Australian Cobotics Centre

Australian Cobotics Centre submission to the House Standing Committee on Industry, Science and Resources' Inquiry into Developing Advanced Manufacturing in Australia

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Contributors
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Australian Government
Australian Research Council

Executive Summary

The ARC Industrial Transformation Training Centre for Collaborative Robotics in Advanced Manufacturing, also known as the Australian Cobotics Centre (ACC), brings together expertise and experience from industry and universities to improve collaborative robotics capability within Australian manufacturing and to assist with the challenges and changes associated with the implementation of new technology for advanced manufacturing. The ACC aims to transform traditional manufacturing processes using collaborative robotics and manufacturing innovation and apply the resulting capability to industrial transformation priorities.

Investment in robotics, automation and digitisation is essential for Australian manufacturing to remain globally competitive and to deliver planned large-scale infrastructure projects. In addition, advanced manufacturing is changing jobs, resulting in a need for continued investment in skilling the current workforce to enable workers to be re-deployed and maintain a career in manufacturing.

The future of advanced manufacturing rests on more sophisticated integration of humans and technology. As manufacturing processes become increasingly more complex, humans and robots need to work collaboratively. Collaborative robotics offers solutions to the main challenges currently faced by Australia's SME-dominant manufacturing industry. Collaborative robotics will benefit Australian companies, especially small businesses (who will benefit from process innovation and lower costs), manufacturing workers (who will have more secure jobs and new skills), and the economy (through the growth of jobs and exports). This submission addresses the complex challenges of developing advanced manufacturing in Australia through recommendations based on research and the perspectives of ACC industry partners.

Recommendations

TOR1: The opportunities of advanced manufacturing for Australia
Recommendation 1: Incentivise and fund industry-university research and development partnerships to support robotics, automation, and digitisation of manufacturing in Australia.
Recommendation 2: Invest in programs to support open innovation and collaboration between industry and researchers that are targeted towards increasing the adoption of collaborative robotics.
Recommendation 3: Support research to ensure meaningful integration of collaborative robots within manufacturing businesses.

TOR 4: Barriers to the growth of advanced manufacturing in Australia
Recommendation 4: Ensure SMEs have low-cost access to access and adapt collaborative robots and other advanced manufacturing technologies for the Australian context.
Recommendation 5: Encourage development of Australian suppliers for equipment and technology to support advanced manufacturing.
Recommendation 6: Support manufacturers to understand cyber security risks, implement mitigation strategies and recover from cyber-attacks.
Recommendation 7: Support research-industry engagements that emphasise participation from workers in the adoption of collaborative robotics within their business.
Recommendation 8: Address labour shortages through a sector-wide retention and attraction strategy supported by industry-led qualification and training partnerships in collaborative robotics for manufacturing.

TOR 6: The opportunities to increase the number of workers employed in advanced manufacturing, including underrepresented groups
Recommendation 9: Develop a national strategy to increase the participation of women in manufacturing.
Recommendation 10: Invest in and train manufacturing SMEs to increase workforce diversity by utilising technology such as collaborative robotics.
Recommendation 11: Support research funding for projects that investigate the use of collaborative robots for inclusion and accessibility for otherwise excluded groups of people.

TOR 7: Skills needs in advanced manufacturing
Recommendation 12: Ensure Australia's education and training system is fit for purpose to skill the future advanced manufacturing workforce who will need to use collaborative robotics.
Recommendation 13: Support research-industry-education engagements to identify and address advanced manufacturing skills gaps, particularly gaps that impede the adoption of collaborative robotics.

Body of Submission

TOR 1: the opportunities of advanced manufacturing for Australia – including in relation to job creation, productivity and capability

Potential for robotic investment to grow national capability

There are significant opportunities available within Australia to improve productivity, create jobs and build manufacturing capability that benefits the Australian economy and society. The Australian Cobotics Centre (ACC) works with manufacturing industry partners[1] to find technological solutions that will improve productivity and create sustainable manufacturing practices, focussing on collaborative robotic solutions (cobots).

Robots are recognised as "a tool to unlock human potential, modernise the economy, and build national health, well-being and sustainability". The 2022 Robotics Roadmap for Australia examined manufacturing, among many industries, and concluded “Australia has a specific need for robotics to act as a force multiplier, augmenting and extending world-class, skilled human capability while reducing human exposure to dirty, dull, and dangerous processes.” and “if Australia invests wisely and shares people, data, and solutions across sectors, it can grow a national capability to support and expand niche manufacturing expertise and remain globally competitive”.[2]

ACC’s focus on collaborative robotics - which combine the strengths of humans and robots in shared work environments - addresses two characteristics of Australia’s SME-dominant manufacturing sector. First, manufacturing is diversifying, with commercial advantages open to companies who can achieve process innovation or integrated service offerings. Second, digitisation and consumer demand are shifting manufacturing towards value creation through customisation and bespoke products. This has resulted in complex and demand-driven manufacturing processes which do not lend themselves to full automation but require some element of human-robot collaboration to be efficient, safe, cost-effective and of high quality. Cobots offer solutions to these challenges.

Early work of the ACC demonstrates that the benefits of collaborative robots for Advanced Manufacturing in Australian have not yet been fully utilised. From a recent collaborative project investigating the feasibility of integrating collaborative robots in a manufacturing setting, we have learned that productivity can be raised. This is especially the case when workflows are planned, so that robots and people can work in parallel with each other.

Opportunity to expand open innovation and R&D collaboration

Advanced manufacturing requires R&D investment. Advanced technology innovation is a cost, and growth and expansion require capital. Most existing SMEs have little resources to dedicate to R&D and may not have existing capabilities to raise capital and achieve innovation and growth. Even though government grants have been helpful for many, some manufacturers are reluctant to apply for grants due to issues such as the time taken, limited knowledge of the process or a lack of prior success. University collaboration with multiple SMEs can help to fill this gap and grow national capability.

The ACC and industry partners are attempting to address these challenges through a program of research that aims to address the fundamental challenges of enabling robots to work with humans in the conditions Australian manufacturing industry demands, and to build skills and capacity for the future workforce. Recent research undertaken by ACC researchers into the barriers and successes of (in particular) Queensland manufacturers found that those organisations advancing their manufacturing capability were expanding their products and markets through new technological adaptations, including, but not limited to, cobots. These companies identified innovation as essential to operate in a small but highly competitive local market and to expand to global markets.[3] ACC industry partner, the Advanced Robotics for Manufacturing Hub (ARM Hub) supports the need for digital transformation to build capability in advanced manufacturing in Australia, noting that advanced technologies such as robotics and AI can transform traditional manufacturing and improve productivity, quality, and economic growth. The ARM Hub assists manufacturers to become more competitive through robotics and AI by giving SMEs access to expertise, facilities and networks to help innovate, and

[1] https://www.australiancobotics.org/

[2] S. Keay (2022), *A Robotics Roadmap for Australia*, Robotics Australia Group. https://roboausnet.com.au/robotics-roadmap/

[3] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing: Exploring the human element of the journey*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

supporting R&D by bringing together industry, researchers, and academics to collaborate on live industry use cases.

ACC industry partner B&R Enclosures[4], an SME advanced manufacturer, notes: "Advanced Manufacturing appears to be different in Australia when compared to other parts of the world such as Europe and America. The local market is much smaller. We can use mass customisation as a differentiator." B&R sees a major competitive strength in Australian manufacturing is "being agile to customer requirements".

B&R has consistently invested in acquiring technology over the past few years, including purchasing a fully automated fibre laser welding machine, an automatic punching and bending machine, and a laser cutting machine, and they have recently moved from paper-based to a digitised workflow. Their investments in robotics and new technology have secured several benefits for B&R, such as improving the competitive position in the market, in-sourcing some processes and innovating its product lines, and expanding its products beyond standardised metal boxes to provide custom products, ultimately supporting them to produce more products overall.[5]

Human-robot collaboration research to support advanced manufacturing capability

Rather than contributing to job losses, early ACC research indicates that the productivity and competitive gains achieved through digitisation and the adoption of new technologies (such as cobots) may contribute to jobs growth in manufacturing in Australia by enabling the expansion of manufacturing capability and the development of new product lines. In the short term, cobots may provide solutions to existing labour shortages that were exacerbated during the Covid-19 pandemic. Without investment in cobotic technology and digitisation, the global competitiveness of Australian manufacturing will be constrained, limiting opportunities for expansion and jobs growth. There is, however, significant further opportunity to leverage digital technologies and robotic solutions to advance Australian manufacturing.

Recently, ACC and the CSIRO's Collaborative Intelligence (CINTEL) Future Science Platform co-hosted an academic workshop at the 2022 Australian OzCHI conference. Experts on the topic of Human-Robot Collaboration (HRC) noted how Australia's geographical remoteness has been central to shaping values and available resources. This, in turn, has contributed to a lack of robotics manufacturing companies, limiting the opportunity to conduct fundamental research that contributes to the hardware design of robots. Because of this, Australian HRC researchers have had to focus more on application-specific research that takes place in-situ. Now is the time to increase support for this type of research to ensure that collaborative robots are integrated in meaningful ways in industry.

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Recommendation 2: Invest in programs to support open innovation and collaboration between industry and researchers that are targeted towards increasing the adoption of collaborative robotics.

Recommendation 3: Support research to ensure meaningful integration of collaborative robots within manufacturing businesses.

TOR 4: barriers to the growth of advanced manufacturing in Australia – including barriers to existing manufacturers, particularly small and medium enterprises, adopting advanced manufacturing technologies and processes such as AI and robotics

Cost of adopting advanced technologies for Australian SMEs

The SME-dominant structure of the Australian manufacturing industry means limited ability to invest in advanced technologies such as robotics. Additionally, existing business systems and manufacturing models are not well suited to Australian manufacturing. Queensland headquartered manufacturer B&R Enclosures notes: "Most of the Advanced Manufacturing machines and software are from overseas (Europe and USA). This can make it challenging to gather the required information to integrate machines between language and

[4] https://www.brenclosures.com.au/about-us/

[5] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing case study: B&R Enclosures.* https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

the time difference. We have taken it upon ourselves to configure and customise these systems using our own Systems Engineering team specifically to integrate machinery and software."

The mismatch between Australian manufacturers' unique needs (e.g. small batch and micro-manufacturing) or manufacturing conditions and advanced technology can lead to hesitancy toward future technology investments. However, the Advanced Robotics for Manufacturing (ARM) Hub (an ACC Industry partner) and the ACC itself, provide an avenue for facilitating partnerships that address the bespoke needs of small-batch manufacturers for the benefit of the whole manufacturing sector. [6]

Reliance on overseas technology suppliers

The dependence of Australian manufacturers on overseas-based technology suppliers for support in training, maintenance, and parts, risks their production and creates additional challenges, pointing to the need to develop capabilities within Australia. For example, B&R Enclosures observes: "the equipment technology is there to help us produce more efficient, better-quality products, but to gain the knowledge of how to use and maintain the equipment, that is still in development, requires constant attention of the manufacturer, located overseas".[7] The Robotics Roadmap proposes support for the Australian supply chain to integrate and supply imported robots/cobots to Australian manufacturers. It also recommends shared resources, tools, and libraries to develop capability.[8]

Cyber security risks

Digitisation for advanced manufacturing brings increased risk of cyber-attacks, increased costs to prevent and mitigate cyber security risks, and a growing need for cyber security skills in the manufacturing workforce. Manufacturers are aware of the significant increased risk of cyber threats and the need for capabilities to detect and avoid malicious cyber-attacks.

ACC industry partner B&R Enclosures are "most concerned about the arms race nature of cybercrime and seeing the business case for committing a crime is getting stronger. The chance of getting caught seems to be negligible, access to the tools and acquiring entry level skills seem to be getting easier, and the community's eagerness to adopt new technologies mean previously effective cybersecurity measures lose effectiveness and new entry points and vulnerabilities open up". B&R Enclosures says that SMEs should "share lessons across industries and communities…to identify opportunities to promote and embed cyber best practice". Governments can also help to build capabilities to block and detect cyber threats, enhance ability to respond to and recover from cyber-attacks.

Worker distrust in automation

Worker resistance to automation may be a barrier to adoption of advanced manufacturing technologies. There is a history of lack of trust in automation in many industrial contexts. This distrust can stem from workers' perception of what automation entails, a perceived risk of job loss or of being redeployed to jobs that are not as enjoyable as the manual tasks, or lack of communication between organisational layers. For instance, the misperception that robots cause unemployment is still widespread and the "current manufacturing workforce finds it difficult to imagine a new role for themselves in the Industry 4.0 workforce".[9] Consultation and holistic design is needed to create seamless integration of humans and machines working together to improve human work conditions and environments, and increase effectiveness and efficiencies in production, as well as workforce acceptance. Organisations need change management, leadership and communication skills to ensure technology acceptance and effective change.

Labour and skills shortage

There is shortage of both labour and required skills in meeting the current needs of manufacturers, as B&R enclosures states:

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[6] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing: Exploring the human element of the journey*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

[7] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing case study: B&R Enclosures*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

[8] [8] S. Keay (2022), *A Robotics Roadmap for Australia*, Robotics Australia Group. https://roboausnet.com.au/robotics-roadmap/

[9] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing: Exploring the human element of the journey*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

> "One of the key challenges is having skilled people to do the job with the right qualification and right experience. For instance, when building a switchboard, we need an electrical engineer who has good design experience in that area. Getting the right people is always a challenge for us. We often struggle with getting the right skill set from the market."[10]

This shortage was intensified by the Covid-19 pandemic. Skills shortages remain in traditional jobs such as welding, ISO 9606 (important to some Defence contracts), skills in boiler making, detailed technical drawing, fabrication and fitting and turning. Therefore, a sector-wide retention and attraction strategy supported by a dual approach to skill development that includes industry-led qualification and training partnerships, and organisation-specific development programs is needed. Such strategies need to consider new models/approaches to work (such as a four-day working week or greater levels of flexibility) and support new entrants and those that wish to re-skill with new ways to provide rapid skill development and certification (such as micro-credentials or short courses). Also, retention and attraction strategies need to address the issue of bad perceptions of manufacturing jobs, such as manufacturing jobs are "dull dirty and dangerous" have limited career progression, and insecure or at risk of automation. Also, manufacturing organisations need to take a holistic perspective on the interactions between technology adoption, skills and labour shortages in investing skills and training.[11]

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Recommendation 6: Support manufacturers to understand cyber security risks, implement mitigation strategies and recover from cyber-attacks.

Recommendation 7: Support research-industry engagements that emphasise participation from workers in the adoption of collaborative robotics within their business.

Recommendation 8: Address labour shortages through a sector-wide retention and attraction strategy supported by industry-led qualification and training partnerships in collaborative robotics for manufacturing.

TOR 6: the opportunities to increase the number of workers employed in advanced manufacturing, including consideration of ways to increase the participation and retention of women and other historically underrepresented groups

Gender diversity in the manufacturing workforce

Diversity in the workforce is vital for reducing labour and skill shortages in the manufacturing sector, and in ensuring the workforce better reflects society and its needs. Even though the percentage of women in the manufacturing workforce has been increasing, gender parity is yet to be achieved and there is limited research that provides insights into the sustainable well-being of women in the workforce. Currently, women workers are mostly concentrated either in business roles or unskilled work in which gender diversity is more balanced. Women's participation in managerial jobs is significantly lower. Further, because of the diversity of manufacturing in Australia, the proportion of women in the workforce varies significantly across manufacturing sub-sectors, with some sub-sectors being female dominated (such as food and textiles) while others remain largely male-dominated.

More research needs to be conducted on gender segregation in manufacturing jobs, and the barriers to and enablers of women's participation in manufacturing. This research needs to extend to the experiences of young women in apprenticeships and how that varies between trades or roles, the barrier to women's progression into management level in manufacturing, sexual violence and sexual harassment or other reasons that hinder the career development of women. The gender pay gap in manufacturing is currently 11.3%[12] which points to

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[10] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing case study: B&R Enclosures*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

[11] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing: Exploring the human element of the journey*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

[12] Workplace Gender Equality Agency (November 2022), *The gender pay gap by industry*. https://www.wgea.gov.au/pay-and-gender/gender-pay-gap-data

the embedded structural barriers to women's participation in the manufacturing workforce, that require highlighting and systematically addressing over extended period of time.

ACC is also investigating how cobots might enhance the participation of women in manufacturing. Technology and provide avenues to minimize or remove barriers to women's participation. For example, in B&R Enclosures, digitisation facilitated remote working for some roles and provided greater flexibility that helped some female employees to manage their work and childcare commitments.

This research will inform future recruitment and retention strategies and contribute to a more gender diverse workforce. Some state-based or region-based strategies exist for boosting women's participation in manufacturing. However, a strategy developed at the Commonwealth level with input from manufacturing businesses and women in manufacturing is required and supported by investment and training for manufacturing SMEs to assist them to increase the diversity of their workforce.

Diversity beyond gender

Diversity in the workforce transcends gender and can be extended to age, ethnicity, cultural diversity, (dis)ability, and neurodiversity. Manufacturing in Australia is currently experiencing both skills and labour shortages that demands strategies to increase the participation of under-represented groups such as First Nations people, people with disability, immigrants, and older workers.

The Australian manufacturing workforce is ageing. Rather than being problematic, diversity initiatives, supported by technology such as cobots, may enable the continued participation of older workers in manufacturing businesses. At present many older workers are transitioned into reduced work hours or a part-time workforce. However, older workers may also offer a new labour source. For example, some regional locations have deliberately targeted retirees, such as retired Defence Force employees, to take up positions in manufacturing businesses. Technology is enabling such initiatives.

For example, collaborative robots can support older workers to stay in work longer by performing some of the more physically demanding tasks in a job. Rather than replacing the worker, the worker's role changes from doing the physical task to programming and working alongside the cobot to complete the entire job. Cobots are developed with input from the worker/tradesperson who has the craft skill and knowledge to complete the task, and the approach to programming is simplified so that workers can learn and program the cobot with limited additional training.

As a result, collaborative robots enable new groups of people to enter specific job markets. This is beneficial both to the workers and to industries that currently lack workforce capacity. Collaborative robots can assist in tasks that require strength, accuracy, and repeatability. They can also perform sequences of work that are considered unsafe for people. Consequently, cobots present an opportunity to open more manufacturing jobs to previously under-represented groups, including women, older workers, and people with a disability.

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TOR 8: Skills needs in advanced manufacturing

Capability of Australia's education system to support Advanced Manufacturing

Partnerships between industry and educators are essential to developing the necessary skills and providing training that meets the changing skill requirements. However, there are gaps between vocational education and training (VET)/universities/industry in understanding of skills and training needs. For example, SMEs often cannot afford to release staff for inflexible training and instead seek on-site training or hybrid training models that combine onsite and offsite experience. There are tailored training programmes and opportunities for online courses and masterclasses to meet leadership training needs offered by various education and training providers partnering with industry experts to deliver joint training.

To prepare the leadership, the current workforce, and future graduates for emerging roles in Advanced Manufacturing, having a combination of practical experience, deep knowledge, and capability is important. This requires building on existing qualifications with trade skills. Yet university or VET is not perceived to be sufficient to build the right mix of skills and experience for advanced manufacturing. However, initiatives such as Swinburne University of Technology, Australian Industry Group and Siemen's Industry 4.0 Higher Apprenticeships Pilot Program demonstrated success in graduate capabilities around digital technologies and practical workplace skills, integrating trade skills into higher qualifications, and integrating skills from traditionally segregated disciplines.[13]

Approaches to re-training and re-skilling the existing workforce

The future of Advanced Manufacturing is determined by both technology and the untapped potential of the human workforce. As new technologies are introduced, workers must re-train, upskill and adapt as production processes and specific jobs are re-designed. Companies that have already transitioned to advanced manufacturing share a willingness to build capabilities by investing in people. For example, B&R Enclosures provides in-house career development opportunities for manufacturing workers. Team leaders and managers have been developed within the workforce, where they are provided with technical knowledge coupled with 'soft skills' through exposure to different roles and experts from outside the organisation. B&R Enclosures is concerned with developing the skills of their workers and adopting job rotation to develop knowledge of the manufacturing process, cross-skill their workers, and build capability across the workforce through training sessions and on-the-job experience and observation.[14] Industrial Transformation Training Centres such as the ACC can also help bridge the gap by training researchers to work with and in manufacturers on real challenges.

Identifying new roles and skills for the future of manufacturing

In the advanced manufacturing era, a wide variety of careers and new job roles are emerging, for instance, business development managers, digital marketing and social media specialists, roles in 3D printing, programming, technicians, electrical engineers, mechanical engineers, as well as roles such as boilermakers, welders and fitters and turners. Further, digitisation and automation have created more job opportunities, such as chief digital officer or chief data officer, software security, privacy officer, workforce health officer, contracting, supply chain positions, sales, aggregated supply roles and chief carbon officer.

Our research has identified future skills needs for advanced manufacturing include trade skills in conjunction with technology and AI skills, communication, leadership, and change management. It is important to develop technology literacy, data analysis, and programming skills as organisations move towards advanced manufacturing. Teaming traditional trade workers with engineers and other digital experts is needed "to tackle on-the-job challenges that can be solved by the application of advanced technology".[15]

AUKUS has highlighted the imperative to build and grow the highly advanced manufacturing workforce needed to support this industry. Industry 4.0/5.0 and Cobotics expertise will be at the very core of the advanced manufacturing capabilities needed to build submarines for AUKUS. A higher apprenticeship training scheme (such as that successfully operating via Swinburne University of Technology) seems not only highly apposite to growing this new highly skilled workforce in advanced manufacturing technologies, but essential. We are not going to get there through traditional apprenticeships alone and it requires developing an apprenticeship ecosystem to skill workers at all levels of expertise, not just entry level.

Developing change management skills in leaders

To successfully transition to Industry 4.0 and 5.0, companies need to effectively communicate their vision to workers so that they can imagine their place in the future and how they can apply their skills to the changing needs. To do this, managers need to develop change management skills. Change management skills enable organisations to cope with (sometimes rapid) growth, to effectively introduce different technologies, and to support staff to adapt to new ways of working. Also, by extending the change management skills to strategic capabilities such as design thinking and environmental scanning skills, managers are better able to adapt to the changes occurred in the macro environment. In addition, risk management, contingency and scenario

[13] AiGroup Workforce Development (2018), *Industry 4.0 Higher Apprenticeships Program*.

[14] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing: Exploring the human element of the journey*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

[15] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing: Exploring the human element of the journey*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/

planning are also playing a crucial role in preparing organisations to survive significant events happening in the environment, such as the Covid-19 pandemic.

Developing business management fundamentals

Many owners of small-to-medium size businesses located in regional areas have limited formal business training. To move to advanced manufacturing, business leaders need to develop certain business planning capabilities, such as learning ways to reduce waste and having access to knowledge of new processes and emerging technologies to produce specialised products and/or improve current production. Before building digital capabilities, it is necessary to develop business capabilities, such as lean manufacturing or strategic planning. Digital capabilities that business leaders need vary but could include anything from Enterprise Resource Planning systems to augmented reality (AR) and virtual reality (VR). Also, there is increasing recognition of the importance of data and data systems. Further, generic management knowledge and process management capability are essential capabilities to develop at the supervisor level. Given the high competition for labour in robotics/mechatronics, manufacturing leaders of SMEs need to have training opportunities and develop skills in how to scale quickly, recruit skilled labour quickly and identify different funding options.[16]

Recommendation 12: Ensure Australia's education and training system is fit for purpose to skill the future advanced manufacturing workforce who will need to use collaborative robotics.

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[16] Hearn, G; Williams, P. & Rodrigues, J.H.P (2022), *Advancing Manufacturing: Exploring the human element of the journey*. https://jobsqueensland.qld.gov.au/projects/advancing-manufacturing/