Preparing for Industry 4.0 – will digital skills be enough?

IBSA
Innovation & Business Skills Australia

About the Project Reference Group

This research was overseen by the Digital Skills Project Reference Group which comprised of nine members and was constituted in July 2017.

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This research was undertaken as part of the Digital Skills Cross-sector project which developed a Case for Change. To view the Case for Change go to https://ibsa.org.au/consultation-project/coding-skills-cross-sector-project/coding-skills-cross-sector-project-outcome/

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Introduction

This research arose from work commissioned by the Australian Industry and Skills Committee – in the form of a cross sector project looking at the need for digital skills in a range of manufacturing and related industries.

The project was managed by IBSA Manufacturing, a Skills Service Organisation,[1] which provides support to the following Industry Reference Committees (IRCs):

- Aerospace
- Furnishing
- Manufacturing and Engineering
- Process Manufacturing, Recreational Vehicles and Laboratory
- Sustainability
- Textiles, Clothing and Footwear

During the course of the project, national consultations were undertaken with more than 40 representatives from large (often multinational) businesses, small and medium businesses, unions, training providers and other VET sector stakeholders.

Many of the individuals involved in the consultations raised questions about how well the VET sector was prepared for the substantial digital changes impacting on the workforce and the manufacturing sector in particular. They questioned whether Training Packages were sufficiently flexible to meet the needs of the manufacturing sector as it responds to growing levels of digital disruption (or what has been termed the 4th Industrial Revolution, or Industry 4.0). The research undertaken to support the project, also identified a vastly greater number of reports and papers focussed on the challenge of upskilling workers for an Industry 4.0 environment, than in relation to the need for specific digital skills for manufacturing and related workers.

This report synthesises the research evidence – in relation to both digital skills and the broader challenges of skilling workers for the Industry 4.0 workplace.

1 For a description of IBSA Manufacturing's work see: https://www.ibsa.org.au/manufacturing-sso/

The Need for Digital Skills in Priority Australian Manufacturing Sectors

In their industry skills forecasts and proposed schedules of work, the IRCs involved in the project identified an emerging need for three key digital skills in their industries. In summary, they are:

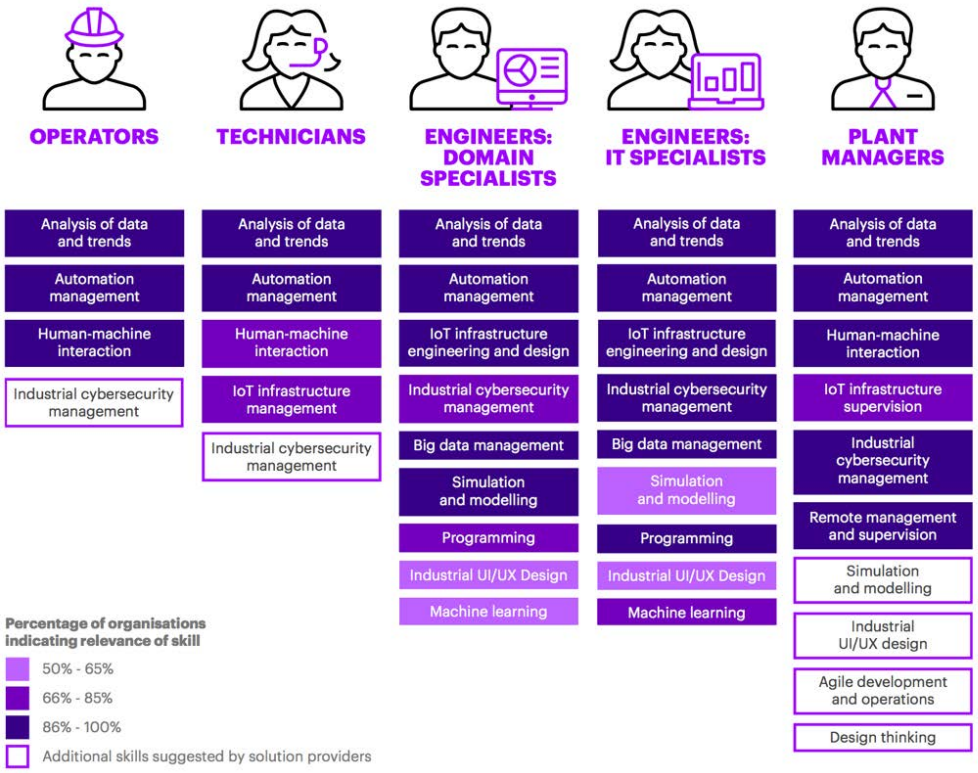
1. **Digital analysis/diagnosis** – arising from the digital augmentation occurring in many industries. The Aerospace; Manufacturing and Engineering; the PMA Chemical, Hydrocarbons and Refining; and the MSL Laboratory Operations skills forecasts all identify a need for people with the technical skills to 'analyse and respond to data provided by the machines in their workplace'. While some IRCs referred to these skills as digital literacy – to avoid confusion with other broader definitions of digital literacy, following the consultations, these digital skills have been identified as digital analysis and digital diagnosis skills.
2. **3D printing/additive manufacturing skills** – the need for these skills is specifically mentioned in the Manufacturing and Engineering; MSL Laboratory Operations; and the Printing and Graphic Arts skills forecasts; and
3. **Programming/coding** – the impact of technological change in the workplace and the subsequent need for digital programming skills is identified in the Aerospace; Manufacturing and Engineering; Plastics, Rubber and Cablemaking; Printing and Graphic Arts; Textiles, Clothing and Footwear skills forecasts.

Research was undertaken to determine what information was available on the need for these digital skills in the manufacturing, printing and related industries. The research identified a plethora of reports discussing the impact of digital change on job roles and therefore skills, but very few which identified specific digital skill needs in the manufacturing sector or other related industries. In relation to Australian research there was even less available (comprising mostly a small number of websites and largely anecdotal information on digital skill needs).

On review of both the external material as well as the IRCs' four-year skills forecasts (which led to this project), some digital skill requirements have started to emerge. The prevalent theme which emerged though was the need to equip workers of the future to have hybrid skills, and be able to apply technical, digital and personal skills and knowledge across a range of contexts and applications.

One of the few sources of information on digital skill needs identified in this research was Accenture Consulting's analysis for Singapore's Economic Development Board of emerging skill needs for Singapore's Energy, Chemicals and Utilities Industries (see Figure 1).[2]

Figure 1: Preliminary Skills Map – Emerging Digital Skills by Job Role/Persona



Source: Accenture Consulting, 2017, Manning the Mission for Advanced Manufacturing: New Demands On Talent in Singapore's Energy, Chemicals and Utilities Industries

While Accenture's research identifies a need for both programming skills and simulation and modelling skills for domain specific engineers, the authors note that this is not an exhaustive selection of the digital skills that manufacturers surveyed by Accenture identified as being required for Industry 4.0 adoption. They go on to note that their works is a "first step towards a comprehensive understanding of emerging digital skills (needed in manufacturing, energy and utilities companies) such as robotics, agile development and design thinking" (p.10).

2 Accenture Consulting, 2017, Manning the Mission for Advanced Manufacturing: New Demands On Talent in Singapore's Energy, Chemicals and Utilities Industries https://www.accenture.com/us-en/insight-advanced-manufacturing

At the recent Industrial Internet Summit,[3] the Director of the Australian Advanced Manufacturing Council cautioned that as low skilled jobs were lost from the Australian manufacturing sector, new jobs would be created but they would be at the "high end". It was noted that there was a lengthy lead-time for workers to gain high-level skills and that Australia must spend more time on educating people in STEM and manufacturing skills now or the country would be unable to exploit future opportunities. Other speakers to the Forum, including the CEO of the Innovative Manufacturing CRC, cautioned that it was not possible to identify which specific technical skills would be in demand in an Industry 4.0 environment but it was clear that a broad set of skills would be required. The likelihood that additive manufacturing would radically change the factory production line was also discussed.

In a 2015 presentation,[4] Manufacturing Skills Australia identified that the industry will require workers with a new set of skills which are focussed on:

- collaboration
- data mining/analytics
- computer proficiency
- advanced materials knowledge
- design skills
- marketing and sales
- logistics, and
- industrial networking.

In the same presentation, drawing on results from their annual survey of enterprises, MSA identified four major skill needs for the manufacturing sector as:

- higher level technical skills
- innovation/design skills
- multi-skilled, broad-based capabilities, and
- IT/digital skills.

3 Industrial Internet Summit Australian Advanced Manufacturing Council, http://aamc.org.au/skilling-industry-4-0/

4 Paton, B & Baker, C; 2015, Presentation to the Australian Workplace Practitioners' Network Conference 2015 http://awpn.com.au/wp-content/uploads/2015/04/MSA_AWPN-presentation-2015.pdf

In 2014 PwC identified 3D printing as a major disruptor to traditional supply chains and manufacturers[5]. In a survey of US manufacturers they found that about half believed that it was 'likely' or 'very likely' that 3D printing would be used for "low-volume, highly specialized products" over the 3-5 years to 2019. Their research identified that manufacturers were looking to re-train their existing workforces or bring in new talent – as they sought to acquire the skills needed to create digital designs as well as oversee the production process. Almost half of survey respondents cited a lack of expertise in 3D printing and the need to find the right talent as barriers to using 3D printing technology.

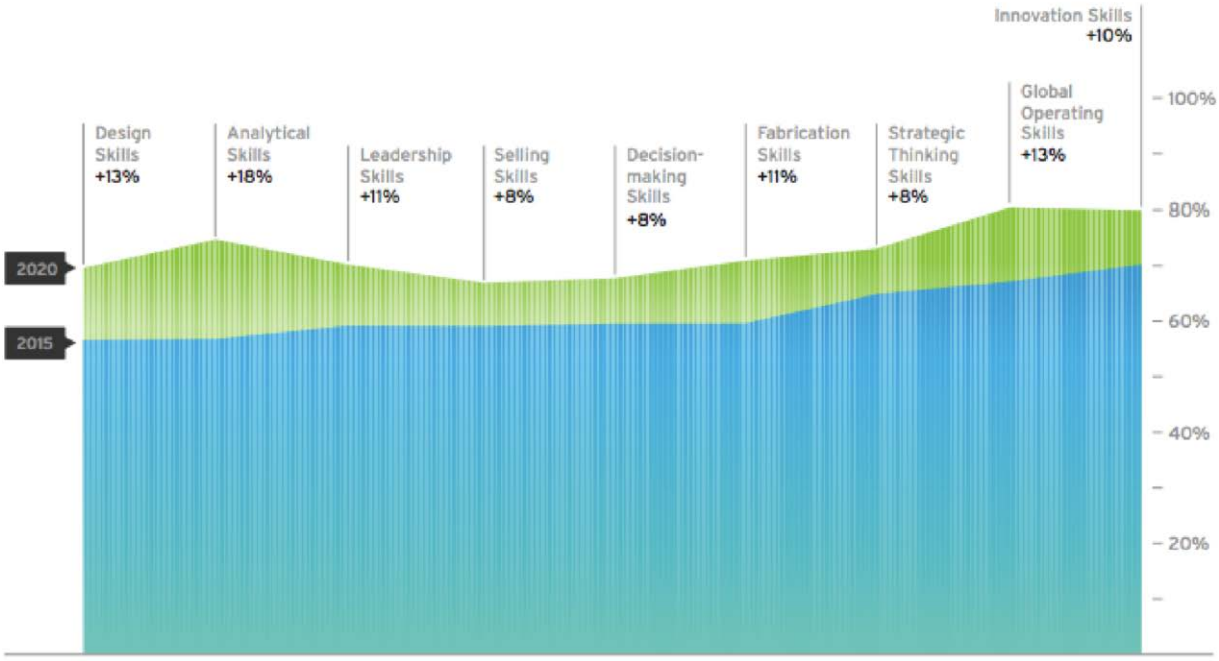
The impact of additive manufacturing/3D printing and the concomitant need for new skills was also examined by Brown and Satyavolu for Cognizant's Centre for the Future of Work. They outline its potential to rapidly change the manufacturing sector – from "legacy industrial models" to "what you want, when you want it" manufacturing. They do not identify specific 3D printing skills as being the solution. They recognise that analytics and artificial intelligence are also transforming global manufacturing processes, and approximately 70 percent of respondents (to their survey of 500 senior manufacturing executives)[6] think this digital change is boosting the need for innovation skills. Their survey also identifies that, as more tasks are automated, work will become more strategic. Specifically they posit that this will mean, less emphasis on discrete manufacturing equipment installation (and skills), and more focus on whether the equipment will improve new digital business approaches.

They predict the following skills will grow even more important in the future – see Figure 2.

5 PwC (2014) 3D printing and the new shape of industrial manufacturing https://www.pwc.com/us/en/industrial-products/3d-printing.html

6 Brown, R. H. & Satyavolu, P. (2017) The Work Ahead: Designing Manufacturing's Digital Future report (p.4) The Centre for Work, Cognizant. https://www.cognizant.com/whitepapers/the-work-ahead-designing-manufacturing-s-digital-future-codex2391.pdf

Figure 2: Skills That Will Grow More Important in the Future



Source: Brown, R. H. & Satyavolu, P (2017) The Work Ahead: Designing Manufacturing's Digital Future report. The Centre for Work, Cognizant

In the aerospace sector, Lappas and Kourousis[7] note that businesses need employees with a raft of skills, including the ability to respond creatively to complex problems, effective communication, team working, and the use of technology to create new knowledge. They go on to question whether an industrial-age curriculum will fully equip students for living and working in the information-age. They cite the applicability of The Assessment and Teaching of 21st Century Skills Project (2016)[8] and its ten priority skill areas as being particularly relevant to the aerospace industry. The priority skills are:

Ways of Thinking:

1. Creativity and innovation
2. Critical thinking, problem solving, and decision making
3. Learning to learn, metacognition

Ways of Working:

4. Communication
5. Collaboration (teamwork)

Tools for Working:

6. Information literacy
7. Information and Communication Technologies (ICT) literacy

Living in the World:

8. Citizenship — local and global
9. Life and career
10. Personal and social responsibility — including cultural awareness and competence

Despite the lack of emphasis on specific technical skills in their list of priority skills, Lappas and Kourousis argue that this is because there is a major and rapid shift occurring in the way people work in the aviation sector, and thus there is a need for a new emphasis on 21st Century skills. They cite as an example, the design of the Airbus A380, which was divided across design offices and engineering centres located across Europe and North America; its large main components were produced in France, Germany, Spain and the United Kingdom, and the final assembly line is in France. They note that the design offices used interactive software packages, allowing teams to work collaboratively on common designs from different locations.

7 Lappas, I, & Kourousis, K, I. (2016). Anticipating the Need for New Skills for the Future Aerospace and Aviation Professionals. Journal of Aerospace Technology and Management, 8(2), 232-241. https://dx.doi.org/10.5028/jatm.v8i2.616

8 Launched by Cisco Systems Inc., Intel and Microsoft in January 2008 as a research collaboration to accelerate global education reform The Assessment and Teaching of 21st Century Skills Project, focuses on defining the skills needed for the 21st Century. It drew from the assembled knowledge of 250 researchers from around the world.

As a consequence of the dispersed teams now being used in major aviation projects, communication and collaboration skills have become much more critical to a project, and teams and working arrangements also need to take account of cultural differences. The authors identify that in future the aerospace industry workforce will be required to work in much more diversified environments and while analytical skills will continue to be important, soft skills like leadership, team spirit, three dimensional thinking, risk definition and risk management are expected to be critical.

This dispersed approach to delivering major projects (with teams with different skills working in different locations), is also going to play a part in South Australia's ship building projects. Work is underway at present, supported by the South Australian government, to build the capacity of local SMEs in the manufacturing sector – to assist them to participate in the supply chains needed for the projects.[9]

Also focussed on emerging skill needs in the aerospace industry is Matthews in an article in the Australian Defence Magazine. He focuses more specifically on changing technical skill needs and states that there will be an increased need for computer aided design tools and computer aided manufacturing programming of highly sophisticated machines as manufacturers look to use new additive metal technologies to optimise the weight of new designs.[10]

In relation to the changing skill needs in the printing industry, in a priorities document aimed at articulating the government policies the printing sector requires for a sustainable future, the Printing Industries Association of Australia notes that the industry is in a transition from "a traditional manufacturing industry" to one that "embraces the services, communications, creative and information technology industries". They point out that print is reliant on a highly skilled workforce and list ten policy priorities for skills development, although none of these priorities identify specific printing skill needs.[11]

Summary

While every attempt has been made to identify research on specific digital skills needed in manufacturing and related industries, this review has identified that (a) there is little research available on specific digital skills in these industries and (b) even research aimed at identifying the impact of digital changes to manufacturing processes tends to identify a need for a broader set of skills for future success – rather than singling out specific digital skills. This focus on the need for a broad range of higher level thinking skills, more soft skills and creativity and design thinking were consistently echoed by participants in the consultations which supported this project. The reasons why are outlined below.

9 Advice from participants involved in the consultations undertaken as part of this Digital Skills Cross Sector project.
10 Australian Defence Magazine (ADM) (October 2017) Volume 25, No.10
11 Printing Industries Association of Australia (2014) Priorities for Print Report https://www.piaa.org.au/verve/_resources/Priorities_in_Print_2014.pdf

Industry 4.0

The fourth industrial revolution, focussed on digitisation, will bring "change at a speed, scale and force unlike anything we have ever seen before".[12] Termed Industry 4.0 by the German manufacturing sector – the following case study of the impact of Industry 4.0 on the car industry provides a useful insight into the transformative power of this industrial revolution.

> The example of the car – the epitome of German engineering skill – offers a good illustration of this permeation and the resulting change in business models. The product is changing in line with the technical possibilities and customers' wishes: cars are being individually configured and increasingly connected in the Internet of Things, self-driving cars are becoming reality, and individual inspection intervals and remote servicing are possible thanks to new sensor technology and data analysis. The production processes are almost completely connected, collaborative robot systems are entering factories, and additive manufacturing processes such as 3D printing are making extremely small production runs possible. Design and product conception work is being outsourced via digital platforms, and workers have a say on shift assignments using apps. Alongside the manufacturing and sale of cars, new services are gaining in importance: from app-based car sharing, to carpooling models, to intermediaries for private driver services. This shows the breadth and speed of the digital transformation; and it also makes clear that changes in technology, the economy, consumption and work go hand in hand. (p. 20)[13]

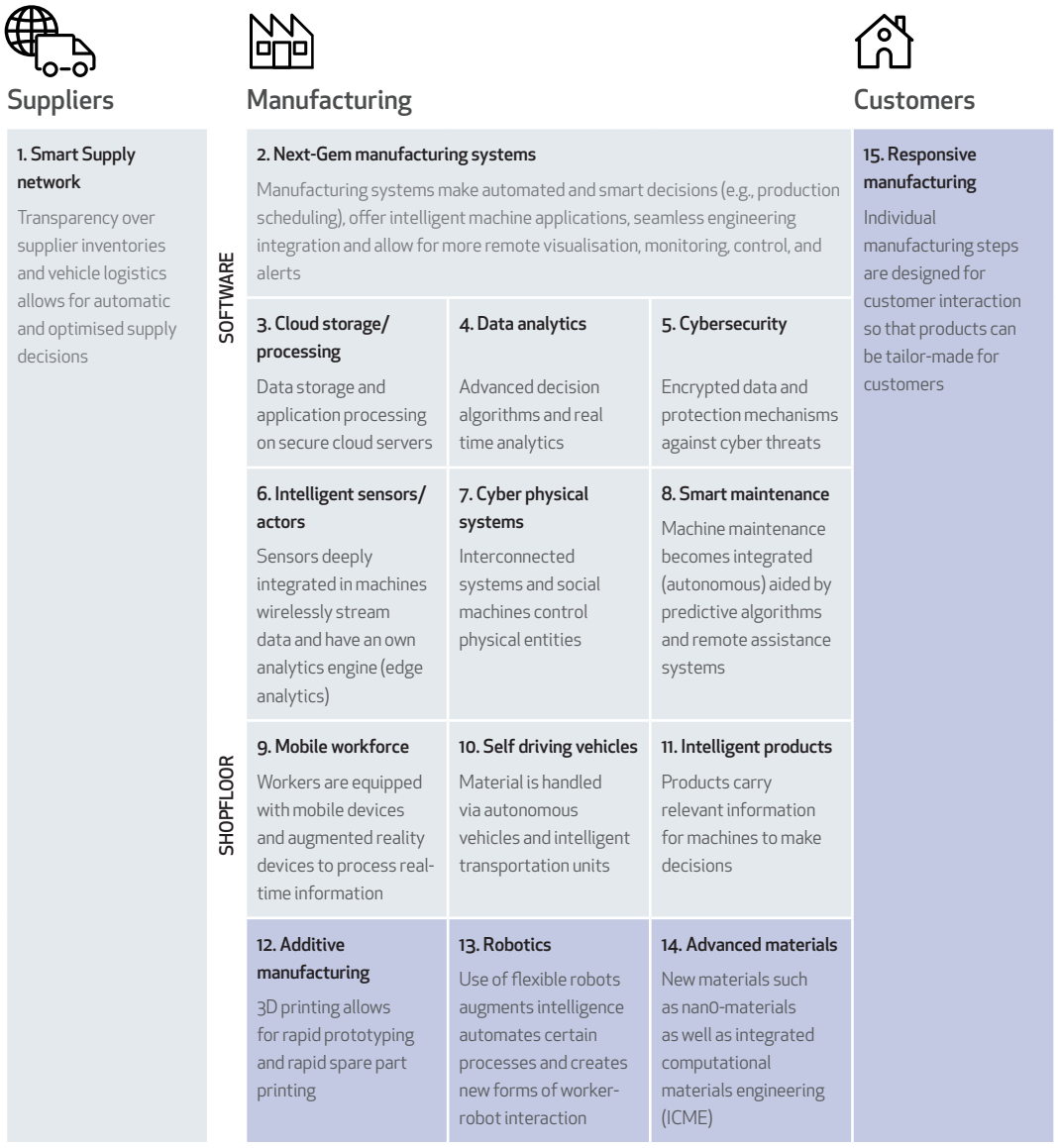
IoT Analytics[14] provides more insights into how manufacturing is changing as a result of Industry 4.0, see Figure 3.

12 World Economic Forum https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab

13 Federal Ministry of Labour and Social Affairs, Germany (March 2017) Re-Imagining Work, White Paper Work 4.0 Federal https://www.bmas.de/SharedDocs/Downloads/EN/PDF-Publikationen/a883-white-paper.pdf?_blob=publicationFile&v=3

14 Source: Lueth, K. L. (2015) Will the industrial internet disrupt the smart factory of the future? IoT Analytics https://iot-analytics.com/industrial-internet-disrupt-smart-factory/

Figure 3: The 15 components of the smart factory of the future



Source: Lueth, K. L. (2015) Will the industrial internet disrupt the smart factory of the future? IoT Analytics

AIIA identifies that although no-one can accurately predict what the jobs of the future will look like decades in advance, it is clear that in the next 10 to 15 years there will be a much greater use of data and analytics, and technologies such as automation, AI, augmented and virtual reality and robotics in the workplace. They also state that these technologies will be integrated at a much faster pace than for previous technological changes

and that workers doing "routine, repetitive and predictable tasks such as assembly line work" are likely to move into "higher value training jobs and operating and maintaining equipment, scheduling and supervising 3D printing runs and quality assurance roles." [15]

While AIIA do not identify specific skills gaps in the manufacturing sector – their research does identify manufacturing and nine other priority industry sectors as being at high risk of digital disruption and the impact of demographic change, and finds the following common, recurring skill sets are required:

- Social perceptiveness and instructing
- Speaking and management of personnel resources
- Monitoring, supervision, coordination and time management
- Critical thinking, judgement, negotiation and persuasion
- Reading comprehension and quality control analysis
- Active listening
- Writing
- Service orientation, system analysis and operation monitoring
- Mathematics, Science, Complex problem solving and Learning strategies, and
- Quality control analysis, systems evaluation and troubleshooting.

Instead of looking ten to fifteen years ahead as AIIA attempts to do, the World Economic Forum 2016's Future of Jobs survey,[16] set a much shorter time horizon for predicting future job and skill needs. They determined that 35 percent of the skills deemed important in today's workforce will have changed in four years. Unsurprisingly they identified the ability to work with data and make data-based decisions would play a major role in the jobs of future. They went on to suggest that creativity, complex problem solving, and critical thinking would be the top three broad skills that people would need for Industry 4.0, arguing specifically that these are the skills that computers cannot perform as well as humans yet.

15 AIIA (2017) Skills for Today. Jobs for Tomorrow https://www.aiia.com.au/_data/assets/pdf_file/0020/81074/JOBS-FOR-TOMORROW-FINAL.pdf

16 World Economic Forum (2016) Future of Jobs, https://www.weforum.org/

The Boston Consulting Group offers a similar view of the skills needed to perform effectively in Industry 4.0. They state that workers will need to combine the knowledge related to a specific job or process, with IT competencies "that range from basic (using spreadsheets and accessing interfaces) to advanced (applying advanced programming and analytics skills)". As a result of the changes taking place on the production line "soft" skills are also predicted by BCG to become more important than ever. Employees will be required to be "even more open to change, possess greater flexibility to adapt to new roles and work environments, and get accustomed to continual interdisciplinary learning".[17]

In a related report, BCG go further and state that the number one challenge in progressing Industry 4.0 is training or retraining the workforce. They note that simple tasks will be taken over by robots as factories and supply chains become increasingly digitised; and that humans will need the skills to oversee these tasks. They will also need to be multi-disciplined and have the ability to adapt to changing roles".

Industry 4.0 is poised to significantly transform Australian manufacturing jobs and skills profiles. In their 2015 Australia's Future Workforce? Report, the Committee for Economic Development of Australia (CEDA) focused on the future of Australia's workforce and identified that 'computerisation' threatens to radically reshape the future workforce. Specifically they stated that:

'Australia is on the cusp of a new but very different industrial revolution. Technology is going to dramatically reshape our workforce in coming years and the nation's ability to rapidly adapt to technological change, and even more importantly, innovate, will be paramount for job creation and our future economic success.'[18]

17 Boston Consulting Group (2015) Man and Machine in Industry 4.0 https://www.bcgperspectives.com/content/articles/technology-business-transformation-engineered-products-infrastructure-man-machine-industry-4/?chapter=6#chapter6

18 CEDA (2015) Australia's Future Workforce? http://www.ceda.com.au/research-and-policy/policy-priorities/workforce

Australia's preparedness for Industry 4.0

The Australian Industry Group's most recent employer survey[19] finds not only that the use of digital technologies in Australian companies has improved since 2013 but there appears to be a correlation between increased use of digital technologies and improved productivity. Despite these pleasing results only 41 percent of those surveyed had planned investments in digital technologies to improve their business operations (although the report notes that while the manufacturing sector has previously been less likely to invest, it appears that their digital investment is now growing more rapidly than in other industries).

The impact of Australian businesses' uncertainty and unwillingness to fully embrace digital technology is evident in our performance on the International Institute for Management Development's ranking[20] of global digital competitiveness. It ranks countries on the following performance characteristics:

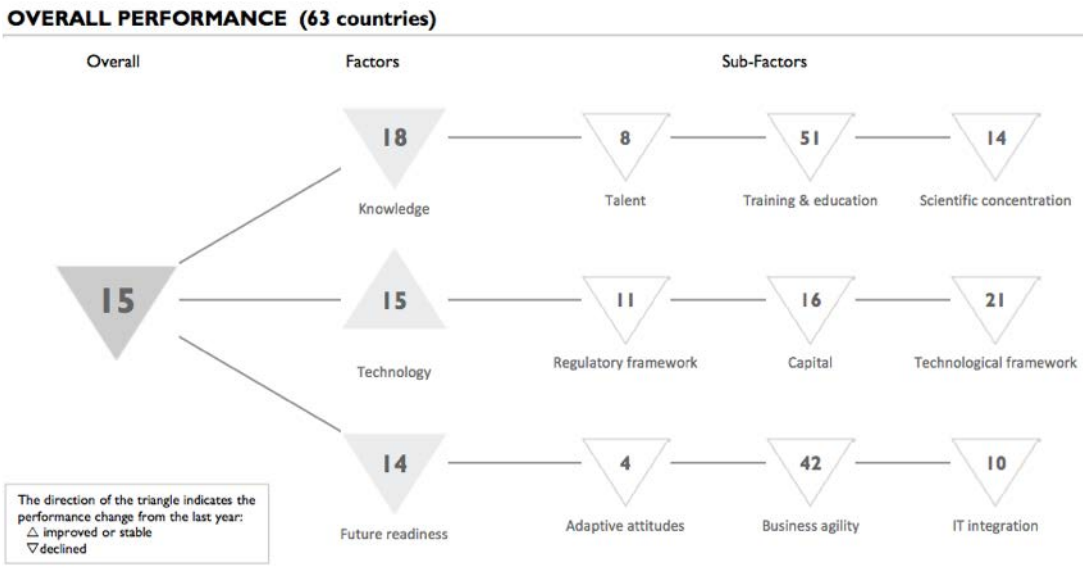
- knowledge: the capacity to understand and learn new technologies, which includes talent, training and education, and scientific performance
- the technology environment: encompassing regulatory and technological frameworks, and capital; and
- future readiness: based on adaptive attitudes, business agility and IT integration.

19 AiGroup (2017) Business Beyond Broadband: Are Australian businesses ready for the fourth industrial revolution? https://www.aigroup.com.au/policy-and-research/mediacentre/reports/beyond-business-broadband-report-download/

20 International Institute for Management Development (2017) IMD World Digital Competitiveness Rankings https://www.imd.org/globalassets/wcc/docs/release-2017/world_digital_competitiveness_yearbook_2017.pdf

According to the IMD, Australia has fallen four places this year to 15th (of 63 countries) in digital competitiveness. Of most concern is that our lowest ranking (51st) is on the education and training sub-component of the knowledge criterion, see Figure 4.

Figure 4: Australia's declining digital competiveness



International Institute for Management Development (2017) IMD World Digital Competitiveness Rankings

Broken down further, the sub-components of Australia's lagging education and training performance is based on the following sub-criteria:

- **Training and education**
  - Employee training (rank 43rd)
  - Total public expenditure on education (25th)
  - Higher education achievement (15th)
  - Pupil-teacher ratio – tertiary education (52nd)
  - Graduates in Sciences (50th)
  - Women with degrees (31st)

In the CSIRO's submission to the House of Representatives Standing Committee on Employment, Education and Training Inquiry into Innovation and Creativity (2017)– the authors note that "a national approach to identifying what professions and skills will be needed to meet future challenges and opportunities is required".[21] In relation to the manufacturing sector specifically, CSIRO notes that Australia has the lowest rate of percentage value add across the OECD for high technology. They go on to observe that high-technology value-add is often due to poor internal capabilities which limits innovation and slows the uptake of new technology.

In the 2017 Deloitte Access Economics report, Australia's Digital Pulse[22] for the Australian Computer Society, the authors caution that digital/technological transformation may be particularly disruptive outside the ICT and services industries. They specifically identify the potential impact on areas such as mining, manufacturing and agriculture – as these industries have "a greater capacity to be affected by physically manifested technological developments" (p. 4).

At the request of the Chief Scientist, the Australian Council of Learned Academies (ACOLA) undertook a three year research project on 'Technology and Australia's Future: How technology will transform the workforce of the future'.[23] The report is an extensive, scientific analysis of the future impact of technology. In relation to skills – the authors note that Australia will not realise the benefits of leading edge technology unless it has the workers available to develop and use these technologies, and that workers with 'general problem solving skills', those who are 'trained to experiment', and those who 'learn by doing' will be well placed to help Australian businesses with new technologies.

The ACOLA report goes on to caution that 'occupational obsolescence' must be mitigated and suggest that this can be done by "ensuring that vocational training targets tomorrow's jobs rather than yesterday's (and that) the development of trainees' adaptive capacity may require a shift in vocational training from its present focus on highly job-specific competencies in favour of vocational streams which group a number of closely related occupations" (p.20)

This is a theme picked up by Dr Martin Parkinson, in this year's Sir Roland Wilson Foundation Secretaries dinner address[24] when he warned that in relation to technological disruption… "we're talking about skills we don't have yet; jobs that don't exist yet; an industry we're building from the ground up, and for which a siloed approach simply won't work".

21 CSIRO (2017) Inquiry into innovation and creativity: workforce for the new economy House Standing Committee on Employment, Education and Training CSIRO Submission 16/574 http://www.aph.gov.au/Parliamentary_Business/Committees/House/Employment_Education_and_Training/Innovationandcreativity/Submissions

22 Deloitte Access Economics (2017) Australia's Digital Pulse: Policy priorities to fuel Australia's digital workforce boom. Report for the Australian Computer Society https://www.acs.org.au/content/dam/acs/acs-publications/Australia's%20Digital%20Pulse%202017.pdf

23 Williamson et al (2015) Technology and Australia's future: New technologies and their role in Australia's security, cultural, democratic, social and economic systems, ACOLA http://acola.org.au/wp/project-5/

24 https://www.pmc.gov.au/news-centre/pmc/sir-roland-wilson-foundation-secretaries-dinner

Lessons to be Learned from Other Countries

Some countries have embraced Industry 4.0 and are making changes to their education and training systems as a result. The approaches of three other advanced manufacturing countries have been chosen for analysis – as they respond to massive technological change: Germany, Singapore and the United Kingdom. Lessons from other nations are also included where they were available.

Germany

A global manufacturing leader with a highly advanced VET system (which has both similarities and key differences from Australia's VET system) ,the German government have not just embraced Industry 4.0 as the future of their manufacturing sector, they have also recently released a white paper identifying the impact on the world of work from profound technological change[25] – and the consequent changes government intends to make as a result.

In developing a White Paper on the Future of Work 4.0, the German Ministry of Labour and Social Affairs note that in their consultations on the preceding Green paper they heard repeatedly of "the vital importance of education, continuing vocational education and training, and skills development for a successful digital transformation" 26 (p. 119).

As a consequence of the advice received from experts involved in the consultation process, as well as by studies and responses to the Green Paper, the German government intends making a raft of changes to its education and vocational training system to assist businesses and individuals to adapt, and continue to adapt, to Industry 4.0. They include:

- systematic monitoring of future demand for skilled labour to provide a regularly updated forecast of trends in demographic, regional and skills related mismatches
- the Federal Ministry of Labour and Social Affairs intends to update the Federal Government's Skilled Labour Concept, which was established in 2011, and link it with a skills strategy for the changing world of work.
- the education and vocational training system will focus more on digital skills – specifically, additional digital qualifications for almost all sectors and occupations
- social, communicative and intercultural skills, systemic and creative thinking, the capacity for abstract thinking, and rapid information processing and data selection capabilities will also be needed
- lifelong vocational learning will play a much more important role in future and Germany will look to develop a national strategy to guide this – recognising the challenges this poses in a diverse system where continuing training institutions currently follow their own mandate
- new and evolved formats for training will be introduced, including a greater use of both blended learning and work integrated learning facilitated through computer based training
- qualified counselling and comprehensive skills assessments will be strengthened and the quality of advice enhanced by "properly taking into account the individual's formal and informal skills, state of health and life circumstances, requirements of the labour market and the complex continuing training landscape", and
- improved support options and incentives will be made available to low-skilled and semi-skilled workers to undertake vocational training and gain qualifications later in life.

25 Wahlster, W (2017) Industry 4.0 Smart Manufacturing for the Future, Germany Trade and Invest https://industrie4.0.gtai.de/INDUSTRIE40/Content/EN/Media/Publikationen/industrie4.0-smart-manufacturing-for-the-future-en.pdf

26 Federal Ministry of Labour and Social Affairs, Germany (March 2017) Re-Imagining Work, White Paper Work 4.0 Federal https://www.bmas.de/SharedDocs/Downloads/EN/PDF-Publikationen/a883-white-paper.pdf?_blob=publicationFile&v=3

United Kingdom

With a VET system that is broadly comparable to Australia's – it is interesting to note that the government of the United Kingdom is also planning changes to better address digital skill needs and to lift the overall quality of its training system.

Firstly, in terms of digital skills, the UK is introducing a Digital Strategy,[27] which includes access to digital skills as one of its seven pillars. Not only does the strategy include an explicit commitment to supporting all citizens to develop the skills they need to participate in the digital economy. It also commits to providing businesses with the skills they need to benefit from digital innovation, including through the creation of a 'pipeline of specialist skills'.

The strategy acknowledges that the UK will also need to develop a range of specialist digital skills to fill specific digital jobs. They use modelling from the UK's Commission for Employment and Skills to estimate that 1.2 million new technical and digitally skilled people will needed by 2022 to satisfy future skills needs.

Initiatives underway at the vocational education and training level include:

- reform of the technical education system to create a specialist "digital route", with employers setting standards and specifying the knowledge, skills and behaviours that individuals will need (13 standards having been approved for delivery and more in development)
- new innovative digital degree apprenticeships have been introduced
- Ada, the National College for Digital Skills, opened in September 2016. It will train 5,000 students over the next five years for a wide range of digital careers, and
- the introduction of a new Digital Skills Partnership, which will see government working with industry and other partners including technology companies, local businesses, local government, charities and other organisations to improve the coherence of digital skills provision, for example by setting ambitions for increasing the level of certain types of training on offer and agreeing how it can be targeted where it is needed most.

The UK government is also in the middle of developing an Industrial Strategy through a Green paper/White paper process.

The Green Paper for the strategy contained 10 pillars of which the second is "Developing skills". The Green Paper recognises that while the UK's higher education system has its strengths, the country's poor performance in basic and technical skills is a key reason for its 'persistently lower levels of productivity' compared with other advanced economies.

27 Department for Digital, Culture, Media and Sport (United Kingdom) (March 2017) Digital Strategy, https://www.gov.uk/government/publications/uk-digital-strategy/executive-summary

The report goes on to note that skills shortages in some areas contribute to imbalances in productivity in the UK. And that, excluding apprenticeships, other forms of technical education have "fallen behind". To address its skills shortages and reduce its reliance on migrant labour, the paper proposes the following solutions:

1. Action to improve basic skills
2. The creation of a new system of technical education
    C. Clear, high quality routes for technical education (reducing the number of qualifications offered in their system and replacing them with 15 technical 'routes' which can be studied as an apprenticeship or in an institutional model)
    D. High quality, technical providers with excellent teaching (more training at higher levels, new qualifications to meet the needs of industry)
    E. Higher level technical education and new Institutes of Technology in all regions (fewer approved providers)
    F. Ensuring Technical Education routes are demanding
    G. Creating a course-finding process for technical education similar to the UCAS process (like our Tertiary Admissions centre processes)
8. Addressing STEM shortages
9. Identifying and addressing sector-specific skills gaps
10. Higher quality careers information and advice
11. Testing new approaches to lifelong learning

To date a White paper has not been produced outlining how the government intends to progress its reforms but the proposed consolidation of qualifications within the VET system to be replaced by 15 technical 'routes' all of which can be studies as an apprenticeship or in an institution, fewer institutions, and new institutions as well as higher standards are all noteworthy.

Singapore

The Singapore government has a very strong commitment to advanced manufacturing and engineering (AME). RIE2020 (its Research, Innovation and Enterprise Plan 2020) includes AME as one of four industry sectors for the government's $19 billion research and innovation investment.

Specifically in relation to advanced manufacturing and engineering, RIE 2020 contains the following strategic goals:

- support economic growth, create good jobs for Singaporeans and prepare our economy for the future
- strengthen linkages across public research performers and both large and small enterprises to sharpen value creation from public R&D investments, and
- build capabilities where Singapore can offer a differentiated value proposition, including making strategic bets ahead of industry to position Singapore for emerging opportunities

There are eight industry verticals within AME in Singapore (including aerospace, electronics, chemicals, etc). Underpinning these different verticals are four "cross-cutting technology areas" which are seen as essential enablers. They are:

- Robotics and Automation
- Digital Manufacturing
- Additive Manufacturing
- Advanced Materials

In addition to the funding available through RIE2020 to employers looking to adapt their businesses and innovate, the Singaporean government also offers other employer focussed training initiatives:

- **Skills Future** (which includes the Operations Management Innovation (OMNI) Programme – the aim of which is to train key personnel - engineers, managers and senior staff to be technology innovators to achieve manufacturing excellence. The program promotes the use of operations management techniques and technologies to support the organisation's strategy), and
- **Adapt and Grow** (which includes the Digital Workplace initiative aimed at helping Singaporeans, both individuals and employers, develop the mindset and some of the basic technology skills for the future economy).

Also on offer to senior employees in the manufacturing sector are Professional Conversion Programmes which have helped more than 1,000 professionals, managers, executives and technicians re-train in new skills (eg data analytics). Following the success of the first 36 programmes, an additional eight have been launched focussing on mid-level managers in manufacturing organisations. [28]

Earlier this year, Singapore's Committee on the Future Economy released a seven-point national Economic Strategy[29]. While the strategies are intended to be mutually reinforcing, the second focuses on skills development – and specifically vocational skills.

The report intends that to facilitate the acquisition of deeper skills, training providers and Institutes of Higher Learning (IHLs) should support more modularised and technology-enabled training programmes, and that the nexus between the acquisition and utilisation of skills needs to be strengthened, including through more company-led programmes. The Committee also intends that the government of Singapore and businesses should support more place-and-train schemes and work-learn programmes, not just for new graduates, but also for existing employees. They go on to note the success of the Professional Conversion Programme.

28 Economic Development Board, Singapore (March 2017)
https://www.singaporebusiness.com/2017/how-singapore-is-addressing-talent-gaps-in-the-smart-manufacturing-sector.html

29 https://www.gov.sg/microsites/future-economy/the-cfe-report/7-strategies#2

Other approaches

The OECD recommends four priorities for skills policies to meet the challenges of the fourth industrial revolution. Three are of particular relevance to the VET system:

- Education and training systems need to better assess and anticipate changing skill needs (including through the use of big data).[30]
- The skills workers need for the digital economy include reading, numeracy and problem solving in technologically rich environments, and work practices including teamwork, work autonomy, training, and flexible work hours are required to help people make maximum use of their skills. Employers may in turn need skills to help them introduce better work organisation and management practices.[31]
- As skill demands change, continuous training for workers to keep up with new skill requirements is crucial.[32]

The South African Chairman of the BRICS[33] Business Council Skills Development Working Group group of nations commissioned research from German Consulting Firm, Roland Berger, [34] to identify the specific skill needs for Industry 4.0. The research identified the following skills:

- Knowledge about ICT
    - Ability to use and interact with computers and smart machines
    - Understanding machine to machine communication
    - Data and IT security
- Ability to work with data
    - Processing and analysis of data and information
    - Basis statistical know how
- Technical know-how
    - Inter disciplinary knowledge
    - Specialised knowledge about manufacturing processes
    - Specialist maintenance skills

30 OECD (2016) Getting Skills Right: Anticipating and Responding to Changing Skill Needs, OECD publishing Paris. http://dx.doi.org/10.1787/9789264252073-en

31 ibid

32 OECD (2016) New Markets and New Jobs, OECD Digital Economy Papers, No. 255, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jlwt496h37l-en

33 The BRICS nations comprise Brazil, Russia, India, China and South Africa.

34 Roland Berger (2016) White Paper Summary: Skill Development for Industry 4.0 http://indiainbusiness.nic.in/newdesign/upload/whitepaper-summary-skill-development-for-industry-4-0.pdf

Personal skills

- Ability to change
- Ability to learn, unlearn and relearn and lifelong learning
- Decision making abilities
- Team skills
- Communication skills – human and machine"

Based on the research they have recommended the development of a specific Industry 4.0 BRICS qualification to support upskilling of existing workers and the development of new skills, as well as the greater mobility of resources between BRICS countries.

Challenges for the Australian VET Sector

The nature and pace of change as a result of Industry 4.0 pose significant challenges for the Australian VET sector.

There are few studies at this stage which specifically analyse the impact of technological change on the Australian VET sector and how the sector is preparing workers for a future of technological change. Amongst those that do – the following reports are notable.

Firstly TAFE Queensland has commissioned researchers from the CSIRO35 to investigate how the VET sector can best support Australia's future workforce in the context of changing skill needs and digital disruption. They conclude that:

- based on past trends VET enrolments are likely to increase as the workforce responds to technological change and the growth mature age learners seeking new skills is likely to outpace growth in younger learners
- VET providers are likely to struggle with the rate of change as skills become obsolescent at an ever increasing rate and the multi-year process required to make changes to Training Packages in the VET sector is a 'major hurdle' to developing skills to meet the rate of change occurring in the workplace
- VET faces reputational problems which combined with a move to online learning opens up competition from overseas providers and could further impact on quality in the system

The report makes the following recommendations:

- Increase use of digital technology to achieve both efficiency and quality in the delivery of VET.
- Identify those basic and core skills associated with a qualification (which need to be standardized at a national level) and allow high-performing VET providers the flexibility to modify other components of the training package in line with current industry practice.
- Build high-quality, two-way communication between VET providers and employers to support agility and responsiveness in a fast changing environment.
- Use predictive analytics and modelling (drawing upon big data available online) to obtain real-time insight into job demands and student pathways.

35 Reeson, A et al (2016) The VET Era: Equipping Australia's workforce for the future digital economy Report for TAFE Queensland. http://tafeqld.edu.au/resources/pdf/about-us/research-papers/vet-era.pdf

A follow-up report[36] examines how the changing demand for, and supply of, skills impacts at a regional level (in this instance the Fraser Coast).

In considering the changes that are coming from digital change in the workplace and being cognisant of the way in which the Australian VET system is currently funded – Francesca Beddie and colleagues in a 2014 research report[37] for the National Centre for Vocational Education Research found that "the current emphasis in public funding on entry-level training can work against the need to refresh STEM skills and potentially inhibits readiness to meet demand for growth in all industries" (p. 27).

The New South Wales Department of Industry is taking a very different approach to meeting rapidly changing skill needs. In their submission to the House of Representatives' Standing Committee Inquiry into Innovation and Creativity they provide preliminary details of a 'capabilities framework' that they are piloting initially for qualifications within the agriculture sector.

They are working with a consortium of universities (the University of Sydney, UTS, and the University of Melbourne) on an approach that recognises the uncertainties regarding the future labour market. They go on to state that the project advocates for the benefits of a capabilities-based, rather than competency based, approach to VET qualifications. They anticipate the pilot will achieve increased autonomy and job flexibility for learners, and a streamlined and enhanced set of qualifications within the sector. And that, if successful, this pilot could be transitioned to other industry sectors, including STEM areas.

New pilots have also emerged to tackle the digital disruption which looms for the Australian manufacturing and related sectors. For example, the WA Minister for Education and Training, the Hon Sue Ellery MLC, recently announced[38] a $2 million partnership between South Metropolitan TAFE and Rio Tinto to pioneer a new curriculum required for the mining industry's jobs of the future. The training scheme is specifically focussed on preparing workers for changes in their industry as a result of innovation and digitisation. The training is aimed at the post-school level and incorporates industry based traineeships.

36 Reeson, A, Mason, C & Sanderson, T (2017) Growing Opportunities in the Fraser Coast: Informing regional workforce development https://jobsqueensland.qld.gov.au/projects/growing-opportunities-in-the-fraser-coast/

37 Francesca Beddie et al., Readiness to meet demand for skills: a study of five growth industries, NCVER Research Report, 2014, page 27. The growth industries in question are food and agriculture, biotechnology and pharmaceuticals, advanced manufacturing, mining equipment and oil and gas.

38 https://www.mediastatements.wa.gov.au/Pages/McGowan/2017/10/Industry-training-partnership-to-future-proof-Western-Australian-jobs.aspx

Other initiatives

The agility available to the universities as a result of their self-accrediting powers is assisting them to quickly respond to new opportunities in an Industry 4.0 environment.

RMIT University, for example, has an explicit aim to "to become a first mover in training for Industry 4.0". RMIT has recently identified a 'surge' in demand for graduates with skills in Industry 4.0, including the industrial internet of things (IIoT) and augmented reality (AR) for the enterprise.[39]

Their aim is to 'comprehensively' expose all engineering students to state-of-the-art virtual prototyping and Industry 4.0 tools. They also intend to ensure that their engineering students acquire new employability skills. They have entered into a partnership with ThingWorx technologies to expand the university's collaboration with local businesses, especially those without sufficient resources to harness Industry 4.0 on their own.

In another project, funded as part of the Commonwealth government's 'Apprenticeships Training – Alternative Delivery Pilots' AiGroup, Siemens and Swinburne University have developed two higher level apprenticeship courses in Applied Technologies. They are designed to help new entrants to the labour market work in an Industry 4.0 environment. The apprenticeships are respectively at Diploma and Associate Degree level. While both courses were initially accredited as higher education offerings by Swinburne University, the Diploma is now being considered for reaccreditation by the VRQA, which would make the diploma available in the VET sector.

At the 2017 Asia-Pacific Regional Conference[40], Siemens announced that they were also making an investment in a partnership with the University of Western Australia – offering researchers at UWA the same access to the software Siemens has provided to Swinburne University. Supported by a $5 million investment from the Federal Government, the aim of the partnership is to assist Australian SMEs to transition to the digital economy (and meet the challenges of Industry 4.0).

Beyond Australia, a wider threat to the Australian VET system looms – technology itself. Panasonic is already using augmented reality to assist its aircraft maintenance engineers to learn new tasks and deal with more complex situations. They have also developed a system they refer to as "Remote Expert," which is a form of teleconferencing that uses smart glasses' front-facing cameras to enable an expert (at the company's headquarters) to see through an operator's glasses and push out information — documents, etc — to guide the inspection/maintenance process.[41]

39 https://www.iothub.com.au/news/rmits-plan-to-lead-in-industry-40-training-472578
40 http://www.afr.com/business/german-tech-giant-hands-software-to-top-universities-20171102-gze1im?btis
41 https://up.panasonic.aero/augmented-reality-maintenance/

Conclusion

The fourth industrial revolution is rapidly changing the world of work and broader society. The evidence is that the pace and nature of change is more profound than any previous period of change. Australian businesses are realising the need to invest in digital technologies but are still doing so at what appears a relatively low rate. As a consequence Australia is falling behind in its digital competiveness and education and training is a key drag on our ability to compete.

While there is a need for specific new skills to accommodate technological change, these typically have only a very short life cycle. Being able to accurately predict new skills and make them available to education providers in a timely manner is a significant challenge. It was noted during the consultations underpinning this project that universities self-accrediting powers allow them to offer new courses in a matter of weeks rather than the much longer lead times required in the VET sector.

In addition to the challenges in making specific new technical skills available quickly in the VET sector, the consistent view from the research and the consultations was that there is a need for a wider range of skills (beyond the sector's current notion of employability skills) required for workers to adapt and thrive in an Industry 4.0 environment.

Other countries are making significant changes to their VET systems to ensure they can deliver the workers of the future. It is recommended that further work be done in the Australian VET system to determine how Training Packages can continue to meet the needs of the workforce as Industry 4.0 introduces profound change to manufacturing and related industries.

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