Skills for Industry 4.0: Navigating Uncertainty in a Digital Era

Author

Houghton, Luke, Loy, Jennifer

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Section I

Skills for Industry 4.0

Abstract

This chapter discusses the skills required to navigate uncertainty produced by 'digital convergence' manifest as Industry 4.0. Key skills for future working, such as identified by the World Economic Forum Global Risks Report 2023, include analytical thinking, creative thinking, systems thinking, curiosity, lifelong learning, and adaptability. These skills are increasingly needed because digital convergence, where the synergy of two or more digital technologies significantly changes practice, combines technical aspects of computing with design and innovation requiring a different emphasis in skills development. The chapter discusses how new skills for digital convergence could help organisations better navigate the ambiguities of integrating Industry 4.0.

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Skills for Industry 4.0

Navigating Uncertainty in a Digital Era

Luke Houghton and Jennifer Loy

1.1 Introduction: Digital Skills

A key problem facing those involved in workforce planning is the growing uncertainty around the roles and responsibilities of working with maturing digital technology innovations. One of the most significant of these is artificial intelligence (AI; Basu et al., 2023), which is replacing many aspects of work that were traditionally only thought possible for humans. Another is digital manufacturing, which is enabling remote management of processes and shared inventory, which demand new ways of working. When digital technologies are aggregated and added into a society that is increasingly networked (Barney, 2004;Castells, 2009), there is a noticeable convergence effect (Iosifidis, 2002). The impact of this digital convergence has been described as disruptive (Danneels, 2004). Digital convergence in this context refers to the integration of different types of media, technology, and platforms over a consistent and common digital ecosystem (Seo, 2017). Commonly the term 'digital convergence' is used to describe the coming together of digital applications to perform an outcome. This often includes telecommunications and media forming a unified and connected network, a digital environment facilitated by mobile devices and the Internet (Matt et al., 2023). Arguably, society is moving rapidly towards a constant state of disruptive digital convergence (Hinterhuber & Stroh, 2021; Vial, 2021).

An example that illustrates the paradigm shifts digital convergence is creating is found in the entertainment industry. Consider the way recorded entertainment has been, and now is, consumed. Fifty years ago, storytelling was only available through a limited number of formats and media. Now, on-demand television, film, and video content as well as audio can be accessed through multiple devices and platforms. A similar shift to prolific production and availability can be seen in other industries (Kapoor & Lee, 2013; Wei & Pardo, 2022), and in each case, the experience of the worker in that industry has changed. For the knowledge worker in particular, digital convergence has serious implications (Lenkenhoff et al., 2018). The ability to share information across and between organisations is creating challenges (Jiang et al., 2023), just as the responsibilities of managing those interactions is becoming increasingly complex.

1.2 Towards Industry 4.0

Table 1.1 outlines the rapid technology cycles of the last 24 years that a knowledge worker would have to navigate.

Table 1.1 Technology Cycles

Technology Cycle	**Date**	**Transformation**
Dot com bubble burst	1999–2002	Internet enters the business world; the birth of Amazon and e-commerce platforms
Web 2.0	2005–2010	Web 2.0 introduces interactive web technologies, such as Digg, MySpace, YouTube, and Facebook
Web 3.0	2006	Web 3.0 content is available across apps and devices as a single web; artificial intelligence (AI) enables computers to distinguish results based on an understanding of the meaning of words, rather than purely recognisable words, described by Tim Berners-Lee as the rise of the 'semantic web'

Smartphones	2007	Personalised computing on a smartphone introduces the idea of portable handheld computing
Cloud computing	2008	New technologies run from the web drastically decrease the cost of infrastructure for businesses and increase flexibility, portability, and scalability
Big data and analytics	2008–2010	Introducing the idea of being able to use data for more meaningful predictions based on accurate representations collected from transactions
AI and machine learning	2010	Over the past decade, digital technologies have led to increased automations in businesses and the replacement of many jobs
Blockchain	2016	Disrupted supply chains and automated authentic identity verification
5G	2017	Although slow to be introduced in countries such as Australia with vast regional areas, wireless working becomes more reliable
Remote working (COVID-19)	2020–2023	Hybrid working introduced during the pandemic, with many businesses now focusing on developing semi-permanent remote working practices
Hacking and cybersecurity changes	2023	Massive investment required to prevent bad actors from breaking into digital systems
Rapid uptake of AI, the Metaverse, and beyond, Web 4.0	2023	Accessibility to AI through developments such as ChatGPT, the increased use of automation with AI, and the emergence of Web 4.0, including the Metaverse

Studying patterns of interaction over recent years, relationships between people and machines have become more intertwined. The skills base for a graduate 25 years ago from a specialist technology discipline, such as systems analysis, would be typically narrow. However, recent graduates are expected to work with machines in a collaborative manner as using the technology becomes more intuitive. Therefore, the skill set from an undergraduate degree now tends to be seen as less technical and more collaborative and creative. As society moves through Industry 4.0 and towards Industry 5.0—characterised by a human-centric use of technology

(Maddikunta et al., 2022)—the human–machine interface is designed to be increasingly accessible.

Looking beyond Industry 4.0 brings with it the need to move technical proficiency back from the forefront of computer technology and into the world of enabling technologies, an era of innovation (Aslam et al., 2020). Industry 5.0 is envisaged as a world where humans are central and technologies therefore designed to be easier to use and developmental (Nahavandi, 2019). This shift in emphasis is illustrated through the evolving of communications, as outlined in Table 1.1. Consider the example of using a web interface to build an e-commerce website to be installed in the 1990s and in the early to mid-2000s. Logistically, this would have been a difficult exercise at the time. In 2023, however, it is possible for individuals to access high-end server technology from home. As argued in recent research publications (Boobalan et al., 2022; Kukreja & Kumar, 2021; Matt et al., 2023; Xu et al., 2021), because technology has become easier to use, it is therefore more readily adopted. One illustration of the growing ease of use of technology is the Metaverse. This is a user-centred, online immersive environment that is accessible across multiple devices without specialist equipment.

In the example of the Metaverse, whilst programming for the Metaverse is still an emerging skill, the usability of the interfaces involved is significantly more palatable than a COBOL interface was in the 1980s. The need for specialist skills diminishes in exchange for an adaptable set of skills, able to handle the disruptions these technologies bring (Danneels, 2004). As the capabilities of disruptive digital technologies (Robertsone & Lapiņa, 2023; Subramaniam et al., 2019) replace technical skills' requirements, the challenge then becomes, what are the new skills required for future practice? According to the latest World Economic Forum report, analytical thinking, creative thinking, systems thinking, curiosity, lifelong learning, and adaptability are key abilities for workers in 2023. When considering recent developments in AI and natural language processing (NLP) models, and their disruptive potential, the emphasis on creativity and imagination becomes clear. Analytical thinking and systems thinking are equally critical to build solutions within the complexity frameworks that curiosity, creative thinking, and digital convergence inspire. Given the rate of change in the field, as outlined in Table 1.1, and the uncertainties that digital convergence creates, lifelong learning and adaptability are fundamental to worker development for this era.

1.3 Disruptive Ambiguity and the Need for Integrated Skills

During the past 50 years of problem-solving research, the concepts of complexity and disruption have been a focus. One of the main areas of concern has been how to manage and harness ambiguity in complex problem-solving situations. Unfortunately, this research tended to be limited to group problem-solving interventions for organisations, instead of society-wide responses (Mingers & Rosenhead, 2004; Rosenhead, 2006; Houghton & Loy, 2023). In this section, these shortcomings will be briefly examined in the context of understanding the future of work on a broader scale. This section also scopes out a possible way forward for digital era skills integration—and integrated skills—for the future.

In historical problem-solving research the idea of ambiguity as a disruptive influence is a central concept (Checkland, 1994; Weick, 1993a). The term 'disruptive ambiguity' was coined by Karl Weick (Weick, 1993b). Seen through the lens of sociology and management, disruptive ambiguity is about the unanticipated disturbances that derail expected practice. Ambiguity is therefore argued by these authors as a 'sense of not knowing', characterised by an inability to understand how the activity had been derailed (Price, 2004). An example is the emergence of a new technology that upends the market, such as was the case with Blockbuster Video when streaming disrupted conventional business models. The uncertainty created by the emerging technology is frequently only understood after the fact, hence the term 'sense making' (Weick, 1993a, 1993b).

The scale of today's disruptive ambiguity is arguably creating cognitive dissonance in which the reality of the situation is so different to established practice that it is difficult to comprehend. Think of the rise in AI and data analytics over the last few years and trying to anticipate their impacts on markets and the reshaping notions of the future of work. This can be unsettling and inevitably has destructive side effects that can exclude particular groups.

With increasing cycles of technological change come increasing cycles of ambiguity. When considering the number of disruptions caused by technological innovations over the last 20 years, as per Table 1.1, it can be argued that the degree of ambiguity and uncertainty in the work environment is stronger (Kearney et al., 2022). The rate of technological change and the need for markets to adapt means that the average knowledge worker must adapt to more frequent cycles of ambiguity and change than in previous times in history.

An illustration of this increasing speed can be seen in a comparison between the time it took for VHS technology to be replaced by DVD, and then DVD to be supplanted by streaming. Four years ago, the online short form video provider TikTok was called music.ly and was an under-subscribed platform for teenagers to share music videos. In 2019, TikTok had approximately 219 million users worldwide. By September 2023, they had 1.6 billion. This type of exponential growth is possible because of changes in how people can consume their media. TikTok now hosts a wide variety of content that is selected by algorithms based on user input. The videos are now shorter and more tailored to people's needs, and the scrollable format enables faster consumption. So strong was this disruption to the market that other platforms, such as Facebook, Instagram, Snapchat, X (formerly Twitter), and YouTube, introduced a similar video format. This shift to consuming video content online took place over a relatively short time span, disrupting advertising budgets and conventional marketing plans.

Where does this leave the knowledge worker? With this pace of technological change disrupting the workplace, the core sets of skills that a knowledge worker is likely to need to be able to adapt have changed, as identified in the latest World Economic Forum report. Broadly speaking, these skills are less technical than before because technology has become easier to use and adopt (unless the worker is a specialist in enterprise architecture or other similar field, such as cybersecurity) and as such these skills fall under the heading of 'adaptability'. A knowledge worker needs to be able to have a core set of skills that give them the ability to be flexible and adaptable no matter what environments change around them, because one thing is certain: technological change is accelerating (Matt et al., 2023).

In the following section, skills under the broad heading of adaptability are discussed to provide a set of outcomes for the knowledge worker to work towards, given the ongoing pressures of digital convergence. In summary, this argument is twofold. First, a knowledge worker must respond to the constantly changing, increasingly complex technical environment caused by digital convergence. Second, the response to this complexity and disruption is not to learn more technologies or to learn them faster, but to build an underpinning set of skills that makes one more adaptable to change. Whilst this proposal is speculative in nature, it is based on established research, as discussed in the following section.

1.4 Skills for Digital Convergence

It is unlikely that the pace of change will slow down or be rationalised because it is beyond the individual's ability to control (Maddikunta et al., 2022). Author Tim Harford (2016) argues that it is better to think of ambiguity as the beginning of a change process. The world is becoming so interconnected and complex, and the pace of change extremely rapid and at a large scale, that more progress needs to be achieved in supporting individuals to meet this challenge head-on. That is, a different way of thinking or operating is required to support the workforce in constructing meaning and acceptance in a time of ambiguity. Large international bodies, such as the World Economic Forum, have mapped this trend, putting technological literacy below curiosity, and including empathy, motivation, and self-awareness on the Top 10 Skills of 2023 list (Figure 1.1).

[Insert 15064-4713-001-Figure-001 here]

Figure 1.1 World Economic Forum most in-demand skills for 2023 ((World Economic Forum, 2023).

It is interesting to note that these are not 'skills of the future', so to speak, but skills of the present that are currently in demand by the myriad of companies surveyed for the report. As part of the research, the skills of the future that would-be employers thought were necessary are different, and it's interesting to compare the difference (Figure 1.2).

[Insert 15064-4713-001-Figure-002 here]

Figure 1.2 World Economic Forum skills on the rise for 2023–2027 (www.weforum.org/agenda/2023/05/future-of-jobs-2023-skills).

Employers highlighted skills such as systems thinking, AI and big data, as well as talent management, service orientation, and customer service. Returning to the argument of this chapter that the skills of the future are embedded with the use of machines, it is interesting to note that the top skills in demand appear to be creative thinking, analytical thinking, technological literacy, curiosity and lifelong learning, and resilience, flexibility, and agility. Using these identified skills as a basis, the discussion then becomes why these skills are the most important to surviving the future.

1.5 The Cybernetic Knowledge Worker

The term 'cyborg' is used in public discourse to describe the melding of people with machines (as described in James Cameron's *Terminator* films). During the First Industrial Revolution, the nature of work changed with the move from an agricultural society to an industrial one. Centralised factories and mass production machines took over the processes of production. During the information age computers rose to the forefront. In the coming cybernetic age, following on from the current Industry 4.0 era, and increasingly referred to as Industry 5.0, machines and humans will integrate for a complex working arrangement (Novak & Loy, 2018).

In fact, controversial entrepreneur Elon Musk has already argued that humans are increasingly cyborg because there are many different digital versions of people on various platforms.

As work moves into a more complex era, the human as a cybernetic organism becomes increasingly realistic. This thinking is not new, it was described in the work of UK theorist and cybernetician Stafford Beer (2002), who described humans and computers collaborating through work on the viable system model. In 2023 technology is converging in every aspect of human life, with the adoption curve increasing as the complexity of the user interface decreases. Embedding AI is also enabling greater ease of user interaction, opening to a wider group of users programs that were previously the domain of specialists, such as video production, image editing, and even academic writing. Businesses still need the different technologies that are converging to integrate effectively into a business model and system. The current challenge for businesses and the knowledge worker is which bespoke pieces of technology should be integrated—and can integrate—to address a specific challenge, and how can the effects of digital convergence be anticipated and problems mitigated before their introduction. For workers there is the added complication of which technologies they learn to keep pace of the changes, and how to learn new applications created by digital convergence if there is no existing expertise and body of knowledge to learn from.

Based on current trends, as illustrated by the World Economic Forum report previously cited, employers have the perception that technological literacy will not be as important as creative thinking over the next decade. This is because of the rise of machines and systems-embedded Industry 4.0 technology mean that human beings will interact with machines as augmentations to themselves, rather than as tools to be used. People are already dependent on access to the Internet and the use of personal supercomputers in the form of mobile phones (e.g., to use maps for wayfinding, and for communication). There is also an increasing uptake of portable wearable devices that monitor the individual, such as Apple Watches. Equally, workplaces are becoming increasingly dependent on a multitude of applications to run their enterprise. On the horizon is the more comprehensive integration of work with machines on a global level. The augmentation of humans with machines is an enabler that may in the short term alter humanity's priorities and behaviours but will ultimately underpin more economically viable, connected healthcare, new ways of working anywhere and anytime, and effectively upskill a generation to take on new roles. This approach gives rise to the need for different skill sets for schools and universities. For businesses, future graduates need to have investigated the new business models enabled by digital convergence and augmented human activities. In the following section, these potential skills are discussed in the context of how they will be used to support the augmented knowledge workers to live and thrive in the digital age.

1.6 The Human–Machine Complex

Humans and machines have long been learning to work—and live—together. Taken to the extreme, this could point towards a future where neural chips or Internet of Things devices will be inserted into the bloodstream or under the skin as a matter of course (Haleem & Javaid, 2019). Researchers have proposed many times the possibility of transhumanism. However, before then, the knowledge worker will increasingly work with AI to augment their skills—and augmented intelligence—and access real-time intelligence through communication technology, such as augmented reality. In addition, tools are emerging for greater collaboration online, which in itself is a form of augmented intelligence. If a worker can access meaningful collaborative insights in real time—and becomes dependent on that information sharing, surely that is a stepping stone to transhumanism.

It is unlikely that in the near future, employers will ask employees to submit to communication and monitoring chips to be inserted into their brains. However, many organisations are using as 'software as a service' as a way of making their operations more visible, and integrating workers' everyday activities and interactive software solutions. Whatever the case, the knowledge worker is likely to become ever more integrated with the machine as time goes on, in essence becoming a cybernetic organism.

The augmentation of humanity by machines is a significant theme for this generation. The challenge for the next generation is developing a skill set that supports being cognitively flexible enough to work with machines akin to early-stage evolution for man-plus-machine. The ‘human–machine concept’ refers to work that includes integrated technological architecture that is relatively easy to use because of a reduction in complexity in interface design. For the knowledge worker of this generation, as is often the case within large organisations, they are faced with navigating a world where technology convergence is slowly adopted by large risk-averse corporations who have a focus on short-term profits to maintain shareholder commitment.

1.7 Melding with the Machine

In this section it is assumed that future knowledge workers will all be technologically literate. This assumes that in the future these devices and applications will become significantly easier to use, unless they are specialist applications that require a high degree of knowledge. As discussed, the World Economic Forum report highlights skills needed for future practice. The skills identified are analytical thinking, creative thinking, curiosity and lifelong learning, adaptability and systems thinking (Table 1.2).

Table 1.2 Skills Rationale

Skill of the Future	**Justification**
Analytical thinking	Skill is needed to frame hypotheses for testing and the development of robust processes to measure the effectiveness of the proposals
Creative thinking	Skill is needed to craft creative solutions and work with machines to deliver those solutions
Curiosity and lifelong learning	Skills needed to identify the learnings required for emerging technology landscapes and changing practices/having an

	open-growth mindset to skills adoption and a positive attitude to change
Adaptability	A set of complex problem-solving skills, a growth mindset, the ability to adapt to new environments, stress and well-being management for the rapid onset and relentless continuation of technological change
Systems thinking	Skills to understand 'big picture thinking' and the leverage points that make systems work

These skills are not separate but are part of an interlinked and interdependent set of skills that the future knowledge worker will need to succeed.

During the history of technology, as discussed earlier, technology has become easier to use. The classic story of the rise of Apple and the downfall of Nokia is often used to demonstrate the inability of large companies to adapt, but in reality, it is a story of technology adoption. As mentioned previously, theory has suggested for some time that when technology becomes easier to use, it becomes easier to adopt (Mueller, 1999). When comparing the different offerings from the two communication giants back in the early 2000s, the iPhone was easier to use but had much the same functionality as the Nokia phone did. The ease of use (Pavlou & Fygenson, 2006) of the phone was arguably what made it a game changer for most people. These developments in the early 2000s led to a shift in how theorists thought about technology adoption. In most developing countries at the time, the use of mobile devices drastically outstripped the use of desktop devices. Android phones flooded the market, making it easy to connect even where the power supply was limited.

When considering the modern phone and the connectedness of humanity via apps, people have, arguably, begun to merge with machines. Perhaps it is not as science fiction would have predicted, but with developments in AI, less technical expertise will be needed to be a successful knowledge worker in the future. The interface will take care of the complexity and be an ever-present technical assistant that will help humans make decisions that are complex but also require creativity and critical thought.

In the next section, the term 'artificial heart of the enterprise' is used to extend this metaphor to discuss what this might look like. Of concern to the authors is how skills evolve when technology is much easier to use and adopt. At the time of writing, companies such as Ford have argued that traditional manufacturers can now be considered software companies. What does this mean for the future of the enterprise?

1.8 The Artificial Heart of the Enterprise

In science fiction, such as *The Minority Report* by Philip K. Dick written in 1956, there has been an assumption that technology will drive decision-making and collaboration in the future. Early thinkers in this space, such as Stafford Beer (Beer, 2002), described the need for corporations to create a practical set of cybernetic skills to be able to cope with the complexity that technology would bring to an enterprise. Beer designed an information system for the Chilean government in the 1970s that would run their entire government services and automate the majority of important decisions (Discussion & Beer, 2000). This experiment failed due to a political coup but held the promise of being an early example of what would now be termed e-government (Beer, 2002). For it to work, technology would need to be part of a managerial system that could automate key tasks and create a sense of intelligence inside the firm that would outlast any management group, the proposal being that complexity could be managed by a system that was designed to be cybernetic (Stephens & Haslett, 2005).

The introduction of AI and recent rise of NLP models suggest that this might be achievable in the not-too-distant future. The problem until now is that technology adds processes and does not necessarily bring the levels of automation or intelligence required for the system to be effective. Take, for example, the long history of research on enterprise resource planning (ERP). The level of work required to operate at a reliable level of efficiency has frequently made ERP software and systems unviable. Overall, systems holding the promise of intelligent automation assisting human decision-making in complex situations are only now realistically emerging.

Keeping track of numerous, interconnected, deployed software frameworks is challenging, particularly with respect to making sure that access to the knowledge contained therein can be controlled. The challenge is how to automate a layer of intelligence to differentiate the contexts and constraints.

An emerging solution is to build digital twins of the process library of software solutions and create user interfaces that mean authorised persons could inquire about capabilities inside the software framework. In a similar way to J.A.R.V.I.S. (Just a Rather Very Intelligent System) described in the *Iron Man* comic books and movies, the systems should provide an intelligent digital twin of multiple software frameworks. Digital twins are used as virtual replicas of objects, systems, and processes (Huang et al., 2022). Generally, they are used as a simulation to track operations, and, to a lesser extent, take control of the real-world version through networked inputs. An example would be the use of digital twins in Formula One car racing. A virtual model of each car is used for simulation testing. The replica is used to replace, augment, or even redesign physical processes. Data would be collected on the actual use of the software frameworks and how they are applied by an internal application program interface (API) whilst collecting data on each process and comparisons between cycles. This data could be anything from the application of a framework to a specific business problem, to the modelling of a certain piece of software to deliver a business process or how often data is sent to and from the cloud in any application. The digital twin can be programmed to perform analysis of the simulation and identify issues the company may not be aware of. For example, a simulation may highlight where business operations are related across multiple projects, highlighting the potential to add efficiencies into the system. The simulation the digital twin runs can uncover insights, to be actioned and turned into automated processes using other software tools. These are then applied back to the use and deployment of these frameworks, with machine learning and AI employed for analysis and synthesis of the processes involved.

Another use case of this system would be in the shared deployment of a software framework that is often used but adapted for clients. The digital twin could use the data provided to model out a simulation on the implications of deployment automated across different client bases, including time and resources. It could also theoretically provide suggestions for troubleshooting and optimising performance over time.

Digital twins, characteristic of Industry 4.0, provide an ongoing feedback loop that can be applied to the software frameworks over time and therefore help them to bring optimisations to both the allocation of resource and the development of future software frameworks. For example, the system deployed can analyse all the frameworks currently in use and look for similarities to model and simulate what would happen when those similarities were combined into one singular process, rather than a myriad of executable processes. The digital twin will learn from the data and make increasingly accurate predictions on how to identify issues before they happen. In the example of sharing software frameworks, it would be able to make new suggestions based on the existing patterns of work behaviour and data fed into it. This leads to continuous learning in which the digital twin takes the data it learns and uses it to improve real-world processes.

The goal for software companies is to build a complete AI-driven model that has comprehensive data from inside the corporation fed into both an NLP model and an inbuilt knowledge base to which data is consistently added. The adding of this data enables the improvement of results from the digital twin and a degree of intelligence to the use of searching for data and software frameworks from inside the business. By drawing on this API the company could ask questions of it in a similar way to how people can ask questions of the AI program, ChatGPT version 4 (the latest at the time of writing). This could be asking a question about which software framework would be used to develop what application for a basic example and how it might be deployed at the client site.

The total goal would be to make the heart of the corporation completely digital. Ultimately it would mean that a client could approach their business with a project idea on how to use the software. Within a short period of time, a basic framework could be built based on this input and the existing digital twin, plus data inside the company and a reasonable prediction of details, such as price, scope, and design to reduce time and personnel. Practically, it would mean that the machine would take control of the existing processes and with the input of data could build real-time predictions with a fraction of the time involved. With an 'artificial heart' in the company through a commitment to a comprehensive artificial intelligent system and digital twin, companies could build deployable frameworks to a client site in a fraction of the time and resources. Almost any enterprise where processes are used and automation is possible could employ a degree of AI and digital twin, and it is likely to become more prevalent in the future.

1.9 Into the Metaverse

One interesting development in digital technology in recent times has been the proposition created by the Metaverse concept. In essence, this is a virtual platform in which 3D avatars are used to interact and perform certain tasks in the online world. Whilst this proposal was initially envisaged as a communication space, engineering and design tools are increasingly being developed and tested for the Metaverse. This is interesting not only from a technical perspective but also in relation to its impacts on workflow. The link between Industry 4.0 digital threads and digital twins, and now modelling practice within the Metaverse, is growing. This development is arguably a step change in practice for digital transformation illustrating the use of digital convergence as the basis for more flexible, accessible, and critically more autonomous enterprise mobility.

For a large country, such as Australia, where markets tend to be dispersed, the prospect of a more comprehensive shift to an immersive Industry 4.0 profile for an organisation, such as a connected Metaverse, has the potential to enable asymmetric advantage. This concept comes from finance, where asymmetry refers to an advantage that comes from multiple different angles in a network and returns are adjusted in relation to different points of view. For example, the concept of the 'loss leader' in business, that is a product that may be sold at a loss to attract attention in the market, refers to the concept of asymmetric returns. A company may also put out a product at break even or at a loss to sell second- and third-tier products, which give an asymmetric advantage. In the training industry, for example, this might be a master class that is offered at low cost so that more expensive training can be sold to the people who registered, without needing additional advertising. This raises the overall cost per acquisition but also provides asymmetric returns magnifying and multiplying the lifetime value of the customer. In the world of hedge funds, the term ‘asymmetry’ refers to using different funding sources that balance in favour of the investor. Insurance agencies often pay out small amounts to customers but receive an asymmetric return when customers keep paying premiums every year. The insurance business provides asymmetric returns through these payments because not every person who is a customer will make a claim.

The Metaverse combines digital technologies, the Internet, and 3D technology in increasingly interesting ways. People involved in the Metaverse can be located at strategic vantage points anywhere, and this can provide asymmetric advantage. Spreading resources across multiple locations on multiple fronts, each additional positional difference giving a small return, then their return compounds together could provide an advantage. This is still in its infancy, but the potential is interesting and the technology increasingly sophisticated, as is the thinking.

1.10 The Metaverse and Asymmetric Warfare

The conflict between Ukraine and Russia that began in 2022, when Russia invaded its neighbour, has provided numerous examples of asymmetric warfare, where Ukraine’s investment in agile thinking and digital technology has helped the country to defend against an arguably overwhelming force. Whilst Russia has relied on conventional warfare methods, with consolidated forces and heavy artillery, Ukraine has subverted the battlespace by employing a strategy of deploying distributed artillery, focusing on smaller armaments of lower cost as part of a more guerrilla warfare approach (Porter, 2023). In particular, Ukraine has invested heavily in the use of drones. According to the European Council on Foreign Relations (Söderström , 2023), although drones have been used in multiple conflicts, including the Vietnam War, 'The Ukraine battlespace features the most intensive use of drones in a military conflict in history, marking a shift in warfare tactics and technology.' This approach allows the Ukraine military to build and deploy low-cost armaments from numerous sites for reconnaissance and to deliver missiles. The challenge for an opposing force is keeping track of a myriad of small groups of adversaries, rather than meeting a single force head-on. For the Ukrainians, the ability to move around reduces their vulnerability. This does, however, create communication and tracking difficulties from their side.

In other countries there is an awareness of the vulnerability of centralised forces. Large bases are inevitable targets and therefore vulnerable. For some countries, such as Australia which is a very large country, the prospect of introducing agile basing could reduce those vulnerabilities and, at the very least, provide outposts of resistance should they be required. Taken to its extreme for the future, it may be that fully mobile and flexible basing would provide an asymmetric advantage against a larger foe. In such a scenario, effective, comprehensive communication strategies would need to be in place. Conventional communication platforms at this time tend to be generic and do little to add value to distributed practice specifically. There is no sense of place or relative position, or inventory or operational dependencies or efficiencies articulated by a conventional communication platform. However, if a Metaverse, supported by a digital twin, was strategically developed for agile basing, then it may be able to provide the means to frame, visualise and manage facilities that were constantly on the move. This would support logistics and decision-making and provide the organisation overall with a virtual sense of place where a physical base was missing.

Building real estate within the Metaverse involves creating connected spaces, which can be visualised and navigated using a map. The spaces themselves can be created bespoke to the organisation's needs, and can include areas to socialise and break into smaller meetings. It is possible to use cameras so that an individual's face can be seen overlaid on their avatar and sound works as in the real world, whereas as a person moves away, their voice becomes fainter. If Australia were to adopt a drone manufacturing, agile-based approach using the Metaverse and digital twins combined with digital manufacturing, then it would be possible to have the designers in one location and manufacturers in another, and even the operators in yet another, driving using augmented reality. This is a totally networked, immersive approach enabled by digital convergence that represents a paradigm shift in practice. It is only now a possibility because of Industry 4.0 and Web 4.0 and has the potential to provide asymmetric advantage if the investment in processes and organisational reform is made now.

Drawing on the skills argument from earlier, the move towards the Metaverse being a totally networked and immersive approach requires the person operating in it to think critically and creatively. For example, how would a design team create in such an environment if they're used to working in an office? If a threat emerged, how quickly can people assemble into the Metaverse and build a drone, and from that, how quickly can it be deployed if the key people involved are dispersed across wide geographical areas?

In the Ukraine example, they didn't solve this problem by having heavy technical skills, although that was a part of it to some extent. They used networked thinking. Instead of relying on traditional military techniques that are often used in battle, they relied on hiring a chief technology officer (CTO) from a start-up to run the technological infrastructure behind their resistance. The agile thinking required to be a CTO is usually focused on a combination of what technical stack to use to reach a business goal and the best methods of deployment of using that technology, as well as what specialists to use. This is a strategic position that uses systems thinking but also draws on the concepts of a networked and integrated workplace

The CTO in this situation coordinates responses built on the assets in the network. If the Metaverse was active during this time, the CTO or advanced knowledge worker would have access to the assets required to deploy a response and be able to marshal the team together online to make that happen. In theory, future technology could be used to autonomously build a missile to respond to a threat or create a specialised drone to be deployed on demand after being specified by an online group of workers acting in concert in a Metaverse environment. What underpins this is the idea of a dispersed community working across the broad geographical distance, thinking creatively and knowing how to deploy that technology in a networked environment.

1.11 The Network

The network for any organisation adopting the possibilities this immersive approach allows would contain a variety of activity hubs and spokes, but these would be virtual based rather than physical, and therefore able to move locations in the real world whilst remaining in contact in the virtual one. Employees can operate within a Metaverse with very little additional equipment. Unlike virtual or augmented reality, the Metaverse does not require headsets or projectors. It is possible to access through most standard devices, such as desktop computer, laptop, tablet, or phone, though interacting within the Metaverse is currently easier using a computer with a wired mouse, mostly for latency reasons. The Metaverse does need to have seats booked in a particular location (though this can be a country-wide location) with whoever is hosting the service. Service providers currently include Amazon and Azure.

Distributed manufacturing hubs themselves can be very small units if the application allows. Unlike traditional manufacturing, a small number of digital manufacturing machines are needed to take the object from concept to production—within the limitations of those processes. With digital fabrication and digital twins, the blueprint of an object can be contained in a digital inventory, which can be updated or adapted in one location, and sent digitally to another for production. This does create vulnerabilities, particularly with respect to cybercrime, but it also allows for continuous updating of a product for a genuinely adaptable manufacturing strategy. This creates a short-run strategy over a conventional mass production one.

Another interesting development in the Metaverse is the ability to bring real-world data relatively easily into the space. 3D scans can be used to build an accurate environmental model as the basis for the Metaverse, and increasingly sophisticated technology for converting 2D data to 3D is making highly detailed 3D views accessible. At the time of writing, Gaussian splatting enables nanites in software, such as Epic's Unreal Engine, to enable building high-resolution 3D models. As Gaussian Splatting and similar applications evolve, the Metaverse environment will become increasing accessible and realistic. This suggests that business and organisations need to invest in this now to be better prepared for the future of work. For Defence, the most interesting promise of this technology is the idea that people can be immersed in a 3D environment and not be on the battlefield but be creating responses to emerging threats as they happen, because they can network with others in the virtual environment across military silos.

Early examples of this can be seen in the recent skirmishes in Ukraine and Russia. If the Metaverse was involved, then it could have given an advantage in terms of networking, collaboration, and dispersal. In theory it could allow for conventionally divided silos across Defence to coexist but also to deploy resources in a horizontally integrated manner. For example, if there were personnel on the eastern side talking to personnel on the western side, then they could converse within the Metaverse, sharing virtual resources is and talking about strategy in real time—even whilst their forces were active. In the Metaverse they could design, model products, and schedule for deployment. The complexity of engaging online is reduced because the interface is more instinctive than traditional online collaboration tools, enabling more freedom in creative thinking and allowing for a desperate group to be more adaptable.

1.12 Trained to Think Rather Than to Use

These kinds of digital technologies move the idea of a use case from the end of the process towards the beginning of it. That is, designers and others involved in bringing this kind of technology into practice can start to think about the advantage the technology and test that advantage quickly, rather than wait years for it to be developed as in conventional practice. Software in organisations such as customer relationship management is becoming intuitive because of the development of intelligence technology. This moves the thinking from looking at the machine as framing the process to thinking about what might be achieved if one worked with the machine. As Industry 4.0 technology becomes more integrated into practice, and digital convergence adds layers of capability, thinking increasingly revolves around what can be achieved creatively with machines, rather than mimicking existing practices but more efficiently with the aid of the technology. This returns to preparing for the use of these technologies to the central thesis of this enquiry, what will the world look like once machines are fully 'intelligent' and autonomous, and what are the challenges for the future in developing skills for humans to maximise these capabilities and not be replaced by them?

1.13 Reframing Digital Upskilling

So far in this chapter it has been argued that there is a new set of skills required due to the fact that machines and humans will need to work together in some kind of cybernetic fashion. What has happened in the past is that organisations have relied on technology training to cover this gap. As society moves into the newer world in which humans and machines will work together, the way these skills are developed and trained will have to change. Google certification, for example, now allows people to pick up a skill in 6 weeks that they can then use in their careers (e.g., https://grow.google/intl/ALL_au/certificates/). Traditionally universities and higher education institutions have filled this gap. Admittedly, most of these courses are technical in nature and aimed towards filling gaps in the professional information technology sector. However, in preparation for Industry 4.0 and 5.0, these skills could be out of date as soon as 5 years.

In fact, early signs of this are on the horizon. Consider the afore mentioned World Economic Forum Report on Skills (World Economic Forum, 2023) The pipeline problem mentioned in this report refers to the problem modern organisations are having with retaining and recruiting Generation Z talent. Although many companies perhaps did not invest in this past the pandemic, good-quality talent are objecting to a return to the office, even now the threat of the pandemic has passed. Employees want the lifestyle of choosing when and how they want to work, and the pandemic has demonstrated that this can be possible. Given the current talent shortages, certainly in Australia, companies are forced to offer remote or hybrid working as an option. As time goes on, these workplaces are likely to become more hybrid (Haan, 2023). The Metaverse is a complex an as yet untested environment for remote communications and real-time work. Digital upskilling therefore needs to be thought of as learning to work with machines not only for practical tasks, but for communication and engagement. The learning curve required to successfully adapt to this environment is not technical, rather it is social and practical. For example, when moving into the world of creative thinking and finding useful ways to deploy new technologies using a hybrid networked Metaverse environment, the question is how can it be used to make employees more productive instead of simply replicating existing outputs? Digital upskilling would therefore not be how to use the Metaverse effectively to leverage teamwork where it is not possible for everyone to be in the same room together.

Google runs a course on the technical skills required to run a successful e-commerce business. These skills point towards the use of Google's product to encourage more people into a business, such as a store. The skill set required to run ads on Google is a technical skill set, but arguably absent are elements such as designing customer discovery, concept testing, and the use of creative thinking and adaptability for mapping, for example for seasonal offers and fluctuations in the market. Current certificate skills programs are frequently framed as the future for education, but these tend to lack the additional aspects of education that will help the individual to be successful. Technical skills in a digital environment are not enough. Additional skills include how to create lifetime value by building a relationship with the customer and exploiting emerging technology to better serve the customer journey. The world of digital upskilling needs to change.

Cybersecurity is inevitably a key issue in this realm. As hackers become better at breaking into systems, it could reach a point where a small number of people engage in creating protective computer science models, whilst most of the team have to think creatively about working around a breach. Addressing a network exploit involves technical skills, but it also requires imagination and lateral thinking to recognise or anticipate possible vulnerabilities. For example, consider the unexpected threat to solar rooftop panels. According to a recent report (ACSM_Editor, 2023) solar panels are a leading cause of breaches for many organisations because hackers understand they operate on a networked environment, and it is possible to use the same network access to breach the company operating systems.

A leading skill in the future of any cybersecurity analyst will be understanding bridge patterns and their use to divide a system into several hierarchies. Creative thinking and an agile mindset will be needed to help employees adapt the workings of a company to avoid potential breaches on a continuous basis. In addition, companies need to be able to adapt to significant disruptions such as COVID-19. No amount of technical knowledge or technical literacy on its own will help them create step-change innovation in the face of challenges such as supply chain disruption. It is key that the future workforce be imaginative, collaborative, and resilient in a rapidly changing digital era.

1.14 Discussion

In Table 1.3, the skills from Table 1.2 are shown with possible approaches as to how these could be applied to adapt to the use of emerging technologies.

Table 1.3 Applications

Skill of the Future	Application
Analytical thinking	Using artificial intelligence to find interesting ways to solve old problems, such as finding new chains of reasoning and programming design
Creative thinking	Responding to the possibilities of digital convergence with original solutions
Curiosity and lifelong learning	Exploring new angles to create programmes and finding ways to develop asymmetric advantages by using technology in new and interesting ways to support creative innovation
Adaptability	Adjusting thinking to automated human thinking through the use of intelligent machines that can suggest new programmatic structures
Systems thinking	Seeing how the systems can be built together to create outcomes to solve complex issues at a strategic level; that is, building automated and digitally enhanced systems to create new programmes and connectivity.

It is clear that skills development needs to be considered from a new perspective. It is interesting to consider how sets of skills need to evolve to support the development of coherent models of original thought for dealing with digital convergence. The skills to work effectively with machines in the future need to enable the user to move between different states and to consider different angles of a problem. For example, they will need to understand how AI and machine learning could be applied to a new scenario, and to build an innovative framework and prompts for this approach. This is largely because the complexity of programming machines has become foundational rather than at the interface, and the design of what might be achieved using these machines leads to more creative thinking. This creative thinking might be about synthesis, bringing together disparate parts of a system previously not thought of as connected. It is likely to involve agile working and continuous adaptation. History has demonstrated that when technologies become easier to use and their level of AI integration increases, humans will find creative and useful ways to exploit them.

The challenge now is what to build with the synergistic technologies now available. This is a question for society, but at an organisational sector level, how can a company future-proof by exploiting these technologies, and what skills should they develop in their workforce in preparation? Do those projected by the World Economic Forum report go far enough? Should companies be thinking about other skills? Or could it be that the value placed on the different skills should be weighted to emphasise aspects such as curiosity at this time of transition?

The central point is the design of a human future that goes beyond continuing along the same paths that society has walked previously, with the same problems, such as unsustainability. Could digital convergence be used to bring advantage to a greater whole, rather than perpetuating current issues and inequalities? The skills referenced in this chapter are arguably the foundational skills needed in the new world of digital convergence. This is because the methods of working with machines when AI is incorporated are evident, but the direction is not. People need to question practice to see a big picture to exploit the potential of these machines. Even now, there are AI-driven machines that are intelligent, but their applications are uncertain, especially when creating a positive picture for society is a factor. Skills for a future living with digital technology therefore need to be framed as intellectual rather than technical. Industry 4.0 is the first opportunity humanity has had to reimagine the world of work enabled by the paradigm shifts that digital convergence allows. It is therefore arguably the right time to rethink the relationship of workers and technology, and the priorities for the skills needed to effectively and humanely operate emerging digital systems.

1.15 Conclusion

This chapter discussed the changing skills required for businesses adapting to the opportunities and challenges that Industry 4.0 provides. Over the last decade, digital technologies have converged to create a digital era, where Industry 4.0 and digital skills have combined to create step-change in practice across industries. In many ways, the headlong development of digital technologies has itself been disrupted with the realisation that convergence and layering of digital technology is creating such radically new ways of working that it is the thinking that needs to catch up. It is no longer enough to upskill workers technically; there needs to be a mindset change to be able to shape businesses to exploit the technology available. In addition, the ability to continuously adapt, both in terms of business model development and in thinking about practice and operations, is as critical as building the system itself. Core skills for the future were considered in relation to digital convergence and the differences between being a knowledge worker in the past to the near future. Finally, it was suggested that the use of digital technologies described within an Industry 4.0 framework require a vision and a deeper sense of purpose in relation to their contribution to human achievement. This arguably leads society beyond Industry 4.0 and the capabilities it creates, towards what is defined as Industry 5.0, where humans are at the centre of the machine-enabled environment. The point made is that the future should not involve workers adapting to single machines, but collaborations where people and digital capabilities merge in new ways to create positive benefit for all stakeholders, not inhibited by past actions and assumptions. The question remains what to do with digital technological capabilities to redirect the future.

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