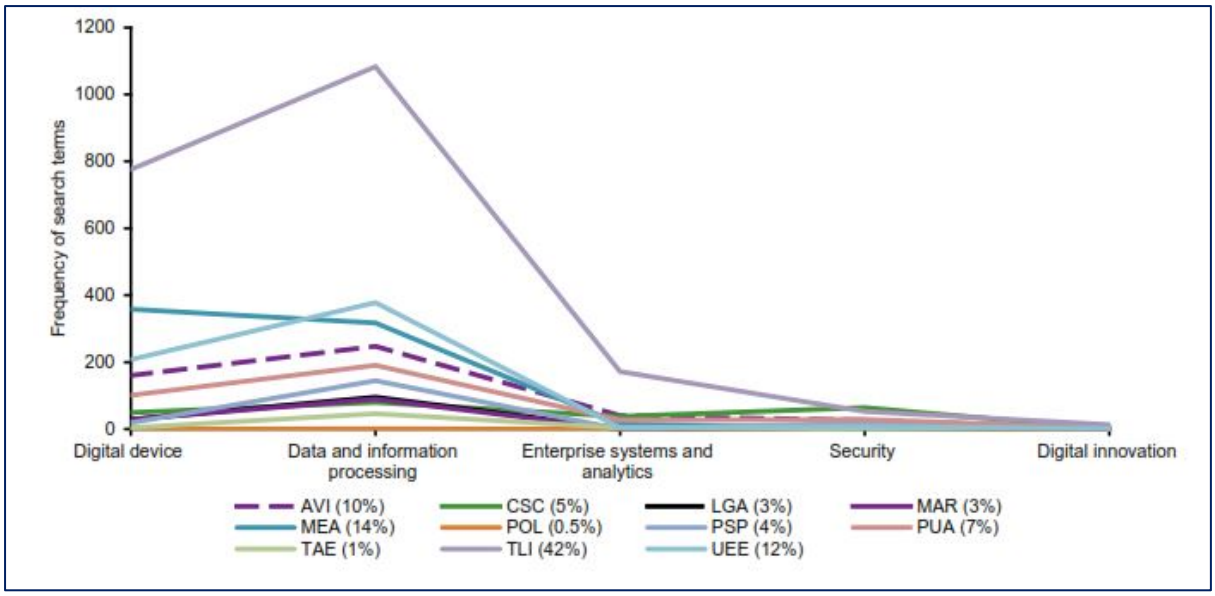
Training package	Total units	No. of units containing digital skills search terms
TLI – Transport and Logistics Training Package	706	241
UEE11 – Electrotechnology Training Package	612	54
PUA12 – Public Safety Training Package	431	75
PSP – Public Sector Training Package	396	28
MEA – Aeroskills Training Package	262	117
LGA – Local Government Training Package	223	40
AVI – Aviation Training Package	212	98
MAR – Maritime Training Package	199	39
Pol – Police Training Package	141	3
CSC – Correctional Services Training Package	95	51
TAE – Training and Education Training Package	54	10
Total	**3331**	**758**

While this analysis indicates a significant presence of digital skills, most of the content refers to digital device use and information processing rather than other types of digital skills. This is perhaps surprising given the assumption of the increasing importance of digital skills to the workforce and the economy. This lack of a focus on skills relating to enterprise systems and analytics, security and

[76] Reeson, A. et al: The VET Era, Equipping Australia's workforce for the future digital economy, CSIRO, 2016.
[77] Atkinson, G, Work-based learning and work-integrated learning: fostering engagement with employers, NCVER, 2016.
[78] Gekara V. et al: Developing appropriate workforce skills for Australia's emerging digital economy: working paper, NCVER, Commonwealth of Australia, 2017.

digital innovation suggests that the digital skills description occurred at the lower levels of basic operations. Whether this indicates an assumption that higher skills occupations already have the necessary skills, digital skills still need to be integrated at higher levels.

Chart 9: Distribution of digital skills across training packages



This research also notes that the training packages lack skills related to social media, social networks, big data analytics, online collaboration, online security, data breach, digital risk and process innovation.[79]

4.4 Higher Education

Higher education provides the high-level skills and research base and a culture of enquiry and innovation that the new economy needs. It is one of the key enablers in the development of our human capital and is crucial to the business sector.

The higher education sector is largely responsible for the development of the high-level STEM-based advanced technology knowledge and skills increasingly required in many workplaces. Australian Government data show that from 2011-2016 the proportion of university students in STEM related fields of education including natural sciences, information technology and health increased, while they decreased in architecture, environmental and related studies.[80]

Regardless of discipline, graduates will need to be sophisticatedly technically proficient, with higher level cognitive skills in, for example, analytics, applications, network management, security and privacy. Dealing with global interconnectedness and automation needs intellectual openness, being able to work in a business in real and virtual ways, and with artificial beings through human-machine interfaces. Problem solving, creativity, communication, collaboration, adaptability and initiative will increasingly need to be all part of the package.

[79] Gekara V. et al: Developing appropriate workforce skills for Australia's emerging digital economy: working paper, NCVER, Commonwealth of Australia, 2017, page 32.
[80] Higher Education Student Data, Australian Government, 2017.

4.4.1 Industry – university cooperation

The current transforming economy, with a faster fusion of technologies evolving at an exponential pace, means that university graduates need to be work ready, preferably having experienced time in industry. There has been goodwill and agreement across the education and business sectors for some years now driving greater employability by exposing students to authentic work environments as the foundation of their course experience. Their involvement should preferably build in interacting with people and systems, self-managing and working in teams – the areas in which employers have found graduates can be lacking.[81]

Acknowledging employability skills are built over time through a number of complementary activities, universities now include a major strategy to drive employability through work integrated learning models. Work integrated learning is an umbrella term for a range of approaches and strategies that integrate theory with the practice of work within a purposefully designed curriculum.[82] Whilst the number of innovative arrangements for cooperation is increasing – not only around work integrated learning but for research and development – opportunities for students need to increase through greater and broader collaboration between universities and industry.

Ai Group has championed work integrated learning, through our work on the National Strategy for Work Integrated Learning in University Education, our representation on a number of national WIL projects, and our guide for employers which outlines benefits to companies, provides tips and project ideas, outlines legal requirements and lists university contacts.

The models of connection between industry and higher education providers will need to become even closer as change becomes quicker. Shared campus/business operations well established in some areas must become more widespread. The diverse nature of industry is relevant to the search for ways that the two sectors can better connect. The capacities and resources of large, medium and small businesses to collaborate is broad and different. Many large companies have long standing projects with universities and operate placement programs, or share facilities. Smaller companies do not always have the resources to take long placements, but they may be able to offer less resource intensive engagements such as a visit/tour of the workplace or be a guest speaker at a lecture once a

[81] Workforce Development Needs Survey Report, Australian Industry Group, December 2016.
[82] Patrick, Peach and Pocknee, The WIL (Work Integrated Learning) Report: a national scoping study, Australian Teaching and Learning Council, 2009.

year. These are minor activities but can be embedded into the curriculum as work integrated learning, and still offer some exposure for students. Working with employers to ensure these smaller engagements can be designed to encourage as much student reflection as possible will assist the development of both discipline-related and enterprise skills.

Relationships developed at the local level between universities and businesses allow for the exploration of engagements that are not too onerous for each particular business. Where universities establish flexible and differentiated strategies these are more likely to develop into cooperative long-term relationships. Innovative models of collaboration being applied across the higher education sector include micro-internships,[83] virtual placements, students operating incubators for start-ups, and students researching issues for SMEs. Connections can also be made through the online services connecting businesses with students. Given that local regions are also an important factor in collaboration, some local councils and agencies are acting as intermediaries for SMEs to connect with students.

Ai Group's 2016 Skills Survey asked employers what support they need when considering engaging university students. One third said they need information on supervising/mentoring students, 28 per cent a relevant point of contact at universities, 26 per cent examples of student activities that could assist the business, and 13 per cent information on legal requirements.[84]

Our Survey also found that of those employers that had links with HE providers, it was across a range of activities: 30 per cent provide placements, 23 per cent provide talks/tours or shadowing, 15 per cent said they input to the design of student programs with universities, and 15 per cent partner for research. Ai Group's employer guide has helped to address these fundamentals but it needs to be part of a broader framework for future collaboration.[85]

4.4.2 Leadership and management development

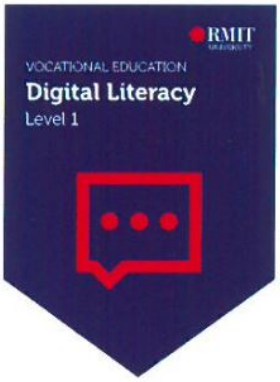
The higher education sector plays a key role in leadership and management development through various business faculties. These skills are particularly important in driving the digital innovation and organisational change needed at the firm level in the new economy. Managers need to be able to manage workforces through different ways of working. The ability to apply systems thinking and effectively manage new processes for people and machines will be more crucial than ever. Universities must enable leaders to be open to and adapt to automation advances and to develop digital strategies involving change management for their organisations.

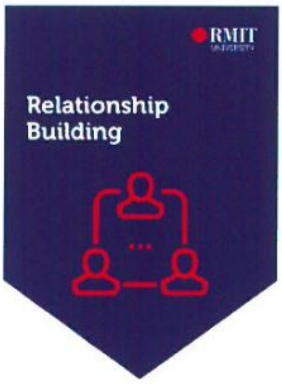
4.4.3 Different ways of learning

Further to these challenges for the higher education sector, there is a growing need for universities to create a range of environments allowing different ways of learning. They may be formal or informal. The needs of the digital economy are also leading to the availability of shorter units of study often termed micro-

[83] For example, the University of Oxford Micro-Internship Programme.
[84] Workforce Development Needs Survey Report, Australian Industry Group, December 2016.
[85] The Australian Industry Group, Uni students: good news for your business, 2016.

credentials. Companies and workers need to have available greater opportunities for new skill development whenever required as a result of constant new technologies and organisational change. Micro-credentialing, sometimes called badging, is an evolving way to quickly build capabilities as companies' requirements for work and business change. A number of universities have developed or are developing sets of credentials to meet these new needs.





4.5 Company workforce training and development

The more rapid changes in the economy mean individuals will need regular upskilling throughout their working lives. Within a broader digital skills strategy, employers must plan to up-skill existing workers in order to take advantage of growth opportunities and adapt to the digital economy. By assessing their own capabilities and then implementing training, companies will develop employees who are more capable of taking control of their roles, need less supervision and are more engaged.

Beyond formal education, learning occurs in a range of settings, including in the workplace, at home and through self-directed individual activity. For skills to retain their value, they must be continuously developed throughout life. Lifelong learning opportunities are relevant for workers in both high-skilled and low-skilled occupations. In high technology sectors, workers need to update their competencies and keep pace with rapidly changing techniques. Workers in low-technology sectors and those performing low-skilled tasks must learn to be adaptable as routine tasks are increasingly performed by machines.[86]

There are major advantages to upskilling in workplaces. Workplace training offers a high-quality learning environment for acquiring practical skills, using current equipment alongside current working methods and technologies.[87] For new entrants to the workforce, the increasing use of work-based learning and work integrated learning approaches reflects the effectiveness of these models.

[86] OECD 2013, Skills Outlook 2013: First Results from the Survey of Adult Skills, OECD Publishing, Paris, 2013.
[87] OECD 2013, Skills Outlook 2013: First Results from the Survey of Adult Skills, OECD Publishing, Paris, 2013.

5. Company action for skills development in the digital economy

To address these issues facing companies there are several key actions that can be implemented.

5.1 Develop a Strategy Plan

To understand and recognise the upcoming changes in digitalisation and automation, leaders of business need to identify where and how technology and automation will transform their own organisation and then implement plans to migrate to new business processes enabled by digitalisation. A **digital strategy** needs to be developed, a key component of which is the digital skills capability and development of the company's workforce.

To prepare for automation's advances, business leaders should challenge themselves to understand the data and automation technologies on the horizon. Data and technological savvy is required to capture value from automation. The greater challenges are the workforce and organisational changes that leaders will have to put in place as automation upends entire business processes, as well as the culture of organisations, which must learn to view automation as a reliable productivity lever.

Senior leaders will need to learn to operate in ways that run counter to a century of organisational development.[88] An increasingly global workplace is also likely to create some specific people-management challenges.

[88] Dewhurst, M. and Willmott, P: Manager and machine: the new leadership equation, www.mckinsey.com/global-themes/leadership/manager-and-machine

Understanding the activities that are most susceptible to automation from a technical perspective can provide an opportunity to rethink how workers engage with their jobs and how digital labour platforms can better connect individuals, teams, and projects.

This planning will also assist managers to think about how many of their own activities could be better and more efficiently executed by machines, freeing up executive time to focus on the core competencies that robots or algorithms are yet to replace.

5.2 Review Work Organisation

The digital economy requires a cultural change in the way work is done and managed. In the past, much of the role of a senior manager was tied up in expertise and knowledge. Now that is becoming less important and instead it is the ability to locate knowledge, assess how valid it is and then put it to use in collaboration with other people. Implementing and realising the full productivity benefits from new technologies entails significant organisational restructuring, which in turn requires considerable managerial skill.

Quality managers are associated with productivity, where better managed companies are able to address skills challenges such as screening job applicants, developing new work practices, internally reallocating over-skilled workers, and retraining or removing under-skilled workers.[89]

5.3 Develop Leaders and Managers

There is a renewed emphasis on management and workplace innovation as the key to a competitive, knowledge-based economy. In order to capitalise on this, businesses need to build management capability as well as workforce skills.[90] The concept of management, and particularly innovation management, covers a wide area incorporating governance, leadership, culture, finance, skills and strategy, new product and service developments and intellectual property management.

There is a positive association between investment in training and company performance. This is particularly so where training forms part of a business or wider human resource management strategy. Effective workplace training is also an important aspect of a business's response to potential skills shortages.[91]

> *Businesses that prepare managers as leaders and decision-makers who are adept at dealing with uncertainty and constantly changing landscapes succeed in a networked-knowledge economy; innovative performance will be improved by strengthening this management talent pool.*[92]

The globalisation of innovation and the increasing geographic dispersion of knowledge, research and development also requires new forms of collaboration and levels of coordination. This is a

[89] OECD, 2017, Key Issues for Digital Transformation in the G20, G20 German Presidency/ OECD, <https://www.oecd.org/g20/key-issues-for-digital-transformation-in-the-g20.pdf
[90] Green, R, Marsh, I, Pitelis, C: 'Future skills, industry policy and a new social contract' in Australia's future workforce, Committee for Economic Development of Australia, June 2015.
[91] ACOLA 2014, The role of science, research and technology in lifting Australia's productivity, Australian Council of Learned Academies, Melbourne.
[92] Australian Business Deans Council, The Future of Management Education, Final Report, July 2014.

management challenge in a new world where knowledge is dispersed across firms, industries and countries.[93]

5.4 Form Partnerships with Education Sectors

To shape the skills needed in recruits at all levels, to influence positive organisational change and to potentially access research, businesses will benefit from establishing and maintaining links with local universities, vocational education and training providers and schools in projects and activities suited to the business. Workforce development strategies require partnerships with the key providers of knowledge and skills.

5.5 Re-skill Existing Workers

The more rapid changes in the economy mean individuals will need regular upskilling throughout their working lives. Employers need to plan to up-skill existing workers in order to take advantage of growth opportunities and adapt to the digital economy. By assessing their own capability and training when necessary, using trainers, supervisors, managers and leaders, companies will develop employees more capable of taking control of their roles, needing less supervision and being more engaged.

5.6 Invest in Research and Development

To remain competitive companies must participate in innovative practices. The development of innovation necessarily requires research collaboration, an area in which historically Australia has performed poorly. For example, Australia has the lowest level of business to research collaboration among comparable countries in the OECD. Specifically, Australia ranked second last out of a total of thirty-three countries on business to research collaboration for small to medium enterprises and last for large enterprises.[94]

There are barriers to collaboration which need to be addressed in this context. Some of these are cultural such as different language and terminology and differing motivations. The inclusion of business liaison representatives in research units would assist in overcoming these cultural barriers. Also, intellectual property issues can impede collaboration with public sector research organisations. Businesses often have little patience with time consuming internal procedures in this regard. Transactional approaches do not assist the development of long-term mutually beneficial relationships.[95]

Whether the collaboration is with tertiary institutions or research organisations, there is a clear need for business to engage in order to improve. There are clear benefits from research collaboration such as the generation of more commercial outcomes. Collaboration provides business with the opportunity of influencing the direction of research for mutual benefit. Research can be aimed at commercial problems to which business partners are seeking solutions.[96]

While technology is a driver of business transformation, innovation management is critical for corporate competitiveness, enabling business to deal with disruption and flourish in a rapidly

[93] Australian Business Deans Council, The Future of Management Education, Final Report, July 2014.
[94] Benchmarking Australian Science, Technology, Engineering and Mathematics, Office of the Chief Scientist, Commonwealth of Australia, November 2014.
[95] Joining Forces: Innovation Success through Partnerships, Australian Industry Group, July 2016.
[96] Joining Forces: Innovation Success through Partnerships, Australian Industry Group, July 2016.

changing environment of new innovations and emerging markets. It is critical that there is significant interaction between innovation activities by businesses and their management practices. Innovation management enables adaption to new challenges. Collaboration, problem solving capability, harnessing employee skills and technology and the ability to monitor and respond to changing customer needs are all key attributes of high performing businesses. There is a clear link between the quality of management and company productivity.[97]

There is a recognition that there is scope to improve higher degree by research (HDR) training practices in an effort to increase the skills, knowledge and abilities of our future workforce.[98] The Australian Government has released a Research Training Implementation Plan which encourages, amongst other things, greater industry-university collaboration including the greater uptake of internships by industry and templates to inform the development of intellectual property arrangements involving HDR students in collaborative research activities.

5.7 Utilise Government Support

Identify existing forms of government support available for skills development. Whilst organisational change, workplace innovation and management are key themes in which companies need to invest in skills to support rapid technological change, these investments must be supported by complementary public investments in education.

Government needs to make a greater investment in building enterprise, digital and literacy and numeracy skills development into the curriculum frameworks of all education and training sectors. The support from Government for closer industry and education partnerships is becoming increasingly important as quick changes to industry mean changes to skill requirements. Funding to increase the breadth of schemes linking companies and the school, VET and higher education sectors are needed to benefit the business sector through greater work readiness, access to fresh ideas and organisational culture changes. With rapidly changing work practices and technologies, exposure by students at all stages of education and training will ultimately assist business.

A successful model for supporting companies, in particular small business, to develop and implement training plans and upskill existing workers in line with new strategies involves the assistance of skills advisers, such as those that operated under the Australian Government's Industry Skills Fund. Under this Fund subsidies were provided for existing workers to undertake training. The introduction of a similar scheme that delivers expert advice and information on workforce development planning and skills opportunities for the new age would assist businesses.

Final Key Message

Ensuring that everyone has the relevant skills is key to enhancing the uptake and use of digital technologies in businesses. What is clear though is that specialist technical skills are not enough to drive innovation. They need to be coupled with a range of other skills such as entrepreneurship, organisational know-how and cognitive and people skills. At the same time, the take-up and diffusion of innovation needs people – as workers and as consumers – to have general skill levels that enable them to make the most of the benefits that innovation generates.

[97] Joining Forces: Innovation Success through Partnerships, Australian Industry Group, July 2016.
[98] Review of Australia's Research Training System, Australian Council of Learned Academies, 2016.

This requires not only foundation skills such as literacy, numeracy and problem solving in technology-rich environments but also complementary people skills such as openness to new experiences, adaptability, resilience, communication and teamwork, and ability to learn new skills. These same skills are also important to enable people to adjust to the possible negative impacts of innovation on their jobs and not only cope, but thrive, in a rapidly changing world.

Businesses will need to invest in ongoing skills development to promote the deepening and broadening of skills, commit to flexible organisational practices to facilitate retention, and effectively utilise skills. Workers and management holding the right skills is central to businesses being able to achieve their ambition on innovation, exporting and growing the business.

> *It's not the largest company, it's not the most successful company, it's not the strongest company that will benefit the most from digitalisation, but the most adaptable companies. For those businesses that learn to thrive in an unpredictable and uncertain digital environment, rapid change and complexity need not be a liability.*[99]

[99] Durrant-Whyte, H, McCalman, L , O'Callaghan, S, Reid, A and Steinberg, D, 'The impact of computerisation and automation on future employment', in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

References

Abraham, M and Annunziata 2017, 'Augmented Reality Is Already Improving Worker Performance' *Harvard Business Review*, 13 March 2017.

Adhikari, S 2017, 'French cloud giant lands in Melbourne', The Australian, 12 May 2017 <http://www.theaustralian.com.au/business/technology/french-cloud-giant-lands-in-melbourne/news-story/67f313fd4bcc2c209e569ea8e023243e>

APH Senate Inquiry into innovation and creativity: workforce for the new economy.

Arntz, M., T. Gregory and U. Zierahn (2016), 'The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis', OECD Social, Employment and Migration Working Papers, No. 189, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jlz9h56dvq7-en

Atkinson, G, Work-based learning and work-integrated learning: fostering engagement with employers, NCVER, 2016.

Australian Business Deans Council, The Future of Management Education, Final Report, July 2014.

Australian Computer Society 2015, Australia' Digital Pulse: Key Challenges for our nation - digital skills, jobs and education, Deloitte Access Economics, Sydney <https://www.acs.org.au/content/dam/acs/acs-publications/02062015-Australias-Digital-Pulse-FINAL.PDF>

Australian Council of Learned Academies, STEM: Country Comparisons, Final Report, May 2013.

Australian Council of Learned Academies, The role of science, research and technology in lifting Australia's productivity, Australian Council of Learned Academies, 2014.

Australian Curriculum and Assessment Authority, National Assessment Program – ICT Literacy Years 6 & 10, Report 2014, 2015.

Australian Industry Group, The Emergence of the Gig Economy, August 2016.

Australian Industry Group, Joining Forces: Innovation Success through Partnerships, July 2016.

Australian Industry Group, Progressing STEM Skills in Australia, February 2015.

Australian Industry Group, Strengthening School-Industry STEM Skills Partnerships, June 2017.

Australian Industry Group, Uni students: good news for your business, 2016.

Australian Industry Group, Workforce Development Needs Survey Report, December 2016.

Autor, D 2015, 'Why Are There Still So Many Jobs? The History and Future of Workplace Automation', *Journal of Economic Perspectives*, Vol. 29, No. 3.

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

Beddie, F, Creaser, M, Hargreaves, J & Ong, A, 2014, Readiness to meet demand for skills: a study of five growth industries, National Centre for Vocational Education Research, Adelaide.

Beitz, S 2015 'Developing the capacity to adapt to industry transformation' in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

Bhalla V. et al; Twelve forces that will radically change how organisations work, The New Way of Working Series, www.bcg.com/publications/2017/people-organisation-strategy

Borland J. and Coelli M., 'Information Technology and the Australian labour market', in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

Bradlow, H 'The impact of emerging technologies in the workforce of the future' in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

CEEMET Position Paper on the New Skills Agenda for Europe, 27 February 2017 http://www.ceemet.org/sites/default/files/ceemet_-_position_paper_on_the_new_skills_agenda_for_europe.pdf

Chui, M, Manyika J, Meremadi M, 2016, 'Where machines could replace humans—and where they can't (yet)', McKinsey Quarterly, <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet?cid=other-eml-ttn-mkq-mck-oth-1612>

Coppola, F, 2014, 'Automation and Jobs: Competition or Cooperation?' in Our Work Here is Done: Visions of a Robot Economy, Nesta, London.

Craig, Elizabeth 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.

DBI&S and DE, 2016 Post-16, Skills Plan, Department for Business Innovation & Skills and Department for Education July 2016 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536068/56259_Cm_9280_print.pdf

Dewhurst, M. and Willmott, P: Manager and machine: the new leadership equation, www.mckinsey.com/global-themes/leadership/manager-and-machine

Durrant-Whyte, H, McCalman, L , O'Callaghan, S, Reid, A and Steinberg, D, 'The impact of computerisation and automation on future employment', in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

Ferguson, Z 2017 'Lawyers, accountants join list of workers who could lose their jobs to AI, warns report', *ABC News*, 5 April 2017, <http://www.abc.net.au/news/2017-04-05/artificial-intelligence-taking-lawyer-accountant-analyst-jobs/8415286>

The Foundation for Young Australians, The New Basics: Big data reveals the skills young people need for the New Work Order, Melbourne, Australia, 2016.

The Foundation for Young Australians, The New Work Smarts: Thriving in the New Work Order, , Melbourne, Australia, 2017.

Frey, C & Osborne, M 2015, Technology at Work: The Future of Innovation and Employment, Oxford Martin School and Citi <http://www.oxfordmartin.ox.ac.uk/downloads/reports/Citi_GPS_Technology_Work.pdf>

Gabriel, S & Gurría, A 2017, 'Policy 4.0: Bringing the People on Board in a Digital World', The World Post, <http://www.huffingtonpost.com/oecd/policy-40-bringing-the-pe_b_14114510.html>

Gekara V. et al: Developing appropriate workforce skills for Australia's emerging digital economy: working paper, NCVER, Commonwealth of Australia, 2017.

Gratton, L, 2015 'Reshaping work for the future' in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

Green, R, Marsh, I, Pitelis, C: 'Future skills, industry policy and a new social contract' in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

Hajkowicz, S, Reeson, A, Rudd, L, Bratanova, A, Hodgers, L, Mason, C, & Boughen, N, Tomorrow's Digitally Enabled Workforce, Commonwealth Scientific and Industrial Research Organisation, 2016.

Innovation and Science Australia, 2030 Strategic Plan: Issues Paper, Innovation and Science Australia, Canberra, 2017.

Kim, Q 2016, 'As Our Jobs Are Automated, Some Say We'll Need A Guaranteed Basic Income', NPR, 24 September 2016, <http://www.npr.org/2016/09/24/495186758/as-our-jobs-are-automated-some-say-well-need-a-guaranteed-basic-income>

Lilly, M.: The Future of Australian Apprenticeships, Australian Industry Group, October 2016.

Martin-Guzman, D 2017 'Redefine work to thrive in the age of robots' The Australian Financial Review 13-17 April 2017.

McKinsey Global Institute: A Future That Works: Automation, Employment, and Productivity, 2017.

McKinsey Global Institute; Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation, Executive Summary, December 2017.

Milford, M 2017 'Merging our brains with machines won't stop the rise of the robots', The Conversation, 27 February 2017, <http://theconversation.com/merging-our-brains-with-machines-wont-stop-the-rise-of-the-robots-73275>

OECD 2016, ICTs and jobs: complements or substitutes? The effects of ICT investment on labour demand by skills and by industry in selected OECD countries , Organisation for Economic Co-operation and Development <http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DSTI/ICCP/IIS(2016)1/FINAL&docLanguage=En>

OECD 2017, Key Issues for Digital Transformation in the G20, G20 German Presidency/ OECD, <https://www.oecd.org/g20/key-issues-for-digital-transformation-in-the-g20.pdf>

OECD 2016, New Forms of Work in the Digital Economy, 2016 Ministerial Meeting on the Digital Economy, OECD Digital Economy Papers No. 260.

OECD, Skills for a Digital World, December 2016.

OECD 2013, Skills Outlook 2013: First Results from the Survey of Adult Skills, OECD Publishing, Paris https://www.oecd.org/skills/piaac/Skills%20volume%201%20(eng)--full%20v12--eBook%20(04%2011%202013).pdf

Office of the Chief Scientist, Science and Maths in Australian Secondary Schools, Datasheet 2, Australian Government, December 2017.

Office of the Chief Scientist, Benchmarking Australian Science, Technology, Engineering and Mathematics, Commonwealth of Australia, November 2014.

Office of the Chief Scientist, Science, Technology, Engineering and Mathematics: Australia's Future, September 2014.

Office of the Chief Scientist and Deloitte Access Economics, Australia's STEM workforce: a survey of employers, Deloitte Access Economics Pty Ltd, 2014.

O'Reilly, T 2017, 'Keynote by Tim O'Reilly at the Joint G20 German Presidency-OECD Conference', OECD, 12 January 2017, <https://www.youtube.com/watch?v=KuL4J3Z0eck>

Patrick, Peach and Pocknee, The WIL (Work Integrated Learning) Report: a national scoping study, Australian Teaching and Learning Council, 2009.

Productivity Commission, Digital Disruption: what do governments need to do?, Productivity Commission Research Paper, June 2016.

PwC, A Smart Move, April 2015.

Reeson, A. et al: The VET Era, Equipping Australia's workforce for the future digital economy, CSIRO, 2016.

Ruthven P., 'Where the jobs are', in in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

Tapscott, D, The Digital Economy – Promise and Peril in the Age of Networked Intelligence, 1997.

Taylor, N: 'Introduction: The industrial revolution's next wave' in Australia's future workforce, Committee for Economic Development of Australia, June 2015.

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

World Economic Forum, The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution, Executive Summary, January 2016.

World Economic Forum, The Global Human Capital Report 2017, preparing people for the future of work, 2017.

World Economic Forum, The Human Capital Report 2016.

World Economic Forum 2016, Women and Work in the Fourth Industrial Revolution, <http://reports.weforum.org/future-of-jobs-2016/women-and-work-in-the-fourth-industrial-revolution/