Industry Insights

German Manufacturing 2019 and Beyond

IBSA

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Overview

In 2017, IBSA was selected as the Skills Service Organisation (SSO) for the manufacturing industry and its relevant sectors. As a government-funded SSO, IBSA enables the Australian manufacturing industry to establish world-class, nationally recognised qualifications that ensure businesses and their workforce stay at the forefront of global innovation and competitiveness.

To faciltate this work and ensure the Australian manufacturing sector has access to the skills it needs as it innovates, IBSA commissioned this targeted report; the aim being to learn more about the changes German manufacturers are making to their operations, and the advanced manufacturing training they have introduced as a direct consequence. This report outlines these changes and considers their impact in the Australian training context. It is the first of a series of *Industry Insight* publications IBSA aims to produce to support the Australian VET sector in its shift to provide training for Industry 4.0 and beyond.

The World Economic Forum (WEF) identifies six 'principle-based actions' to ensure manufacturing in the Industry 4.0 environment delivers the maximum benefits to society. Four of these are directly relevant to the training questions that lie at the core of this *Industry Insights* report. They are:

- augment, instead of replace, the operator
- invest in capability-building and lifelong learning
- diffuse technologies throughout geographical areas and include SMEs
- collaborate on open Fourth Industrial Revolution platforms and handle data carefully.

The focus of this report does not include the following principles: Protect organisations and society through cybersecurity; and Address the challenge of climate change using Fourth Industrial Revolution technologies.

Context

Manufacturing has endured at least a decade of 'productivity stagnation and demand fragmentation'. according to the WEF.[i] Against this backdrop – the WEF argues that the time for innovation within the sector is long overdue. The Fourth Industrial Revolution (Industry 4.0) is now creating significant disruption to value chains and business models, and factories are at the heart of the changes being introduced by Industry 4.0.

Industry 4.0 Refers to transformative technologies to connect the physical world with the digital world. It includes advanced automation and robotics (including collaborative robots or 'cobots'), machine-to-machine and human-to-machine communication, artificial intelligence and machine learning, and sensor technology and data analytics.

https://www.industry.gov.au/funding-and incentivesmanufacturing/industry-40

The Australian manufacturing sector has been particularly hard hit by the forces of globalisation, increasing competition from cheaper overseas manufacturers and the increasing use of digital technology and automation by other overseas competitors. According to the AMGC, the result has been that "more Australian manufacturers are recognising the need to compete on value rather than cost. Most commonly, this involves contributing innovative products, components or services within global supply chains."[ii]

The Australian government has fostered a number of key initiatives to assist Australian manufacturers in the shift to advanced manufacturing. Australian government initiatives include the establishment of the AMGC and the creation of an Industry 4.0 Taskforce (now managed by the Australian Industry Group as the *Industry 4.0 Advanced Manufacturing Forum*). The government signed an agreement with its German counterpart to formalise information sharing and collaboration Industry 4.0.

Industry 4.0: the German experience

$52,574

GDP per capita in Germany is marginally higher than in Australia (US$52,574 compared to US$52,003 in 2017).

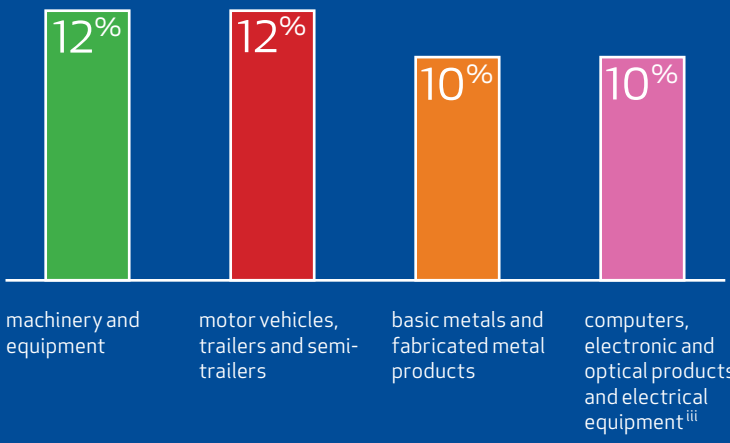
3.7%

Unemployment is low at only 3.7% of the working population.

47%

Trade makes up 47% of Germany's GDP and for 79% of total production.

Biggest manufacturing sub-sectors:



Against this broad economic background, Industry 4.0, referred to Industrie 4.0 in Germany, was one of the future projects adopted in 2010 by the German Federal government, arising from its "High-Tech Strategy 2020". The focus on Industry 4.0 was intended to support and grow the German industry and its international position, by leveraging digital technologies to deliver advanced manufacturing solutions.

In relation to Industry 4.0, the German Trade and Investment agency (GTAI) states that:

> "INDUSTRIE 4.0 is set to revolutionize manufacturing and production. INDUSTRIE 4.0 represents a paradigm shift from "centralized" to "decentralized" smart manufacturing and production.
>
> "Smart production" becomes the norm in a world where intelligent ICT-based machines, systems and networks are capable of independently exchanging and responding to information to manage industrial production processes."[iv]

Furthermore, they offer the following eloquent description of how Industry 4.0 transforms the manufacturing process:

> "industrial production machinery no longer simply "processes" the product, but that the product communicates with the machinery to tell it exactly what to do."

The way in which the Internet of Things (IoT) is transforming the manufacturing process – is frequently described as the 'Smart Factory'.[v]

15 Components of the smart factory of the future

Suppliers

1. Smart Supply network
Transparency over supplier inventories and vehicle logistics allows for automatic and optimised supply decisions.

Manufacturing

SOFTWARE

2. Next generation manufacturing systems
Manufacturing systems make automated and smart decisions (e.g., production scheduling), offer intelligent machine applications, seamless engineering integration and allow for more remote visualisation, monitoring, control, and alerts.

3. Cloud storage/ processing
Data storage and application processing on secure cloud servers.

4. Data analytics
Advanced decision algorithms and real time analytics.

5. Cybersecurity
Encrypted data and protection mechanisms against cyber threats.

SHOPFLOOR

6. Intelligent sensors/actors
Sensors deeply integrated in machines wirelessly stream data and have an own analytics engine (edge analytics).

7. Cyber physical systems
Interconnected systems and social machines control physical entities.

8. Smart maintenance
Machine maintenance becomes integrated (autonomous) aided by predictive algorithms and remote assistance systems.

9. Mobile workforce
Workers are equipped with mobile devices and augmented reality devices to process realtime information.

10. Self-driving vehicles
Material is handled via autonomous vehicles and intelligent transportation units.

11. Intelligent products
Products carry relevant information for machines to make decisions.

12. Additive manufacturing
3D printing allows for rapid prototyping and rapid spare part printing.

13. Robotics
Use of flexible robots augments intelligence automates certain processes and creates new forms of worker robot interaction.

14. Advanced materials
New materials such as nanO-materials as well as integrated computational materials engineering (ICME).

Customers

15. Responsive manufacturing
Individual manufacturing steps are designed for customer interaction so that products can be tailor-made for customers.

Against this backdrop what lessons are there from the German shift to Industry 4.0 and Smart Factories?

Maximising the benefits of industry 4.0

Augment, instead of replacing, the operator

A number of experts interviewed as part of this research project, identified that the work of operators is changing as the factories, in which they work, change. With the introduction of the IoT, there has been a requirement for a much stronger focus on the maintenance of technology.

In turn, this has meant that operators need to understand the whole production process and not just their role in it, which has been the traditional focus for them. Understanding the full production process assists them in making the right decisions about when and in which sequence to undertake the maintenance tasks required in their changed roles.

As operators' jobs change to also focus on understanding and care for whole machines, the complexity of their role is increased. Not only are they taking on more preventative maintenance but, as they work alongside machines ('cobots'), they must also know when and how to respond as the machines tell them that something is wrong. Collectively, this means that the complexity of their work is increasing and training is fundamental to supporting these operators in adapting.

As a consequence of changes to the operator role, a need for more 'on demand' training is being generated. Typically, this is provided by the machine suppliers, who offer hands-on training when the machine is delivered. There has been a shift, however, to fully online, supplementary training using virtual labs around the world, so that training can occur at anytime that suits the manufacturer.

A number of the experts mentioned **F**uji **A**utomatic **N**umerical **C**ontrols (FANUC). With more than 100 models currently available, FANUC offers the widest range of industrial robots worldwide. In addition to offering training when they introduce their robots into a manufacturer's operations, they have also developed a training academy for robots. Their robotics-training bundle helps people (particularly aimed at students) to gain first-hand experience in programming and operating industrial robots. They state that their content:

> "is highly relevant for modern factory applications and contains everything instructors require to teach students to program and operate robots." [vi]

The experts we met also referenced Festo, a leading German manufacturer of automation technology and equipment. In addition, through its Festo Didactic arm it has branched out from simply training people on the components it manufactures to providing training on a vast range of topics including:

- automation
- HVAC and Refrigeration
- Industry 4.0
- mechatronics
- pneumatics digitalisation
- PLC Programming

The cyber-physical factory is now the platform for Festo's training, and they have extended beyond just manufacturing to also provide training in cyber security and RFID (Radio Frequency Identification).

Typically, this is provided by the machine suppliers, who offer hands-on training when the machine is delivered. There has been a shift, however, to fully online, supplementary training using virtual labs around the world, so that training can occur at anytime that suits the manufacturer. Operators with medium and higher skill levels are being taught new skills, including how to maintain and repair the cobots that work alongside them. These skills are being taught to existing workers by the suppliers of the new technology, with some companies like FANUC and Festo Didactic providing an extensive suite of additional training offerings.

Invest in capability-building and lifelong learning

Many of the experts we consulted expressed a view on the skills German manufacturing workers need to succeed in an Industry 4.0 environment.

Dr Wagner, from Fraunhofer IAO Institute for Industrial Engineering, categorised the skills into two types: primary skills, the new technical skills needed for work; and secondary skills, the soft skills many education systems have been teaching for a decade or so.

Using this typography, most of the experts identified more gaps in the secondary (soft) skills of the German manufacturing workforce, than in their primary skills.

Specific secondary skills that people require in a Smart Factory environment include:

- Flexibility: consultations indicated that as old employment models are changing, people need to change too. Some thought this change to more flexible ways of working would be challenging because of what they described as 'German conservatism'.
- The ability and willingness to learn are important, as is an attitude of coming to a new work role with an open mind.
- As businesses restructure and introduce new technologies, this creates situations where people will learn and adapt.
- The importance of teamwork/ collaboration. The nature of the school system and the focus on individual success within it, mitigates against people having more opportunities to work collaboratively. More project-based work within the formal education system was seen as being particularly helpful.

Some experts were explicit that these skills will be critical for future success and will need to be embedded across organisations.

In terms of the primary (technical) skills that workers need in an advanced manufacturing workplace, the experts identified that the skills are split between specific manufacturing skills (taught by the equipment supplier) and IT skills. In terms of the IT skills, the examples given were:

- Programming: even where workers are not involved in programming as part of their role, it was pointed out that they need to understand how computers and algorithms works.
- An understanding of data analytics may become increasingly useful, although there was some scepticism about the true value of 'big data'. One expert argued that 'sample data' and 'smart data' may be a better approach to complex problem solving.
- When discussing digital skills, a number of experts noted that the new generation of workers has a much greater comfort level with technology from the ubiquity of smart personal devices like the iPhone.

It was noted that the German education system (at both school and university level) is subject to different approaches because the 16 states, which make up the German federation, are responsible for education at these levels. The German vocational system is largely the responsibility of the Federal government, in conjunction with the Chambers of Commerce, the unions and employers (the dual system, with its focus on both theoretical and practical training in a real-world context).[vii]

Lucas-Nuelle is an important provider of learning resources to the German VET system, and increasingly to VET systems and providers across the world. They supply learning resources to a wide range of Australian TAFE Institutes and offer resources across a range of different topics, both online and with specialist equipment.

These include:

- building management
- power engineering/smart grid
- renewable energies
- transformers/power electronics
- communication technologies
- process and chemical engineering
- process control
- machinery and systems engineering
- fluid power
- instrumentation
- micro-computers/micro-controllers
- automotive – hybrid and electric vehicles
- automation – Industry 4.0.

Sensor-manufacturer, Balluff, is involved in a dual program at university level, whereby students undertake university study and then work at Balluff on a digital project with a real-life application (e.g. how to value add to one of the Balluff sensors). This program benefits both the learner, who gets to hone their skills on a real-life project, and Balluff, which is provided with a source of new ideas for its product lines.

While the concept of lifelong learning clearly relates to people learning throughout their careers, a related shift is occurring in terms of product development in Germany. Arising directly from the increased use of technology in the manufacturing process, product development is changing from a lengthy and quite isolated pure research-based approach to a more iterative and collaborative model (that is continually learning and refining the product during the development process). This shift improves speed to market and reduces development costs as the process allows adaptations based on changes happening on the factory floor and/or amongst consumers; in turn this improves reliability.

Diffuse technologies throughout geographical areas and include SMEs

While the German manufacturing sector is known for its global success stories such as Siemens, Bosch and its car manufacturers like BMW, Daimler and Volkswagen, it also has many very competitive SME manufacturers that focus on niche industry segments. As a result of their emphasis on quality and superior performance, many are ranked at the top globally in the industries they supply to.[viii]

One of the reasons for the success of Germany's SME manufacturers is the Fraunhofer-Gesellschaft, an independent non-government organisation which provides high-quality, short-term, affordable applied research that small and medium-size firms could not otherwise afford. Fraunhofer enables smaller manufacturers to continually upgrade their processes and products, and keep ahead of the competition.[ix]

The research activities of Fraunhofer-Gesellschaft are conducted by 72 institutes and research units across Germany. The organisation employs more than 26,600 people (most of whom are qualified scientists and engineers), and manages an annual research budget of more than €2.5 billion.

Fraunhofer IAO Institute for Industrial Engineering is located at the University of Stuttgart and amongst its work it operates a **Future of Work** laboratory, which allows businesses that are looking at introducing Industry 4.0, to bring their workers to trial and test equipment before it is introduced to the workplace.

Technologies that are available for people to trial and experiment include:

- collaboration with a large manufacturing robot
- personalised assembly workstations, allowing workers to go step-by-step through the assembly process
- mobile industrial workstations
- mobile robots bringing tools, materials and even workbenches to workers when they are needed
- optical 3D sensors and state-of-the art Industry 4.0 technology for accident prevention
- Stuttgart Exo Jacket, which is an exoskeleton designed to support workers in tasks involving lifting and overhead work, allowing particularly older workers to stay in the workforce for longer

- Industry 4.0 'knowledge nuggets'; short online training units, which can be accessed at any time to help workers learn how to use new technology
- KPI dashboards for supervisors to improve shop floor management
- virtual and augmented reality
- 'Sense and Act'; a solution that allows manufacturers to apply smart sensor technology to old machines and systems.

In addition to the investment the German government makes in research to support SME manufacturers, another government initiative is also driving changes in the workplace. One of the experts we spoke to identified how the German legislative change allowing white collar workers to work from home[x] is also influencing the thinking of other German workers and employers.

Local governments in germany are monitoring this development closely given the obvious infrastructure changes that will result as a consequence of these changes, with fewer people heading into and out of large factories and city centres at the same time.

With technologies such as digital twins and virtual reality in the manufacturing process, it is now increasingly possible for blue collar workers to also work part of the week from home should they and their employers choose to do so. Operators do not always ned to be onsite to keep machinery running.

Collaborate on open Fourth Industrial Revolution platforms and handle data carefully

ARENA2036 (**A**ctive **R**esearch **E**nvironment for the **N**ext **G**eneration of **A**utomobiles) is a flexible research factory built both on collaboration and to encourage collaboration.

Its goal is to be "*the pacemaker for sustainable automotive engineering for the next generation of cars.*"[xi] The focus is on lightweight design and production and is based on a close-knit link between science and industry, as well as between lightweight design research and production technologies.

Described by the experts with which we consulted as a 'problem solving' hub for industry, ARENA2036 fosters mutually beneficial research partnerships between its industry partners that are further enhanced by the co-location of Europe's largest start-up incubator 'Autobahn' and the involvement of PhD research students on ARENA2036 research projects. Staff at ARENA2036 assist their industry partners in numerous ways including helping them apply for research grants and publish their research results.

The industry partners located at ARENA2036 include both large and small companies involved in the automotive manufacturing industry.[xii] By co-locating teams of technicians in the ARENA2036 facility, cross-organisational collaboration, problem-solving and innovation is possible. International partners, including Swinburne University of Technology, and graduates from the Autobahn incubator add additional, fresh perspectives.

Start-up incubator "Autobahn"
Autobahn connects start-ups of all developmental stages with industry leading partners to pilot their technology and help them to achieve production-ready technology. The incubator includes 22 active partners, has supported 139 alumni start-ups, and has realised 231 pilot projects.

Autobahn focuses on evaluating and developing technology in a real-world environment, which it is able to do due to the involvement of its long-standing established industry partnerships. Some of the start-up alumni go into ARENA2036 once they leave Autobahn but all of them can access the technicians who work there and share ideas and collaborate on problem solving.

While not as structured or purpose-specific as ARENA2036, other government initiatives are also enhancing collaboration between German manufacturers. For example, recent energy saving initiatives, which incentivise businesses to reduce their energy use, have had flow-on consequences. These include businesses changing how robots move within their factories (because even small changes to robotic movement can deliver energy savings). In turn, this has driven demand for software investment to simulate the savings that will be gained from process/system changes and the flow-on savings. Furthermore, major German car manufacturers are collaborating (as are other companies in the same industries) to find energy efficiency savings.

Implications for the Australian vocational education and training sector

There is much that Australia can learn from the Germany's first mover advantage into Industry 4.0. The government and some of our universities and business peak bodies have recognised this and acted, as evidenced through the partnerships between various Australian and German universities, Australian universities and German manufacturers, as well as the establishment of the *Industry 4.0 Advanced Manufacturing Forum*.

There appears to be work still to be done in the VET sector to understand and engage with the training implications of Industry 4.0. This research indicates that the VET sector needs to ensure that:

- Training providers are aware of the new types of machinery/new processes being introduced into factories across Australia.
- There is a feedback loop between the employers introducing new types of machinery/technology, their training provider partners, and the relevant Industry Reference Committees to ensure that Training Packages are updated to more accurately reflect the maintenance and problem-solving skills needed to keep new types of machinery working. Training on specific new machines should remain the responsibility of the supplier/manufacturer. However, where a new type of machinery/technology is introduced (e.g. mobile robots as a particular innovation, rather than a specific robot), there is a potential role for Training Packages to be amended to ensure workers have the skills to maintain and problem solve with these new additions to the manufacturing process.

- Training Packages for the manufacturing sector include units that allow learners to develop an understanding of the entire production process and not just a component of it, and that they have a sufficient focus on teamwork and collaboration, as well as the other soft or secondary skills identified in this research.
- Work continues with respect to the introduction of digital skills such as coding/programming into Training Packages.
- Explore whether an 'Introduction to Industry 4.0' skill set might be useful to assist employers and their employees to think through the implications and factors involved in moving to a more digitised means of production. The content could be modelled on the 'Factory of the Future' content offered by Fraunhofer IAO.
- Training providers play a role in Industry 4.0 research and start-up partnerships; to help both spread Industry 4.0 innovation through the VET sector, and to inform the existing research partnerships with the inclusion of more practical vocational knowledge.

End Notes

[i] World Economic Forum (2019) White Paper - Fourth Industrial Revolution: Beacons of Technology and Innovation in Manufacturing (in collaboration with McKinsey & Company) *https://www.weforum.org/whitepapers/fourth-industrial-revolution-beacons-of-technology-and-innovation-in-manufacturing*

[ii] *https://www.amgc.org.au/our-purpose/about-advanced-manufacturing/*

[iii] *https://data.oecd.org/germany.htm and https://tradingeconomics.com/germany/manufacturing-production*

[iv] *https://www.gtai.de/GTAI/Navigation/EN/Invest/Industries/Industrie-4-0/Industrie-4-0/industrie-4-0-what-is-it.html*

[v] *https://iot-analytics.com/industrial-internet-disrupt-smart-factory/*

[vi] *https://www.fanuc.eu/se/en/robots/educational-package*

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[viii] *https://www.asme.org/engineering-topics/articles/manufacturing-processing/how-does-germany-do-it*

[ix] *Ibid.*

[x] *https://www.dw.com/en/a-german-right-to-work-from-home-in-your-pajamas/a-46964872*

[xi] *https://www.arena2036.de/en/arena2036/vision*

[xii] *https://www.arena2036.de/en/partnerships*

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