NSW GOVERNMENT

FUTURE FRONTIERS ANALYTICAL REPORT

Preparing for the best and worst of times

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A report prepared for the NSW Department of Education on the key implications for school education of artificial intelligence and other emerging transformations.

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ABOUT THE SYDNEY POLICY LAB

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EDUCATION: FUTURE FRONTIERS

EDUCATION: FUTURE FRONTIERS is an initiative of the NSW Department of Education exploring the implications of developments in AI and automation for education. As part of this initiative, the Department has commissioned background reports on future skills needs. The views expressed are solely those of the authors.

Executive Summary

The NSW Department of Education challenged a consortium of University of Sydney academics to consider the important question of what today's kindergarteners will need to thrive and not just survive in the 21st century. The Department is particularly interested in the predicted changes that Artificial Intelligence (AI) and other developing technologies could bring to Australia's economy, workplace and community. This report, which integrates insights from scholars in faculties as diverse as engineering and medicine, business and education, is not a definitive analysis of all potentially relevant issues; rather, it explores some of the challenges and opportunities around these emerging technologies and what this might mean for education, particularly school education.

Section 1 outlines the methodology for this interdisciplinary approach and how this report was prepared.

Section 2 considers the three dimensions of impact associated with artificial intelligence. Its most *overt impact* is on job numbers and content. Its *covert impact* is on means of decision-making and social connection. Its impact as an amplifier of other changes is significant, especially given its capacity to intensify dynamics associated with labour market fragmentation, globalisation, inequality and climate change. The central challenge is not to predict the future but to prepare for uncertainty. This is best achieved by developing in individuals the capacity to adapt successfully to changing situations.

Section 3 considers how education might best nurture this capacity. The relationship between education and the labour market is not as obvious as commonly thought. Moreover, recent literature on improving people's employability reveals formal education is only one (and not necessarily the most important) factor determining labour market success. That said, appropriate education is a vital ingredient. Arguably the most prevalent current narrative concerns the need for educators to focus on 'soft', 'generic employability' or so-called '21st century skills'. Typically, these are defined as 'literacy and numeracy' and capabilities concerning 'problem solving', 'creativity', 'communication' and 'collaboration'. This narrative, while superficially attractive, is ultimately not sufficient for guiding education policy and practice in an AI era. Any effective approach must grapple with four issues.

1. *What types of pupils are we developing: highly flexible labour or flourishing, productive citizens*? Many prescriptions in the current 'future of work' literature are predominantly concerned with developing what is best described as the ultra-flexible worker – i.e. people able to meet ever-changing market requirements. Drawing on the health, humanities and social science disciplines we highlight the importance of nurturing productive, flourishing citizens.

2. *How can education contribute to the development of human flourishing over the life course*? Human development is a complex, multi-dimensional process. The early school years are critical for developing individuals' 'learner identity'. Primary schools in particular have a crucial role to play in shaping people's learning dispositions. These concern such things as curiosity, the ability to concentrate, resilience and learning relationships. If nurtured well, they result in people empowered to learn, wanting to learn and excited by learning. If not developed early, their absence can have lasting effects on people's willingness, interest in and capacity to learn and adapt.

3. *What is the relationship between developing general learning dispositions and developing specialist expertise*? Using literature from disciplines as diverse as cognitive psychology, education, philosophy, engineering and applied labour economics we show specific knowledge is important. We highlight how gaining 'generic'

skills (or, more accurately, learning dispositions concerning such things as collaboration and problem solving) are often best acquired in the context of mastering specific disciplinary, trade or professional expertise (i.e. having something substantive to contribute to a team or solving a problem).

4. *Are current approaches to gaining specialised knowledge providing students with well-developed learning dispositions?* The mainstream academic curriculum focuses on fairly abstract analytical skills, perceived by many students as 'too academic.' Much vocational education and training in schools, on the other hand, focuses on developing narrow skills relevant to an immediate job. Academic disciplines need to better highlight their potential broader relevance to life (and not just the labour market). Keynes once observed that there is nothing more practical than a good theory. Why this is the case and how abstraction can be appropriately applied 'in real life' deserve closer attention. For vocational education, greater attention needs to be devoted to giving students underpinning knowledge for a broadly defined domain of expertise to increase their capacity to adapt to changing opportunities.

Section 4 considers the implications for schools. There is a need to engage more effectively with AI and its broader impacts. Increasing ICT literacy is important but involves much more than teaching all students how to code. Rather, it involves equipping young people with digital fluency, i.e.; the ability to handle the 'covert' and 'amplifying' impact of AI as well as its more overt consequences for job destruction and transformation of job content.

Widespread debate is needed on how to define domains of specialised knowledge necessary for underpinning the development of 'generic' skills. Recognised academic disciplines are important, but they are not the only categories for defining expertise. Special attention is especially needed for the vocational offering in schools. Take the example of care work. Instead of doing courses in 'aged care', 'disability support', 'youth work' or 'drugs and alcohol support', for example, consideration should be given to preparing people for 'care work' more broadly defined. This would provide the context for practicing in the more specialised sectors. Closer engagement with the world of work challenges us to consider how we define domains of occupational capability. Notions of job clusters or vocational streams of connected occupations deserve closer attention from a wide range of stakeholders, within schools and beyond.

The challenges associated with AI require more than marginal adjustments to established arrangements, best conceived of as an education 'settlement' or 'compact'. Education, like most social domains, is structured by an array of stakeholders contributing in different ways. Currently employers and the community are not as actively engaged in local schools and education as they could be. Many are quick to criticise the status quo, but few are helping build new arrangements. The country's education effort would benefit immensely from closer engagement with employers in the private and public sectors, and community organisations. While schools have been endeavouring to do this, quality engagement from the business sector has been limited. The importance of specialised knowledge – both academic and vocational – highlights the continuing importance of professional teachers. We conclude by asking whether it is time for a new education settlement. Such a settlement would give greater recognition to teacher professionalism on the one hand and support closer connections with quality employers and arts and community organisations on the other to develop the flourishing citizens of tomorrow.

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Prologue

'It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us, we were all going to Heaven, we were all going direct the other way – in short, the period was so far like the present period, that some of its noisiest authorities insisted on its being received, for good or evil, in the superlative degree of comparison only.'

Charles Dickens, *A Tale of Two Cities*, 1859.

The future can be much better than most pessimists understand, but it can also be far worse than most optimists are willing to explore. We need serious, coherent, and integrated understandings of mega-problems and opportunities to identify and implement strategies on the scale necessary to address global challenges.

Jerome C. Glenn, Elizabeth Florescu and The Millennium Project Team, *2015-2016 State of the Future*, 2016

In a sense we have been here before – and in another sense we have not. From the 16th to the 18th centuries world history was profoundly shaped by two revolutions – one in economics and technology, the other in culture and politics. The industrial revolution started in England and eventually spread worldwide. The English, American and French Revolutions heralded the slow emergence of the rule of law and political democracy, both of which shaped the development and ongoing evolution of market economies. These transformations ultimately proved profoundly beneficial for humanity as measured by indicators such as life expectancy and material living standards for growing numbers of people, and respect for the individual as a citizen with important protections and rights. But the pathways to these achievements were prolonged, far from straightforward or fair – and often violent.

The legacy of these revolutions makes the transformations currently emerging different. Artificial intelligence as a source of innovation is not the same as fossil fuel based industrialisation. Importantly, the challenge of global warming now constrains the future as never before. And we have devised institutions to better handle the losses and gains, tensions and upheavals associated with dramatic economic and technological transformations. The significant inequalities consequent upon early adopters making massive early gains from de-facto monopolies do not *necessarily* have to result in deep deprivation on the one hand coinciding with unprecedented concentrations of wealth and income on the other. Increasing inequality is destabilising. The history of the 20th century shows us that the universal right to vote, provision of core social services and public infrastructure like sewage systems, unemployment benefits and universal health insurance emerged to provide basic standards for all. Progressive income tax emerged to ensure that those with the capacity to pay for such arrangements contributed their fair share. Following the trauma of two world wars, leading societies learnt how to devise arrangements that delivered full employment.

With artificial intelligence, deepening inequality, increasing insecurity of employment, and global warming we have a choice. We can build on the positive legacies achieved over the centuries that allow us to navigate transformational change in an inclusive and orderly way. If we do not, we are likely to see dislocation and disruptions of the kind that characterised the transition to industrialised, liberal-democratic societies.

This report is not about making a call on what trajectory into the future will come to pass. Its objective is more modest. It explores key issues that primary and secondary schools in Australia must engage with if their pupils (and through them Australia) are to navigate their way successfully through emerging developments. Revolutions – or more precisely, transformations – of some kind are already underway. The question we answer is: within this context, how can primary and secondary schools in Australia better help someone enrolling in kindergarten this year to thrive – and not just survive?

1. Introduction

21st Century Education won't be defined by any new technology. It won't be just defined by 1:1 technology programs or tech-intensive projects. 21st Century Education will, however, be defined by a fundamental shift in what we are teaching – a shift towards learner-centred education and creating creative thinkers.

- Karl Fisch

The NSW Department of Education is committed to supporting informed contributions to the national conversation about how education is preparing young people for the challenges of life and work post-school. The Department is especially interested in new knowledge concerning the implications of artificial intelligence (AI) and other emerging transformations for school education.

A group of researchers from a diverse range of Faculties at the University of Sydney was commissioned by the Department to prepare this discussion paper. The authors came from the Faculties of Engineering, Education and Social Work, Medicine and Health Sciences as well as the Business School. The project was guided by a series of workshops and one–on–one interviews with a broader network of colleagues from these and other Faculties. More details about the research process are provided in Appendix 1.

The Department's brief was to move beyond sensationalist headlines about AI to present a thoughtful and balanced view of what the key issues are for school education. We were challenged to consider this from the perspective of Australian children starting kindergarten in 2017. They are likely to finish school by 2030, and spend much of their working lives in the second half of the 21st century. What skills should these children acquire over the next 13 years? What is the right mix of cognitive and non-cognitive capabilities, such as adaptability, resilience, collaboration and so on? What is the most effective way of helping children acquire those skills? In short, what will these children need to thrive, and not just survive, in light of some of the predicted future employment market changes?

The findings of our deliberations are reported below. They represent responses to three questions:

- How can we most usefully think about the challenges AI is creating for school education?
- What are the implications of this for the qualities students need to have when they leave school?
- How can schools help develop these?

Our argument is structured as follows. Section 2 looks at the central challenges arising from the accelerating development and deployment of artificial intelligence. Section 3 deals with the qualities people will need to handle these challenges, especially the need for adaptive capacity in light of increasing uncertainty about the future. In Section 4 we consider what this means for schools – both the content of what is taught and who is involved in the education process.

2. Understanding the Artificial Intelligence challenge

General confusion about the definition of Artificial Intelligence (AI) is only surpassed by the hysteria around its potential impacts. In this section, we seek to clarify both for the purposes of this report.

The term AI is a general label for a field of study concerned with investigating the ways in which machines might demonstrate human-like intelligence. It comprises a range of technologies concerned with (but not limited to) pattern recognition, learning, inference, modelling and decision making across a variety of domains.

We use AI as a kind of shorthand to refer to a range of specific technologies, in particular machine learning (ML). The most important thing about AI, and specifically recent developments in ML, is that it represents a fundamentally different way of creating software technologies. Traditional algorithms relied on information, knowledge and processes having to be codified and programmed into machines (for instance the rules for playing chess and successful sequences of moves). Under these conditions computers were only as powerful as the understandings human embedded in the machines. Massive advances in computational power and increasingly large data sets have enabled new ML systems that rely on deep learning using artificial "neural networks" to learn to recognise patterns in digital representations of data. Take the process of analysing images for example. Identifying a cat can be done without us having described what a cat is, but rather by having trained the algorithm on millions of pictures of cats. ML algorithms have the ability to improve their performance without humans having to articulate fully how to achieve the goals or accomplish the tasks that they are given.

Box 1: How does AI work?

There are many different AI learning systems being developed. The most successful machine learning approach used today is deep learning, which uses neural networks that can handle very large data sets. These networks simulate brain neurons in that they adjust their configurations based on the patterns of input data.

Supervised ML involves giving a machine very large numbers of the correct answer to the particular task it is given (for instance pictures labelled "cat", or audio recordings of the word "hello"). The bigger the data set the better the algorithms.

Such supervised ML systems are commonly the most widely used ones. Other fields where systems seek to learn on their own (unsupervised learning, reinforcement learning) are currently being explored and hope to provide further advances. Reinforcement learning systems, for instance, have recently mastered the game of Go. Alpha Go Zero learned to play the game from 'first principles', and given the rules and full information, played itself until it mastered the game. Reinforcement learning still requires a programmer to specify the goal, the current state and constraints of the environment and rules or allowable actions.

Such ML systems trained at specific tasks have achieved tremendous performance in a number of areas such as diagnosing disease, advertising or financial analysis. Furthermore, they will interface with a number of other industry-specific technologies whose impact they can augment. The application of ML – even though task–specific – will have a range of profound impacts, which will be addressed in this section.

Box 2: What AI can do today (and what it can't)

AI can achieve tremendous performance in some areas such as speech recognition, image recognition and problem solving. We are, however, very far from achieving the promise of perfect 'intelligence' in AI systems.

Image recognition: Google and Facebook can recognise images of our friends in photos, self-driving car systems mistake pedestrians once in 30 million frames, software can identify images of skin cancer moles and lesions as accurately as a dermatologist (Esteva *et al*., 2017).

Voice recognition: Smartphone speech recognition is now faster and more accurate than we can type on our screens, whether we do this in English or Mandarin (Ruan *et al*., 2016). Deep learning and big data sets have enabled the error rates in speech recognition to go down to 4.9 percent in 2017. Remarkably, this is half of what it used to be only the previous year.

Problem solving: Machines have already beaten the world's best human players at chess, poker and Go. They are also employed to improve targeting of advertising, to detect fraud, review commercial loan contracts, process insurance claims, prevent money laundering and so on.

Increasingly such systems are able to mimic human intelligence. For instance, researchers from the University of Chicago have developed AI that can write extremely believable fake online reviews that are perceived by humans as 'useful'. However, applicability of AI systems is still very narrow, and they do not exhibit general intelligence across domains (or any form of intelligence). The algorithm playing Go does not suddenly decide to play chess or take the day off to read the news.

The perceived potential of AI, however, has also enabled exaggerated thinking, misplaced concern and 'magical thinking'. This has been particularly prominent in the media, popular trade books and public conversations around AI.

It is probably not too much of an overstatement to say that something approaching a moral panic has accompanied the evolution of AI. We examined all the news stories from the past year to understand what the public conversation around artificial intelligence[1] is. We found that the narrative around artificial intelligence breaks down into three broad themes: partnerships and initiatives around AI, potential effects of AI, and concerns around current AI applications (Figure 1).

If we look at the traction these conversations receive in the public media, it is clear that people are enamoured with the potential effects of these technologies rather than the actual manifestation, implementations and current, real world AI initiatives (Figure 2). Headlines like the Washington Post's "Is AI the end of jobs or a new beginning?"[2] (May 31, 2017) or the Sydney Morning Herald's "Elon Musk among AI, robotics company founders warning against killer machines"[3] (August 21, 2017) dominate the conversation around the world.

A closer look at the conversations around potential effects of AI reveals that the public conversation is split between Elon Musk's apocalyptic message and warnings of killer robots and fear over job losses and adverse effects on the economy (Figure 3).

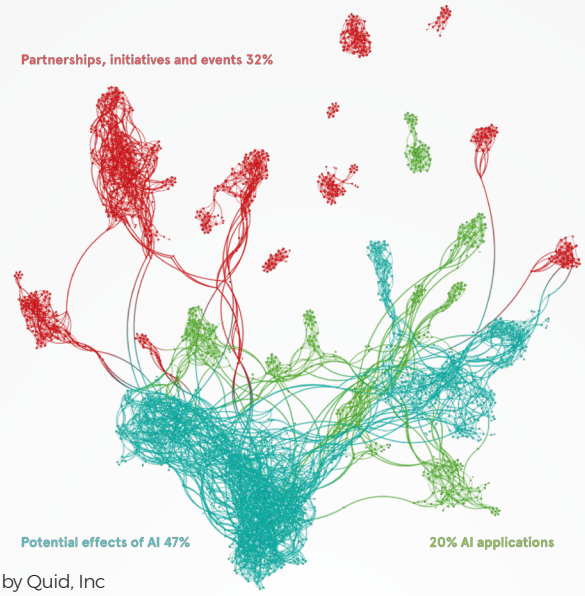
This is unhelpful. While the potential disruptions in terms of job loss are real, these headlines are not grounded in thorough analyses, nor do they present a useful framework for rational discussions. The issue is not whether we should be scared or embrace AI – but how this latest technological development is to be shaped and governed. Governments, individuals, societies and economies need to become active to ensure that technological advancement occurs in ways that advance human functioning and the achievement of collective endeavour. In this section,

[1] ("ai" OR "artificial intelligence" OR "machine learning" OR "deep learning" OR "computer intelligence" OR "natural language processing" OR "machine intelligence" OR "image recognition")

[2] https://www.washingtonpost.com/news/innovations/wp/2017/05/31/is-ai-the-end-of-jobs-or-a-new-beginning/?utm_term=.7e00cc216459

[3] http://www.smh.com.au/technology/technology-news/elon-musk-among-ai-robotics-company-founders-in-new-warning-against-killer-machines-20170820-gy0h12.html

Figure 1: News articles by theme, September 2016 - September 2017

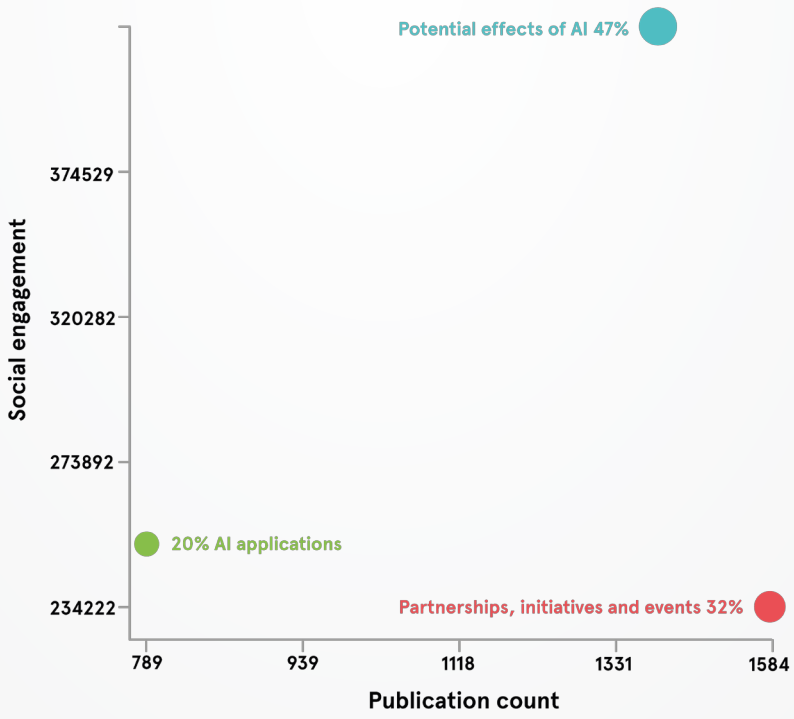


Source: Sydney Business Insights; data by Quid, Inc

Notes:

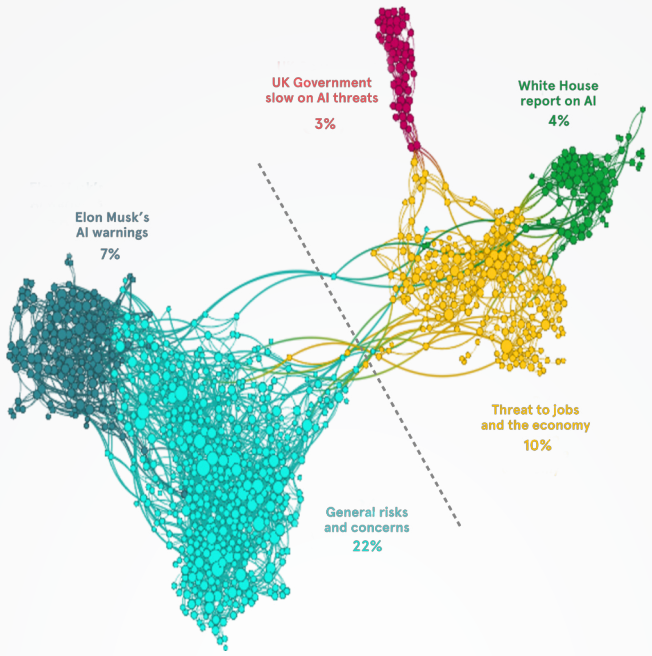
Visualisation based on 2071 articles, dataset by and mapped with Quid. Each node represents an article; node sized by degree represents number of connections (i.e., similarity) to other nodes. Connections represent similar language used across nodes. Dense clusters contain highly similar articles. The greater the distance between clusters the lower the number of inter-related articles.

Figure 2: News articles by theme, traction by theme, September 2016 – September 2017



Source: Sydney Business Insights; data by Quid, Inc.

Figure 3: News articles by theme, potential effects by theme, September 2016 – September 2017.



Source: Sydney Business Insights; data by Quid, Inc.

we briefly consider the evidence and predictions of the impact of AI – not just on the future world of work, but also on individual and collective aspects of human behaviour. We argue that in considering the impact of AI for the future, we must consider not only what it means for our children and young people in terms of work, but also for the ways they function in the world at large. Although understanding how to use or create ML/AI requires deep expertise acquired either through a university degree and/or a de-facto 'apprenticeship' with leaders in the field, having an understanding of the impact of AI in everyday life will be essential for the flourishing of all future citizens. The education system needs to communicate this to students and prepare them for the challenges of a world with AI as it does with any other aspect of our natural, built or cultural environment.

The rest of the section is structured as follows. It begins with a more nuanced discussion of the impact AI is likely to have on existing jobs and occupations. It then considers the more covert and qualitative implications, especially how AI is reshaping the way decisions and social connections are made. This is followed by reflections on how AI is amplifying other large forces shaping the future. The section concludes by noting that our collective future is full of possibility and is in our hands. While dystopian futures, such as 'robots stealing all our jobs' may, theoretically, be possible, a number of more informed thinkers and researchers in government, academia, business and the broader community are showing how technology can be best harnessed in the pursuit of improved social and economic outcomes for individuals and communities.

AI and its impacts

Over the course of human history, technological change has contributed greatly to improvements in productivity, income and the quality of life. As noted in our prologue, AI has the potential to have impacts as significant as the advancements in water, steam and electric power that ushered in the industrial revolution. More recently, in the 1970s and 1980s the growing pervasiveness of information and

communication technologies (ICT) involved radical changes to the production of goods and services, and contributed to significant productivity growth in global terms. What impact is AI likely to have?

Overt impact: implications for the number and content of jobs

The impact of AI and automation on the number of jobs has been the subject of considerable debate. Because AI is not a single technology, but a collection of technologies applied to specific tasks, its effects are likely to be felt unevenly throughout the economy (Council of Economic Advisors to the President, 2016). One frequently cited analysis, undertaken by economists and based on the technical properties of AI and the relationship between those properties to existing occupations, suggested that 47 percent of workers in the US have jobs at high risk of potential automation over the next two decades (Frey and Osborne, 2013; 2017). CSIRO has predicted a similar proportion for Australia (Hajkowicz *et al*., 2016) and the Bank of England (Elliott, 2015) has warned that 80 million US and 15 million UK jobs might be lost to automation.

The methodologies on which studies like Frey and Osborne's rely are based on algorithms that predict the susceptibility to automation of different occupations. Such studies have been heavily critiqued (see Arntz *et al*., 2016), and yet they are, as we have highlighted, heavily cited and publicly reinforced by the media. OECD researchers and others, on the other hand, have argued that jobs are made up of a range of tasks, and that while some tasks within jobs may be automated, this is more likely to lead to changes in the nature of the work being performed, rather than entire jobs being displaced (Arntz *et al*., 2016). In addition, over the course of history technological change has been associated with new jobs. That process can be slow. For instance, only 0.5 percent of US workers are employed in industries that have emerged since 2000 (Berger and Frey, 2015). The McKinsey Global Institute highlighted that already a third of tasks in 60 percent of occupations could be fully automated using today's technology (2017).

It is important to understand that task and job redesign are likely to affect jobs with higher-level skills involving routine, analytical and predictable work in the professions, as well as low skilled jobs. For instance, identifying skin cancer lesions with the help of AI can enable dermatologists to focus on extreme cases, talk to patients and coordinate care. AI can complement human work rather than replace it outright.

AI also influences the number and content of jobs by enabling new business models and/or business processes. For example, companies like Uber and Lyft leverage AI to create entirely new business models, while companies like Netflix and Spotify use such systems to optimise movie and music recommendations. New business models and processes have also resulted – and are likely to continue to do so – in the creation of numerous new low-paid, casual jobs such as inappropriate content moderators, site raters and data cleaners. In the wake of increasing content that does not meet its guidelines (fake ads and news, child exploitation, live-streamed suicides and so on) Facebook hired another 1,000 new content moderators on top of the 7,500 it already employs.

AI is likely to change the nature and design of a great many jobs, the tasks that make up particular jobs, and the types of skills needed to perform them. The pace and extent of adoption of AI is, however, likely to vary significantly across sectors and economies. Factors such as technical feasibility in real-world situations, the cost of developing and deploying solutions, economic benefits and regulatory and social acceptance are all likely to influence these (McKinsey Global Institute, 2017).

It is also important to acknowledge that other factors also determine job creation. Productivity gains associated with innovations like AI generate increased income. Distributed appropriately (i.e. fairly) this can become a new source of demand for new types of labour (e.g. increased disability support workers associated with the operation of the National Disability Insurance Scheme). Whether new technology results in net job losses is, therefore, just

as much a matter of politics and policy choices as it is of technical developments.

Covert impact: Implications for decision making and social connection

While arguments about the impact of AI and technology on the future of work have been energetically debated, the impacts on decision-making processes and social relations at work and beyond are less traversed. The reach of social media, especially amongst young people is ubiquitous. Platforms like Facebook have created completely new dimensions of human connection. Recommender services are now so widespread they are accepted as a quasi-natural feature of the consumer landscape. These new AI-driven technologies generate challenges that are not as obvious as the transformation of jobs – but they are no less real or significant. We need to understand them better and, more importantly, educate students about their implications. AI is entering into countless areas, including decisions that are made in finance, healthcare, education, recruitment and selection processes and the military. ML algorithms are used to help determine who gets a loan, who is shortlisted for a job or who gets paroled. The seductive hyperbole around AI obscures the mounting complexity embedded in algorithms based on deep neural networks as previously discussed. We have difficulty understanding how such systems have reached the decisions that they have and a meaningful explanation of how they have done so is very difficult to produce.

This creates a number of problems. First, such algorithms may have hidden biases that do not come from the intention of the creator. The case of banks making decisions about loans to customers provides an example. Banks often use historical data to 'train' risk-rating algorithms. Such systems carry any pre-existing biases embedded in previous decisions (racial, gender, ethnic prejudices etc.) into the resulting algorithm. These algorithms make use of data sets that are only as good as the information that is contained within them. Since computers are trained on data drawn from the world around us (and hence reflect the nature of our world), companies like Google are grappling with removing bias from such systems without affecting their usefulness. Such biases are not explicitly revealed, and so are difficult to correct. Second, given that such algorithms are based on the interplay of thousands of simulated neurons they are often inscrutable and impossible to explain in detail, even by their creators.

We must find ways of making deep learning technologies more understandable to people who develop them and accountable to those who use them. As such they have profound implications for education, both in how they might directly shape the education system (for example using computer-based marking in the context of standardised testing), as well as with regard to developing an understanding of how they are used and what they stand for.

Such concerns are further exacerbated by the research investment supporting AI development. This is generally being made by private companies. While some of this research is resulting in significant scientific breakthroughs that are contributing to advances in human welfare, this is not what is driving or guiding the industry. Such scientific advances are often used in commercial products that have the potential to influence decisions in ways of which users may not be aware. The assumption that technology does not have 'values', and technologically driven decisions need not be concerned with ethics is discredited in the engineering field. The Institute of Electrical and Electronic Engineers, the biggest professional organisation in the field, has a committee addressing the ethical design of AI and autonomous systems. An essential skill for both children and adults in dealing with AI is to understand how it is used, the values that have been incorporated into technological products, and how outputs from AI can influence human wellbeing and functioning.

An example of this is understanding the ways in which AI can be used to manipulate human decision making. The impact of technologies designed to change our behaviour (for example, through advertising and social media platforms) is significant. There are 2 billion people regularly using Facebook, and 1.5 billion using YouTube. On average, these users spend over two hours per day on social media,

consuming news and information about their close relationships and the world that surrounds them. This form of media is different to that in traditional media. AI is used to personalise and target content in ways that users do not yet understand.

Box 3: Facebook status updates

John checks his status update in Facebook and finds out that his uncle Tom has won the lotto. Mary, John's sister, checks Facebook, but she does not see this news. How is she to interpret that? Does Tom not want her to find out? Or is it something else?

Facebook now has over 2 billion active users like these each month making it one of the most significant media sources today. Each of these users is making their own interpretation of their social media news. Much of the content consumed are status updates from 'friends', but some are public interest news stories. The page that displays these status updates is personalised each time it is viewed using AI algorithms that filter the content based on the prerogative of maximising advertising revenue, and the constraints of 'screen space' and user time and engagement.

In a recent study with 689,000 users Facebook researchers showed that they could manipulate people's emotion by changing the algorithm used to personalise this page. For example, increasing the percentage of positive posts appearing in the news feed reduced negative emotions. Beyond the interest on the impact of Facebook on emotional contagion, this manipulation shows an example of how the company can have an impact on people's psyche (Calvo *et al*., 2015; Kramer *et al*., 2014).

A second example (Box 4) illustrates the ways algorithms can inadvertently attach credibility to news stories and sources through the way they parse and present their results. Much still relies on the user to evaluate and decide on the appropriateness of the information, an ever-increasing burden on the consumers of media.

Box 4: Google 'top stories' search results

Earlier this year a search for 'the great barrier reef' yielded a list of algorithmically compiled stories that featured the following 'top stories': a story from the *Sydney Morning Herald* on the coral crisis, a story from *Wired Magazine* about climate change and saving the reef and a *Breitbart News* story claiming that the coral reef is still not dying and that this is all a great conspiracy.

When a journalist from Gizmodo attempted to find out why the last story would appear alongside scientifically sound stories, a Google spokesperson said that the job of a search engine (in this case Google) 'is to present a range of news and views from across the spectrum' (Turton, 2017). Search engine algorithms are unable to tell the difference between points of view or scientific consensus. Nor is it clear whether they will in the future make efforts to address such issues, as such companies are optimising for engagement with the platform, rather than providing the most accurate results. In the case of breaking news for instance, Google weighs "freshness" over "authoritativeness", again through algorithms that are opaque to the end user.

A third example (Box 5) is found in the decisions that are delivered through the algorithms on which AI is based. The issue of algorithmic bias has been highlighted as problematic, along with increasing difficulties in uncovering how algorithms reached a decision. Filters currently used in today's search engines highlight the complexity of interpreting the information that is shown to us. Although in Australia there are legal protections for such examples of bias, the impact of technology on how we perceive ourselves is obvious. There is some evidence that, for example, the autocomplete function in Google could perpetuate prejudices (Baker and Potts, 2013).

Box 5: Automated teacher performance evaluation

Even though she was getting excellent reviews from students and her principal, fifth grade teacher Sarah Wysocki was fired after receiving a bad score on an algorithm-based teacher assessment tool that supposedly measured her effectiveness at teaching maths and English.

Her case is described in Cathy O'Neil's *Weapons of Math Destruction*. Wysocki's district had used a Princeton consultancy based algorithm to evaluate her students' educational progress and the part of that progress that could be attributed to the teachers, reducing performance (and human behaviour) to an algorithm. As a result, some teachers began to teach to the test. This meant that students had come to Sarah's class with very good scores from the previous year, but lacked appropriate skills. Sarah was fired based on her teacher assessment scores, while teachers who had gamed the system stayed safe.

Unlike data used in other sectors (like sports where there is, figuratively speaking, mountains of data) in this case the algorithm relied on only 25 to 30 data points – by no means statistically sound. The system ended up firing 206 'bad teachers', and with no feedback mechanism that would enable it to learn from its mistakes, its decisions have come to embody 'the truth' (O'Neil, 2016).

The examples featured suggest that the impact of AI for people in the future is not limited to the number and content of jobs. AI can also impact on people's psychological needs for autonomy, competence and relatedness (Ryan and Deci, 2000), and other determinants of wellbeing that we discuss in more detail in Section 3. The fact that technologies have an impact on psychological wellbeing has been acknowledged by the design and engineering communities (Calvo and Peters, 2014) and will hopefully be addressed by the Institute of Electrical and Electronic Engineers (IEEE) Global Initiative for Considerations on the Design of Autonomous Systems. In Sections 3 and 4 we consider why and how schools should ensure that students have the skills that allow them to flourish at a personal level in an uncertain world increasingly shaped by AI-enabled decision making and social connection.

The amplifying impact of AI

In addition to these overt and covert impacts, other transformations are occurring, the impact of which is amplified by the diffusion of AI. Five of the most significant that affect the future of work are outlined below.

Industry disruption

Over the last ten years we have seen accelerating industry disruption. This has happened not only in the technology sector, which now represents the biggest companies in the world, but also across the board, including traditional industries such as mining and agriculture.

In 2007, there was one technology company (Apple) that made the top five world companies by market capitalisation (Bloomberg). By 2016, the top five were all technology companies – Alphabet (Google), Amazon, Apple, Microsoft and Facebook – with large R&D investments into artificial intelligence. In April 2017, they were joined by Tencent, China's tech giant, which surpassed Wells Fargo to become the tenth biggest company in the world.

Tencent alone spans traditional industries, including services in utilities and social services, social media, finance, entertainment, transportation, dining, communication and health. Digital technologies and machine learning have allowed the rise of ecosystems, fundamentally challenging established forms of competition, supply chains and business models. Such changes and companies offer a glimpse into how industries are redefined by shifts in what companies do and changes in where industry boundaries lie.

Industry transformation is not confined to the classically defined 'tech' sectors. A transformation in the number and content of jobs has consequential

effects on the structure of economic sectors and geographic regions. For example, machine learning and robotics are supporting the automation of sectors like mining and, to a certain degree, agriculture. Remote mining, oil and gas operations are already largely automated, and increasingly controlled from locations, often based in urban centres, that can control a large number of such facilities. As both operations and operation centres are automated, employment levels in the rural and resources community are transformed.

Labour market fragmentation

AI technologies are enabling business model transformations and business process reengineering, resulting in deepening fragmentation of the labour market. New business models for delivering goods and services have enabled the emergence of companies like Uber, multi-sided platforms with loosely defined internal and external structures. Such enterprises are able to draw on the large, non-standard workforce that has emerged in Australia since the mid-1980s. The labour market position of such workers is uncertain, making them open to taking on any job opportunity available. The nature of the connection with employers in the jobs in which they work is often loose and on the margins of what would traditionally be called an employment relationship. In some areas of the 'gig' economy (e.g. Airtasker, Deliveroo) it is difficult to determine whether an employment relationship exists at all. Freelancer, an Australian online company, claims to connect workers with over 25 million employers across (allegedly) 247 countries (Freelance.com, November 2017). These arrangements have been enabled through the development of digital platforms linking workers with individuals and organisations wanting specific tasks undertaken. While it is often claimed that workers value the freedom, independence and autonomy that working in this way offers, others argue that these workers are extremely vulnerable and note the loss of benefits and minimum entitlements (such as paid sick and annual leave, workers' compensation and superannuation payments) that are required as part of standard employment relationships (Unions NSW, 2016). Alleged problems with organisations such as Uber have raised questions about its formal – as well as its social – licence to operate in cities like London and countries like Germany and Japan.

It is also important to note that AI/ML has made great inroads with tasks or jobs involving routine, analytical and predictable work. Whether cognitive or manual work, these tend to be middle-income jobs. AI has been less prevalent with jobs that require a lot of human interaction, high mobility and assessing and responding to human emotion. These jobs are often low-income jobs (baby sitters, dog walkers or waiting staff) or high-income creative professional jobs (surgeons, designers, scientists, architects).

Rising social inequality

AI has the potential to vastly amplify social inequality. Thomas Piketty's *Capital in the Twenty-First Century* (2014) and Tony Atkinson's *Inequality* released the following year gave detailed consideration to the issue of inequality and attracted widespread public concern. Expanding machine learning capabilities has the potential to automate a wide variety of tasks in middle and upper level jobs, thus widening earnings disparity. In recent decades, most advanced economies have revealed an inability to generate large numbers of quality, middle-range jobs. While there has been some increase in more highly-skilled work, this has not occurred at the same rate as middle range job destruction. If this trend continues, many of those displaced by automation will be forced to take on less qualified jobs, thereby not only reducing their income but also increasing competition amongst lower-paid workers.

Inequality is not just a matter of income and wealth – it is also about access to skills, resources and knowledge. These in turn shape what Hage (2003: 17) has identified as the problem of inequalities of hope. The digital divide is not just about access to technology – it is about access to knowledge and how to use it effectively and critically. Without the capacity for thoughtful, critical use, technology leaves vast swathes of the population open to uncritical

manipulation by others who use the web and social media as an echo chamber for short-sighted, unreflective views.

Rising social inequality, whether of income or of hope, add to the problems of fragmentation and displacement that accompany the last decades of globalisation.

Changing dynamics of globalisation

It is widely recognised that the ICT revolution of the 1960s and 1970s was an essential ingredient in the neoliberal form of globalisation that emerged in the 1980s and 1990s. Over the last ten years, while growth in global trade and finance have levelled off, the rate of growth of digital products and services as well as global data flows continue to surge.

Whilst globalisation is still underway, it is also facing a countertrend. One of its great paradoxes is that while ICT has increased connections worldwide, within nations it has intensified the dynamics of social fragmentation and thereby deepened fault lines. Recent electoral shifts involving popular mobilisations of those displaced or threatened by closer international economic integration have involved, in part, the novel and creative use of AI to mobilise 'the isolated' or today's 'forgotten people'. The use of advanced AI as developed by Cambridge Analytica, which played a role in the American presidential election and the Brexit vote is a case in point (Cadwalladr, 2017). The broader political development of growing rejection of the neoliberal orthodoxy has not been triggered by AI – but AI has intensified and extended connections that in the past would be more informal and less comprehensive in nature.

Climate change and sustainability

The transformations we describe play out in a context of global climate change. On the one hand AI has the potential to amplify the strain we put on resources. ML algorithms require vast amounts of processing power. New efficiencies allow ever-increasing numbers of people access to technologies or services, and drive economic growth. On the other hand, AI also has the potential to help address the challenges of a carbon-constrained future. Necessity is the mother of invention. AI technologies could help monitor, model and enable the management of environmental systems at a speed and scale that was previously impossible. Weather research, for instance, has benefited tremendously from being able to use AI to model the enormous amount of data in that field to identify tropical cyclones and other weather events. To date however we have yet to realise the potential and promise of these technologies to better meet the challenges of a carbon-constrained future.

Although discussed as distinct, the transformations that we describe above, and in turn, the impact AI has on them, overlap, influence and reinforce each other. Companies like Uber, for instance, have spearheaded the disruption in the transportation industry around the world, and its business model has enabled both deepening labour market fragmentation and a rise in inequality. Instead of removing cars and trips from the city, Uber is actually adding more and more trips to city and suburban streets (Clewlow and Mishra, 2017) increasing the number of kilometres that people undertake and emissions in the process.

Reconceptualising the AI challenge: the best of times, the worst of times or both?

In the vast literature on the future of work, there is no consensus concerning what actually is most likely to emerge from current developments. This should not be regarded as a source of despair or frustration – but rather as a basis for realistic optimism. We do not live in a world where there is no alternative to our current trajectory. The contrary is in fact the case. One way researchers have endeavoured to explore this is by developing alternative scenarios for the future.

Scenarios are plausible formulations of potential future states – devised based on varying assumptions about key determinants of the matter of interest. In

the course of undertaking this project a number of scenarios about the future of work in general and the impacts of AI in particular were considered. These highlight that while profound change is coming, it is by no means clear just what combination of trends emerging in the current situation will actually prevail. Shell International has some of the most advanced capabilities for scenario thinking in the world (Carter *et al*., 2008: 72 – 75). Its deliberations, therefore, deserve especially careful consideration. In 2011 its energy scenarios concluded that we are 'entering a zone of extraordinary opportunity or misery.' (Shell, 2011). We conclude both could come to pass simultaneously.

The critical challenge, therefore, is to prepare for uncertainty. In and of itself, AI may not be the most significant 'disruptor', but its disruptive effects will be profound in combination with climate change, the changing dynamics of globalisation, deepening inequality and intensifying fragmentation in the labour market. In light of this, the central challenge is to deepen individuals' and societies' capacity to adapt to changing situations. This was a common theme arising from all the workshops conducted with the diverse faculties and schools contributing to the deliberations informing this project. Participants in these groups emphasised that adaptability did not just mean 'ability to accommodate forces beyond anyone's control'. All noted that it also meant the ability to 'shape' the future – not in a naïve 'anything is possible' kind of way – but rather in a thoughtful and realistic manner. The ability to accommodate is important. Given the impact on job numbers and content, the ability to handle negative events like job losses and adapt to new ways of working will be vital. However, as we noted earlier, these are not the only challenges associated with AI. People will need the ability to understand what is happening to and around them. They will also need the skills to effect change; they need to be able to not just respond to events but also to shape them in light of their understanding.

Just what qualities of humanity and knowledge do we need to give children if they are to thrive and not just survive in the 21st century world? This question is considered in the next section.

3. The qualities needed

One of the most striking findings of our workshops came from the one conducted with engineering researchers.[4] Despite often being at the frontier of AI transformations, they were humble about their implications for education. All participants thought it important that every student learnt basic ICT skills. None, however, advocated that every student needs to become conversant with computer coding. As with the other workshops, they noted that education's connection to the labour market is dynamic. To the extent that formal education can help people succeed in the labour market of the future, workshop participants argued the key priority must be to ensure it also helps develop people's creativity and ability to adapt to rapidly changing circumstances (as noted in Section 2).

In this chapter we consider the widespread assumption that education's key response to emerging challenges and opportunities is to ensure that students develop so-called 'soft' or 'generic employability' skills – such as 'problem solving', 'communication' and 'collaboration'. Superficially this seems sensible. Closer scrutiny reveals, however, that this popular narrative is not sufficient to guide school education today. We make four points. First, if young citizens are to flourish (and not just be economically flexible) they need nurturing in many of aspects of life, not just those needed for 'employability'. Second, the challenge is to develop sound learning dispositions – such as the capacity to concentrate, resilience, curiosity and ability to function in learning relationships. There are echoes here of the generic employability skills narrative – commonly referred to today as '21st century skills'. Where we take issue with that narrative is that we conceive of these qualities as fundamental dispositions concerning learning and the ability to adapt in the broadest sense – not just as 'skills' essential for meeting the allegedly self-evident 'market' needs. Thirdly, we note that once learning foundations are built in early years education, such dispositions are best acquired, paradoxically, in the context of mastering specific disciplines or fields of vocational expertise. Fourth, while schools have a long tradition of developing specific expertise in both their academic and vocational offerings, as currently taught they do not necessarily deepen learning dispositions as well as they could. Qualities like problem solving developed in academic offerings could, potentially, be made more generally applicable with deeper engagement with the world of practice. Similarly, vocational education would benefit if students were given more access to underpinning knowledge associated with their domain of practice, allowing more generally applicable qualities to emerge from such education. In short, we need to acknowledge that the matters raised by the generic employability skills narrative are important. It is, however, better to conceive of them as being concerned with the development of enduring learning dispositions that are often best developed in the context of mastering specific domains of expertise.

[4] In the early stages of this project three two-hour workshops were conducted with interested researchers from three faculties: Education, the Faculty of Medicine and Health Sciences and Engineering. One-on-one interviews were conducted with other interested researchers, primarily from the Business School. Further details on this part of the process are provided in Appendix 1.

Connections between education and work – not as obvious as is commonly thought

Education and work are connected – but not in ways commonly assumed. The research on returns to education shows that better qualified people are, generally speaking, better paid. There are, however, important provisos to this relationship. Changing (i.e. declining) returns appear to be primarily due to rising levels of education attainment relative to the slower growth in jobs needing such qualifications (i.e. the increase in so-called over-education, or

more accurately: skill under-utilisation). Recent work published by the World Bank demonstrates that rates of return vary dramatically between countries and over time (Montenegro and Patrinos, 2013, 7-11)[5]. Also, within advanced countries rates of return vary – often dramatically – between different types of qualifications. The level, type of institutions awarding them and the field of study are very important determinants (Dalziel, 2017). The most recent research, using 'big data' on hundreds of thousands of UK students' experiences over 10 years, has highlighted that family income levels also shape later earnings outcomes – even after controlling for these variables (Britton *et al*., 2016). As we note below, there is not a general or universal relationship between education qualifications and the labour market.

A particularly useful stream of research has examined the information employers use when making hiring decisions. Sociologists have been particularly active here. They found employers use three types of information when hiring: formal credentials (i.e. education qualifications as assumed markers for human capital), data obtained from networks (i.e. social capital) and 'cultural capital' (i.e. less tangible criteria used by employers when staffing positions like family or socio-economic connections) (Bills *et al*., 2017).

Arguably the most extensive research comes from the human capital literature and its critics, and concerns the formal role of education qualifications. As Bills *et al*. (2017) note:

> Human capital theory adopts a learning mechanism in which schooling teaches students something useful and adds value to potential employees. In contrast signalling theory, which [both extends and challenges HCT], holds that schooling merely sorts students based on characteristics that are already present... schooling serves as a sorting machine... [that] signals ... unobservable abilities (e.g. willingness to learn, perseverance, motivation) supposedly correlated with job performance. Credentialist theory maintains that employers use educational credentials as a means of social closure, often without regard to the content of what schooling either inculcates or signals (Bills *et al*., 2017: 294).

This report is primarily concerned with the knowledge content of education. We recognise schools are also active in labour market signalling/screening and broader systems of social reproduction. Policy about the content of education, however, can do little to overcome these matters. Remedies will require initiatives directed at social inequality in general and labour market segmentation in particular. That said, the way in which knowledge from school education influences labour market success is far from straightforward and is the concern of the rest of this section.

Generic employability skills – necessary but not sufficient for emerging realities

Debate about whether education should provide broadly based capabilities or skills more immediately relevant for industry has recurred throughout the ages. Since the mid-1980s governments and employers in Australia have pursued an approach that combines the two: i.e. support for the importance of 'broad learning' (defined in terms of 'generic skills') and competency based training in vocational education and training. A defining feature of this policy narrative has been the development of formal frameworks and funding initiatives directed at ensuring the education system places greater attention on what are commonly called 'generic', 'employability' or 'soft' skills. In the 1980s this policy approach emerged in response to the restructuring associated with globalisation in general, and deindustrialisation in particular. As Curtis and

[5] Between 2006 and 2010 returns for an extra year of schooling have fallen from 14.4 percent in 1980 – 1985 to 9.9 percent. Across time and countries differences of similar magnitude exist. For example, in the period 2006 – 2010 the returns to an extra year of school averaged 9.9 percent. This was highest in sub-Saharan Africa (12.8 percent) and lowest in the Middle East and North Africa (5.6 percent)). In OECD type countries it was 10 percent (Montenegro and Patrinos, 2013, 7-11).

McKenzie (2001) note, in 1991 the seminal Finn Report into young people's participation in post-compulsory education and training

> ...drew attention to changes in the skill demands of industry and of rapid change in the Australian economy as a result of structural economic change and national and international competition. It noted that "the most successful forms of work organisation are those which encourage people to be multi-skilled, creative and adaptable" (p.6). Because of changing technologies and changing economic circumstances, they argued that "the ability to continue learning and acquiring new or higher level skills will be fundamental". As a consequence, "the emphasis of our training system has to be both on the acquisition of the specific skills for the job/trade and on flexibility" and that flexibility "requires a strong grounding in generic, transferable skills" (p.55). (Curtis and McKenzie, 2001:12 citing Australian Council of Education. Finn Committee, 1991).

For the Finn Committee, these were defined as:

- Language and communication
- Mathematics
- Scientific and technological understanding
- Cultural understanding
- Problem solving
- Personal and interpersonal skills (Australian Council of Education. Finn Committee 1991: 58 as cited in Curtis and McKenzie, 2001:13).

More recently, the concept of generic employability skills has evolved into advocacy for what are today called '21st century' or 'enterprise' skills. As Table 1 shows, concerns with these matters have never been far from the government and business policy mainstream. Both national officials and employer organisations continue to promote the acquisition of skills that are allegedly universally appropriate but yet (as we shall argue later in this chapter) meaningless if not anchored in domain-specific knowledge and expertise.

A quarter of a century after the Finn Report, the 'generic' skills agenda has been reiterated by the World Economic Forum. Their 2015 report, *New Vision for Education – Unlocking the potential of technology* asserts that the basis of economic development today is 21st century skills such as 'creativity, innovation and collaboration' (World Economic Forum (WEF) / Boston Consulting Group (BCG), 2015: 2). They argue that automation is eliminating unskilled work (i.e. work with a high level of routine manual and/or cognitive skills), and the remaining and future high skilled work requires "solving unstructured problems and effectively analysing information". It also reports a shortage of people with the 16 skills required for the 21st century. These are grouped into three broad categories:

- Foundational literacies (i.e. how students apply core skills to everyday tasks)
- Competencies (i.e. how students approach complex challenges)
- Character qualities (i.e. how students approach their changing environment)[6].

A summary of the categories commonly used and defining generic skills since 1985 is provided in Table 1. The table highlights the strong continuing interest in a limited number of key areas. Prime among these are so-called 'tools for working in the world' (e.g. literacy, numeracy and ICT skills), 'ways of thinking' (especially problem solving or critical thinking) and 'ways of working in the world' (especially communication and collaboration skills) (Suto, 2013). Over time matters of interest have extended to include 'skills for living in the world'[7]. In the 1980s and 1990s this concerned things like 'cultural understanding' and 'planning and organising activities'. More recently it has extended to matters of 'citizenship' and 'personal and social responsibility' as well as 'curiosity', 'initiative' and 'grit'.

[6]Details of the types of skills falling into these three broad categories are provided in the last column of Table 1

[7] This term and that used to group the other general 'generic employability skills' has been taken from Suto (2013).

Table 1: Generic employability skills[1]: formulations 1985 – 2015

Dimension of work/ living[2]	Official Australian formulations[3]			More recent International formulations[4]		
	Karmel (Quality of Education Review) 1985	Finn (Aust Education Council Review Committee) 1991	Mayer (Aust Ed Council + Ministers of Voc Ed'n, Employment + Training) 1992	4 Cs - Partnership for 21st Century Learning (nee Skills) 2002[5]	Assessment and Teaching of 21st Century Skills Project 2013[2]	World Economic Forum/Boston Consulting 21st Century Skills 2015[6]
Tools for working in the world	[Literacy as part of communication (1)] Mathematics (2) Science (3) Technology (4)	Language + Communication (1) Mathematics (2) Science + Technology understanding (3)	Collecting, analysing + organising info (1) Mathematics (5) Using technology (7)		Information literacy (includes research on sources, evidence, biases etc.) (6) ICT Literacy (7)	Literacy (1) Numeracy (2) Scientific Literacy (3) ICT Literacy (4)
Ways of Thinking		Problem solving (5)	Problem solving (6)	Critical Thinking Creativity	Critical thinking/ problem solving (2) Learning to learn (3) Creativity + Innovation (1)	Critical thinking/ Problem solving (7) Creativity (8)
Ways of Working	Communication (1)	Language + Communication (1) Personal + Interpersonal skills (6)	Communicating ideas + info (2) Working with others and in a team (4)	Communication Collaboration	Communication (2) Collaboration (5)	Communication (9) Collaboration (10)
Skills for living in the world	The world of work (5) Australian Studies (6)	Cultural Understanding (4)	Planning + Organising activities (3)		Citizenship – local + global (8) Life + Career (9) Personal + Social Responsibility (includes cultural awareness + competence)	Financial literacy (5) Cultural and civic literacy (6) Curiosity (11) Initiative (12) Persistence (13) Adaptability (14) Leadership (15) Social and Cultural awareness (16)

Sources and Notes:

1. The terminology in this area is imprecise. This expression is taken from Curtis and McKenzie (2001). Numbers in brackets refer to the rank order of that particular formulation of 'generic employability skills'.
2. Taken from ATC21S categories of 21st century skills as summarised by Suto (2013: 6 – 7)
3. Summaries taken from Curtis and McKenzie (2001)
4. It should be noted that there have been numerous other international formulations dating from at least the time of the earlier Australian formulations.
5. Johnson (2009).
6. World Economic Forum (with Boston Consulting) (2015)

Many recent contributions to the debate on the future of work in general and the impact of AI in particular put great store on the importance of educators paying more attention to the development of skills of this nature. This is especially the case amongst consultancies that advise business on the future of work (e.g. LaVelle *et al*., 2017; Bain, 2017, Bhalla *et al*., 2017, Evans-Greenwood *et al*., 2017; EY, 2016; McKinsey Global Institute, 2017; PWC, 2015, 2017). In many ways, when it comes to policy responses to the unfolding disruption educators are assumed to be the key agents with the greatest responsibility for supporting successful labour market adjustment.

While the generic and 21st century skills narratives have dominated public debate over the past three decades, other voices have not been absent. In fact, some of the early proponents of this policy stance have become more circumspect in recent years. In the 1980s and 1990s the OECD, for example, was a major advocate of such skills being vital (e.g. OECD, 2001a). This narrative was congruent with a vision of individuals having the primary responsibility for adjusting efficiently to changing market signals. Workers with such skills – and not governments or employers – would bear prime responsibility for economic 'adjustment'. In 2016 key international economic development institutions (World Bank, ILO and IMF) joined forces to release a report for the G20 entitled *Enhancing Employability*. In marked contrast to the earlier vision of 'generically skilled workers' adjusting to market signals, this report identifies 12 distinct policy responses to enhance individuals' employability. Only one of these refers to 'employability skills'[8]. In essence, for these agencies, boosting employability requires improvements in four distinct areas:

- Anticipating emerging skill needs and adapting policies accordingly
- Reinforcing the role of training and work-based learning
- Enhancing the adaptability of workplaces
- Promoting labour mobility (OECD *et al*., 2016).

Similar sensitivities have been evident in recent EU publications. The relatively recent comprehensive *Literature Review on Employability, Inclusion and ICT* (Green *et al*., 2013) is a good example. Based on a close reading of an extensive literature it promotes a revised employability framework (Green *et al*., 2013: 3-4, Ch 11) similar to that contained in the OECD *et al*., 2016 report. This framework notes that 'employability' involves employer practices, labour market intermediaries and an individual's circumstances – of which their formal education is but one aspect.

These recent policy research developments are critical as they highlight the need for greater realism about what employability skills can deliver. In particular, governments and employers need to recognise that employability skills need to be accompanied by additional, more active, policies for improved labour market performance. Educators should not be expected to bear an unrealistic level of responsibility for ensuring people are immediately 'employable'.

Getting the questions right

When thinking about the future it is critical to not only be more realistic about what 'generic employability skills' can deliver – it is also essential to consider their content. While the domains of skill listed in Table 1 are extensive, are they adequate if we are thinking about how schools can nurture students'

[8]See the eighth dot point in 'Policies to enhance workforce employability': 'Pursue a balance between responding to specific employer needs while developing more general transferable skills that will be beneficial to individuals throughout their working lives' (OECD, ILO, World Bank with IMF, 2016: 5, 21 -23).

capacity to adapt to the changing world of work?[9] Can these 'generic' skills be acquired in isolation from the knowledge of the domain to which they are being applied? Problem solving, for example, is often domain specific. A highly skilled 'problem solving' coordinator of a preschool kindergarten has little to contribute to an oil rig facing an uncontrolled fire. Equally, a highly skilled 'problem solving' mining engineer will have difficulty overcoming the regular challenges of maintaining an effective preschool (Wheelahan *et al*., 2015). Do we need to think more carefully about the importance of mastering specific skills and knowledge as a platform for mastering general capacities for things like 'problem solving'? And if so, how adequate are current specialised offerings? It is to these questions that we now turn.

Issue 1: What types of pupils are we developing: highly flexible labour or flourishing, productive citizens?

Drawing on an intellectual lineage that dates from Aristotle, Guy Standing has argued that it is important to distinguish work from labour.

> ...work is defined as rounded activity combining creative, conceptual and analytical thinking and use of manual aptitudes – the *vita activa* [i.e. the vital activity] of human existence.
>
> ...The notion of labour is quite different. Not all work is labour and not all labour is work. The word 'labour' is derived from the Latin (*laborem*) implying toil, distress and trouble (Standing, 1999: 3-4).

This distinction is very useful when considering the categories about work-related skills that inform our priorities in school education.

In the course of the workshops and interviews, the participating researchers noted the existence of longstanding, highly evidence-based categorical frameworks that are used for describing and analysing skills and personal qualities relevant to defining and understanding human development in the labour market and beyond. Health researchers noted the existence of the International Classification of Functioning (ICF) (WHO, 2001). The key distinction here is between 'Physical' and 'Psycho-social' functioning. Physical functioning concerns things like body structure and function. Psychosocial functioning includes matters associated with cognition, affect and social capabilities that are characteristics of the individual. An individual's participation in such life areas of work and education is determined by how the environment interacts with these personal characteristics.

Those working in the positive psychology field reported the existence of a number of such frameworks for understanding how to think about people as flourishing productive citizens, such as Ryan and Deci's (2000) Self Determination Theory (SDT) which explores the factors that motivate people to achieve autonomy, competence and relatedness. Positive psychology approaches such as Martin Seligman's PERMA framework have been adopted widely in some areas of education (Seligman, 2011). This framework identifies five characteristics essential for psychological health: **P**ositive emotions, **E**ngagement, **R**elationships, **M**eaning and **A**ccomplishments.

Economists working in the field of education noted the longstanding work of James J Heckman and his colleagues who identified the importance of early years education in particular for later success in life (including in the labour market). This group's most recent work has been on 'improving cognitive and non-cognitive skills to promote lifetime success' (Kautz *et al*., 2015). This research program builds

[9] It should be noted that the authors think education is and should be concerned about more than adaptive capacity in work and working life. We only pose the question outlined here in this way as this paper is concerned with how schools may better enable students to thrive and not just survive in their future working lives. As will be seen, even though we are focusing on labour market issues – we still take a very broad perspective of the issues vital for human flourishing. Indeed, we show that while advocates of 'generic employability skills' purport to engage with the key issues vital for a healthy labour market their preoccupation with issues of most relevance to alleged market dictates overlooks some of the key issues vital to the flourishing of individuals and the economy at large.

on the OCEAN taxonomy for classifying personality characteristics. The framework's five elements are: **O**penness, **C**onscientiousness, **E**xtraversion, **A**greeableness and **N**euroticism (i.e. mental stability) – although how modifiable these are is debatable as some (e.g.; neuroticism) appear fairly stable across the lifespan.

Finally, it is useful to acknowledge the insights of the capabilities approach of the humanities and social sciences. Martha Nussbaum (2006) persuasively argues that mainstream discussion of education focus.

> ...on internalisation of information, rather than on the formation of the student's critical and imaginative capacities... [instead Nussbaum] proposes a three-part model for the development of young people's capabilities through education focusing on critical thinking, world citizenship, and imaginative understanding (Nussbaum, 2006: 285).

Box 6 provides more details of what is meant by these three terms.

The factors highlighted by the generic skills framework as essential for meeting the needs of the new economy stand in stark contrast to those identified in long-standing research programs in disciplines such as medicine, psychology, education, sociology, philosophy and economics. Aspirations for our young citizens to participate in the new economy need to be higher than being simply able to be highly flexible in the 21st century labour market. It also requires us to ensure that their education provides them with the skills to become flourishing and productive citizens.

A summary of the key categories arising from these respective frameworks – and the gaps they highlight in the most common current approach to generic employability skills today – the WEF's 21st Century skills framework - are provided in Table 2.

Box 6: A capabilities approach – Martha Nussbaum on Education for freedom: three abilities

Martha Nussbaum (Nussbaum, 2006) argues that there are three capacities needed by all citizens:

1. '...the capacity for critical examination of oneself and one's traditions, for living what, following Socrates, we may call "the examined life"'. (388)

2. the 'ability to see oneself as not simply citizens of some local region or group, but also, and above all, as human beings bound to all other human beings by ties of recognition and concern. ... This means learning quite a lot about nations other than one's own and about the different groups that are part of one's own nation' (389 – 90).

3. a 'narrative imagination. This means the ability to think what it might be like to be in the shoes of a person different from oneself, to be an intelligent reader of that person's story, and to understand the emotions and wishes and desires that someone so placed might have' (390 – 91).

She goes on to say: 'We may become powerful by knowledge, but we attain fullness by sympathy... But we find that this education of sympathy is not only systematically ignored in schools, but it is severely repressed' (citing Tagore, 1961: 219) (390).

Nussbaum argues that the narrative imagination is cultivated, above all, through literature and the arts. This includes the performing and visual arts as well as the humanities.

Source: (Nussbaum, 2006: 385 - 395).

What stands out from Table 2 is that when compared with the wider research literature on the determinants of human development, the generic employability framing of issues is relatively narrow or, more accurately, partial in the way it defines the issues of relevance to education. Key omissions are any concern with physical development, silence on emotional development and any notion of

achievement or meaning. While the 21st century skills framework deals with some issues of character, this framework ignores three of the 'big five': extraversion, agreeableness and mental stability.

Of particular note in the narrative that places responsibility on individuals for adjusting to labour market change is the assumption that individuals are equally placed to be able to do so. Socio-economic factors, family circumstances, age and geographical attachments may limit the extent to which individuals are able to develop either employment related skills or the personal skills needed to allow them to flourish over their life course.

An example can be seen in relation to the absence of any concern in the 21st century skills framework with the intrinsic impairment (e.g. sight, hearing, mobility) that a reasonable minority of people have in developing skills required to function well in the workplace. This can be seen particularly in the face of increasing expectations of the degree to which today's workforce will exhibit a higher level of interpersonal and communication skills.

This last point has serious practical implications. An example provided from mental health researchers illustrates the point well. It is now a widely reported 'fact' that the prevalence of Autism Spectrum Disorder (ASD) is on the rise to a reported prevalence

Table 2: The extent to which matters covered in longstanding frameworks for defining and understanding human development are included in the 21st century skills framework[1]

Characteristic of human development	Where 21st century skills[2] line up (or are absent)
Physical[3]	Absent
Psycho-social[4]	
- Cognition	Partial coverage[6] (e.g. compare with 'capabilities approach' to critical thinking and narrative understanding.)
- Affect	Partial coverage[6]
- Social	Narrow (e.g. compare with 'PERMA' on relationships and 'capabilities approach' to world citizenship)
- Meaning	Absent
Personality characteristics[5]	Covered: 'Openness' and 'Conscientiousness' Absent: 'Extraversion', 'Agreeableness' and 'Mental stability'.

Sources: Full details provided in Appendix 2.

Notes:

1. More precise details on how narrow the 21st century skills framework is and what it leaves out are provided in Appendix 2.
2. The categorical system used for comparison here is the account of 21st century skills provided by the WEF/BCG (2015).
3. This category is one of the defining elements of the International Classification of Human Functioning (ICF). See WHO (2001) for more details.
4. This category and associated sub-categories summarise key feature of the ICF and the PERMA framework from the positive psychology movement: Positive emotions, Engagement, Relationships, Meaning and Accomplishments. See Seligman (2011) for more details.
5. The categories here come from the OCEAN framework: Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism (or mental stability). See Kautz *et al.* (2015) for a good summary.
6. 'Partial coverage' means the 21st century skills framework deals with this matter, but in a way that is more narrowly defined than in the other frameworks concerned with human development.

in the US of 1 in 70. A growing number of researchers in this field have argued that this is an artefact of changing social conditions of life at work and beyond whereby the core impairment in social communication that characterises ASD has become more manifest. In particular, in both education and the workplace there has been an increasing focus on group activities, flexibility and interpersonal communication (where people with even milder forms of ASD may be impaired) and relatively less attention to taking seriously the objective of creating meaningful work through specific expertise or development of routines (where they may excel). The latter is vital for drive and motivation in many theories such as Self Determination Theory (SDT) and PERMA. Those with ASD can have much to contribute where work can be found for them that is meaningful and that accommodates their impairments. Where a concern with meaning, however, is neglected and prominence is instead given to 'collaboration' and 'communication', such people are held to be the problem because of sub-standard 'generic' skills when in fact the problem is a lack of appropriate meaningful work. A whole movement addressing the failure of the dominant culture (of which the 21st century skills narrative is a typical element) to accommodate this 'neurodiversity' has begun to adopt this as a civil rights challenge (Jaarma and Welin, 2011).

We are not making these observations because we expect exponents of generic employability skills to engage with every aspect of every domain of scholarship. We do, however, note that each of the frameworks we use to question the adequacy of the 21st century skills framework are highly validated and widely recognised as critical for understanding, measuring and identifying key domains of human development.

The inadequacies of the 21st century skills framework – and those like it – arise from their primary object of concern: meeting the needs of the 21st century market place (WEF/BCG, 2015). A more appropriate starting point (and the concern of all the literatures referred to above) is human functioning and character development in the broadest sense. Development of high functioning, well balanced people with the capacity to flourish is not just good for the individuals concerned – it is a great asset for any community and its associated economy. Traditionally the notion of a liberal education has had such broad concerns. We reduce a concern with these broader notions at our peril. These concepts provide a better frame of reference for thinking about the future than a focus on narrowly defined employability skills relevant for the 21st century marketplace.

Issue 2: How can education contribute to human flourishing over the life course?

Given an interest in nurturing flourishing, productive citizens, the key issue becomes: how can education help? It is widely recognised that human development is complex and happens throughout the entirety of a person's life. Work by UK public mental health researchers has summarised the major factors influencing the trajectory of human capital development over the life course (Kirkwood *et al.*, 2008). A concise account of their findings is provided in Figure 4. This identifies the early school years as being critical for the development of an individual's 'learner identity'. While a host of factors shape this, primary schools in particular have a crucial role to play in shaping what are referred to as people's 'learning dispositions'.

Learning dispositions are critical to the way people engage with new situations and knowledge. Drawing on Bourdieu (1993) and Vygotsky (1978), Deakin Crick and Goldspink (2014) define learning dispositions as embodied characteristics that enable learners to engage with their environment by drawing on affective states and self-narrative. They argue that:

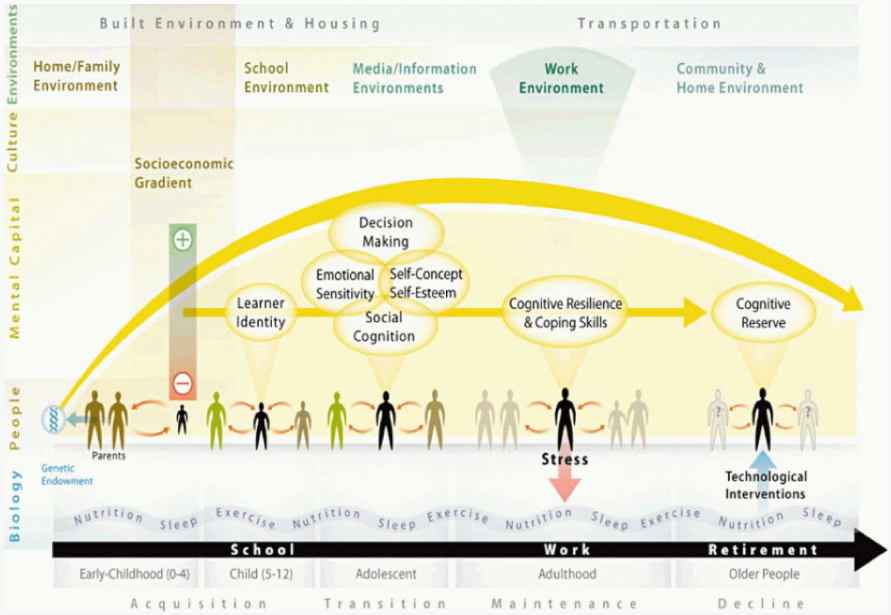
> The current dispositional state reflects the individual's history, including the wider social and cultural experiences that have shaped them as learners and which now influence their very being and their beliefs about themselves. (2014: 32)

Learning dispositions are critical to increasing and sustaining learner engagement in school education (Deakin Crick and Goldspink, 2014). In our view, learning dispositions need to be explicitly supported and developed in different ways throughout schooling to ensure that students are able to develop deep understanding in specific domains but also to develop skills, knowledge and understanding that prepares them for a fulfilling – as well as a productive – life. In this way, an approach that focuses on learning dispositions differs from a 21st-century skills approach, which is predominantly concerned with skills needed to meet changing labour market requirements. While a concern with issues akin to learning dispositions is implicit in some discussions of 21st-century learning (National Research Council, 2012) making these dispositions explicit supports teachers, schools and systems in analysing, diagnosing and then explicitly developing pedagogies that support a broader conception of student learning. Establishing an understanding of dispositions is particularly critical in early childhood and primary learning. Their development in the early years of schooling enables an explicit understanding in young students of the factors that contribute to successful learning. As they go on to specialise in different domains and disciplines in the later years of schooling these dispositions continue to provide the pedagogical infrastructure for learners and teachers to understand effective learning across, between and within domains providing an effective platform for problem-based, complex and interdisciplinary learning.

So what are the learning dispositions? There are several formulations, with most sharing common elements. The Effective Lifelong Learning Inventory (ELLI) identifies the following dispositions based on two decades of learning disposition research (Deakin Crick and Goldspink, 2014):

- Curiosity
- Resilience
- Learning Relationships
- Changing and Learning
- Strategic Awareness
- Meaning Making
- Creativity.

Figure 4: Factors influencing the trajectory of mental capital across the life course



Source: Kirkwood *et al.*, 2008

Drawing on the USA National Research Council's meta-analysis, *Education for Life and Work: Developing Transferrable Knowledge and Skills in the 21st century* (National Research Council, 2012) Jefferson and Anderson, (2017: 39) created the learning disposition wheel (see Figure 5) that identifies three broad domains to organise specific and interrelated learning dispositions: cognitive, intrapersonal and interpersonal.

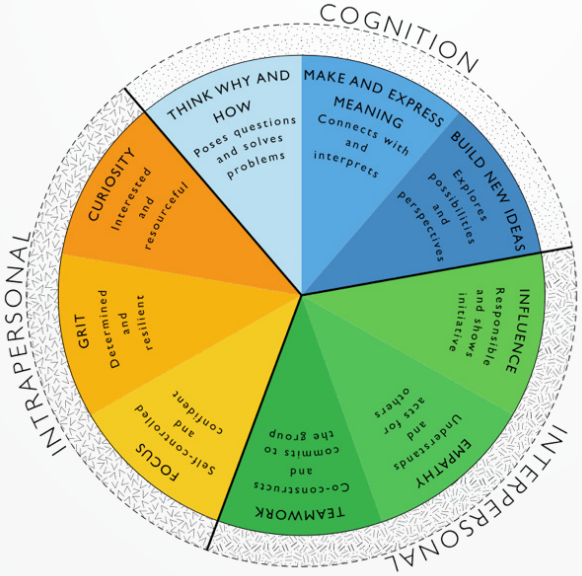
It is critical for people to develop deep understanding of dispositions so that they can build, reinforce and deepen those dispositions over the life course. Formulations of 21st century skills, like the WEF's, are concerned with issues like initiative and 'grit' as well – but they are listed in a somewhat schematic fashion and are not anchored in sensitivities to the complexities of either the ends or means of human development broadly defined. If lifelong learning is to be a reality, students will need more than an accumulation of 16 distinct 'generic skills'. Rather they will require knowledge that makes and builds connections to other domains, concepts, approaches and resources (i.e. synaptic rather than terminating knowledge). Educational strategies that build the dispositions for learning and deep knowledge in an interactive manner are far more likely to deliver on such an aspiration than one preoccupied with check lists of the skills needed for people to be simply 'employable'.

Issue 3: Is it possible to develop general capabilities (like fundamental learning dispositions) independently of mastering a specialist discipline or domain of vocational or professional expertise?

One of the most important insights to emerge from the workshops of researchers from the Education and Medicine and Health Sciences was a concern that so-called 'generic employability skills' could not be learnt in isolation. We argued earlier that generic skills such as problem solving generally only have meaning within specific domains of knowledge. An allied health researcher in one of our workshops put the issue clearly, noting:

> "What's the use of learning to collaborate if you don't have anything distinctive to contribute?

Figure 5: The Learning Disposition Wheel: a diagnostic tool that represents the cognitive, intra and interpersonal competencies needed for self-regulated learning.



Source: Jefferson and Anderson, 2017 : 39

> In the future we will not need vaguely defined 'health workers' who collaborate – rather we need, and in fact are seeing the emergence of, inter-professional teams. Collaborative skills are most effectively learnt in the context of exercising distinctive skills."

Virtually all involved in the workshops and interviews agreed with this observation. It was also recognised, however, that there were few developed research literatures that were exactly 'on point'. In the following three sub-sections we provide short summaries of some relevant studies that address this issue. While none are definitive, all point to the legitimacy of the basic proposition: the development of specialist expertise of some kind is essential for the development of more generally applicable capabilities like problem solving. Furthermore, such specific expertise would bolster key aspects of self-determination, autonomy and competence, which foster enhanced performance, persistence and creativity.

The transferability and adaptability of expert skills

Arguably the most mature academic literature on this issue comes from cognitive psychology. In 1989 Perkins and Salomon published an important review article that answered the question: 'Are Cognitive Skills Context-Bound?' The literature review and the issues covered by it were well summarised in the article's abstract:

> Effective problem solving, sound decision making, insightful invention – do such aspects of good thinking depend more on deep expertise in a specialty than on reflective awareness and general strategies? Over the past thirty years, considerable research and controversy have surrounded this issue. An historical sketch of the arguments for the strong specialist position and the strong generalist position suggest that each camp, in its own way, has oversimplified the interaction between general strategic knowledge and specialised domain knowledge. We suggest a synthesis: General and Specialised knowledge function in close partnership (Perkins and Salomon, 1989: 16).

Their article thoughtfully explores these matters using the narrative device of how a country facing imminent attack could, potentially, use a world-renowned chess master as an important advisor to a war cabinet. They show how over the years the research has veered between holding such a master's deep skills as symptomatic of a deep problem-solving capability in general, to potentially being more confined in their transferability (i.e. just to deal with questions of strategy), to being domain-specific – her skills would be excellent for chess, but not much else. Their conclusion, as noted above, could be regarded as bland – but for our purposes is most relevant. The issue is not either/or, but rather how the general and specific function together. As they note in their conclusion, the relevance of the person's skills depends on many factors. The first is the nature of the core skill itself. Is it of a nature that lends itself to some kind of transferability and if so, to what domains? Is this particular chess master one who abstracts from the specifics and has generalised her underlying analytical capability? They also note in passing that success in any field usually requires years of domain experience (Perkins and Salmon, 1989: 24).

Similar conclusions have been reached in a more recent review article of the literature on 'how experts deal with novel situations' (Carbonell *et al*., 2014). This paper deals with a more limited issue than that examined by Perkins and Salomon, namely, under what conditions can specialised experts successfully adapt to changing circumstances? Their findings highlighted the importance of both individual and contextual characteristics and were, in many ways unsurprising. Individual experts whose grasp of knowledge was less context dependent, who had the ability to abstract general problem-solving skills from their specialised training and who had been exposed to a more diverse range of experiences were more adaptable than those without these characteristics (Carbonell *et al*., 2014: 20 - 21). This paper also highlighted the importance of contextual factors for adaptability. Key features associated with

higher levels of adaptability were experts being responsible for developing their own solution to problems and being allowed to make mistakes or who were overseen by a supportive supervisor (Carbonell *et al.*, 2014: 25).

In a broad sense the implications of these synthesis studies are clear. Focusing on developing general capability in the abstract is of limited utility – getting an appropriate balance between specialised and general cognitive skills is the critical issue.

Sociology of education and the importance of knowledge in the curriculum

A different, but just as important, set of findings about the need for mastering a specific realm of expertise as the foundation for effective problem solving skills and the capacity for independent judgement in particular, has been provided by one of the leading currents of research in the sociology of education. Building on the work of Basil Bernstein, Leesa Wheelahan (2010:70) has noted that '[t]he purpose of education is to help equip students with the knowledge and capacities they need to make their way in the world.' Effective education requires that students be inducted into the ability to reason independently about critical issues on the basis of theoretical knowledge derived from intellectual disciplines. Devoting attention to abstract notions listed as generic employability skills misses the point. As Michael Young puts it: '... powerful knowledge is specialised knowledge' (Young, 2014: 3). Learning to learn, for example, is not just an abstract capacity that can be developed in isolation – it has to be anchored in knowledge. For him, education is about:

> access to a 'relation to knowledge' not [just] facts or scientific laws ... That is why the internet, although a fantastic resource of information can never replace the pedagogy of teachers if pupils are to acquire a relation to knowledge (Young, 2014: 6).

Young's argument builds on the 'Enlightenment idea that knowledge is the only real source of freedom – freedom from being trapped by one's own experience.' (Young, 2014: 7). Powerful knowledge derives its strength from origins and its organisation. First, it is validated knowledge: knowledge that has been tested and is open to further development. In the case of the academic disciplines, this occurs through a community of scholars. In the case of the professions, professional bodies of recognised experts perform the same function. Second, it is differentiated: it provides understandings for distinct domains relevant to particular objects of knowledge. Such knowledge is context free – it enables people to move beyond their own experience and see their experience in a different way (Young, 2014: 8). As he notes:

> Different subjects offer the student different kinds of power. For example, the sciences generate the power of abstraction and generalisation; the social sciences provide weaker sources of generalisation; [but they] also provide new ways of imagining how people and institutions behave. The humanities do not provide the bases for generalisation but they can show, in examples of great plays, films and books, how the particular, a character for example in a great play or story, can represent something about humanity in general (Young, 2014:9).

This approach is not against the acquisition of broad analytical capabilities – it just alerts us to the importance of maintaining coherence in the way they are acquired. Mastery of particular domains is vital for this – ad hoc appropriation of bits of understanding or insight will not achieve it.[10]

Incidental insights from the applied engineering, applied science and applied labour economics literatures

The cognitive psychology and education sociology literatures are well developed. There are two other literatures of relevance. While smaller in scale, they

[10] As Wheelahan puts it (in somewhat academic terms): the implications of this approach are we should be striving for effective 'methodological pluralism but not epistemological eclecticism or relativism' (Wheelahan, 2010: 82).

offer highly relevant insights as they concern the relationship between specific and more broadly applicable skills for success in the labour market.

The T shape – professional literature. This dates from the early 1990s. It refers to 'professionals [who] are deep problem solvers in their home discipline but also capable of interacting with and understanding specialists from a wide range of disciplines and functional areas' (University of Cambridge and IBM, 2008: 11). This literature uses the image of the 'T', with the stem comprising problem solving capability, and the broader set of associated or enabling capabilities referring to the horizontal top of the letter. Interest in developing more well-rounded engineers – especially those in computing – was the original preoccupation of writers in this literature. They were particularly keen to devise more effective teams in the world of computing software and hardware development. Interest in this way of thinking about developing professionals in other fields has steadily broadened over the years (e.g. Donofrio *et al*., 2010). The University of Michigan's Collegiate Employment Research Institute uses the concept as a key organising framework for analysing and tracking graduates from that University (CERTI, 2017). A particularly advanced development building on highly developed 'problem solving' capabilities supported by systematic development of associated business and organisational skills has been the emergence of the Professional Science Master's degree in a number of higher education institutions in the USA (Carpenter, 2012).

This literature does not assume 'problem solving' is a generic skill. On the contrary, it regards development of such a capability as requiring extensive formal education, especially in the scientific and engineering domains. It recognises the importance of other skills like communication and collaboration, but these other skills are connected to deep, specifically focused expertise.

Recent work on occupational mobility in job clusters. This research primarily comes from close analysis of jobs and flows of workers between different types of jobs, especially in Switzerland and Germany. These researchers are interested in a different issue to that of the 'T-professional' writers. They examined how workers with seemingly highly specialised, deep skills can in fact be quite mobile in the labour market. For authors such as Lerman (2017), and especially Geel and Backes-Gellner (2009, 2011), the key issue is not 'general education' versus 'specific vocational training'. Rather, Geel and Backes-Gellner argue there is a need to 'consider the specificity of the skill combination given the skill clusters in the overall economy... Skill combination – and not the occupation per se – crucially determines the mobility and wage consequences of an employee' (Geel and Backes-Gellner, 2011: 3).

For example, an adolescent who wants to become a clockmaker should not necessarily be considered poorly equipped for future labour market requirements, even though his industry is small and shrinking. Rather, he is well equipped because his skill combination is very similar to skill combinations of other occupations in a large and growing skill cluster, which includes, for example, medical technicians or toolmakers. Despite a seemingly very narrow and inflexible skill combination in his original occupation, he is nonetheless very flexible and well prepared for future labour market changes due to the sustainability of his acquired skills and his current skill cluster (Geel and Backes-Gellner, 2011:3).

Geel and Backes-Gellner's findings are clear: in apprenticeship systems like those of Germany and Switzerland highly specific training is not necessarily a barrier to occupational mobility. The more critical issue to consider was: in what skills cluster is the occupation located? Training in an occupation that may appear to be in decline (like clock making) could be better than one with more prima facie stability because the specific occupation was in a skills cluster for which there was an increase in labour demand (Geel and Backes-Gellner, 2011: 19 – 20). As such, the issue is not so much whether the education system should focus on 'general' or 'specific' education as such – but rather that greater attention needs to be paid to skill combinations (or clusters) as it is these that determine the adaptability of a person and a population.

Similar arguments about the importance of job clusters have been associated with the analysis of 'big data' on job vacancies undertaken for the Foundation for Young Australians (2016) by Alpha Beta. Proposals for devoting greater attention to what are described as vocational streams, derived from qualitative and institutional research have also been outlined by Wheelahan *et al*. (2015). Most recently the World Economic Forum has contributed to this literature in identifying and analysing what it calls 'job transition pathways'. Each of these literatures highlight, in their different ways, the centrality of education and workforce development calibrating a balance between supporting people to develop some specialised capability and using this as a basis for mastering more generally applicable skills. The employability skills approach of isolating and prioritising generic skills in the abstract misses this basic insight. We ignore the need to develop specialised skills and capability at our peril.

Issue 4: Are current approaches to gaining specialised knowledge working to provide students with more generally applicable capabilities?

One of the core rationales for making primary and secondary education compulsory and garnering government support was to ensure the population was equipped with the core abilities to function effectively in modern society. How these abilities are nurtured varies with age, reflecting changing levels of social, emotional and cognitive capabilities. One of the key questions we raised earlier in this section identified that, arguably, the key role of education is engaging with and ideally deepening individuals' learning dispositions. In primary school these are developed in the course of mastering the basics of English (especially reading and writing), maths, basic science, social studies and sport. In high school the traditional academic disciplines structure school organisation, architecture and the timetable. In recent decades secondary education has offered Vocational Education and Training (VET) in schools. The focus on specialised domains of knowledge provide, potentially, appropriate bases for developing more general capabilities like problem solving and collaboration skills. Questions exist as to whether this potential is currently being fully realised.

The mainstream secondary curriculum, defined as it is by final year 12 exams, is overwhelmingly organised around academically defined domains of knowledge – disciplines. There are longstanding concerns that much of the content of this curriculum is too abstract. It is this feature of much contemporary education that attracts some people to the generic employability skills narrative. As the analysis in the previous section revealed, however, this is not a serious alternative for anyone interested in quality education for productive, flourishing citizens. While it is clear the generic employability skills narrative has serious ethical, analytical and practical limitations, current school offerings are far from perfect. Over 30 years ago Connell and colleagues (1982) devoted special attention to understanding, inter alia, the dynamics of the mainstream curriculum in Australian schools. This was based on a close analysis of secondary students, their families and their teachers. They found that the roots of the problem lay in what they called the ascendancy of 'competitive academic curriculum'. Prior to the emergence of mass university education, upper secondary schooling was confined to a tiny minority of the population. The high schools involved were equivalent to today's academically selective or elite private establishments. The curriculum was pre-occupied with meeting the requirements for university entrance (Connell *et al*., 1982: 20, 171). With the emergence of comprehensive secondary schools, following reports like that of Wyndham in NSW in the 1950s, the objective was to give all students 'access to a general culture and to the most developed account of the wider world [possible]. Anything else [was regarded as] second best' (Connell *et al*., 1982:199). The end result has been a contradictory legacy. It has been very good for those interested in a university pathway, giving many who may not otherwise have had the opportunity access to this scholarly knowledge. A large proportion of students are not on this track.

A lack of academic ambition does not necessarily mean a lack of interest in the world of ideas or abstraction. Many of the best ideas and innovation come from beyond the academic realm, but rigor remains important in the development of these ideas and in successfully translating them into actuality (Toner, 2011). As Keynes once famously observed: there is nothing more practical than a good theory. In thinking about mainstream education we support priority being given to helping students master the basics of key disciplines, thereby empowering them to live richer, more informed lives that allow them to transcend their immediate experiences. But this requires more than mastering particular bodies of knowledge. It also requires knowing how to apply them across discipline boundaries: in essence how knowledge becomes connected – and most importantly of all – knowing their limitations and when not to apply them in life.

If a problem with the mainstream academically-derived curriculum is that it is too abstract, the problem with the major alternative – VET in schools – is that it is too specific. It limits students' capacity to extend insights gained to a broader range of settings and problems. Schools' vocational offerings deserve special attention because of changes in the levels and character of the student population. Since the early 1970s, the proportion of high school students staying on from the equivalent of year 7 until year 12 has increased from around one in four to around three in four. While many more now complete the Higher School Certificate (HSC) in New South Wales, a considerable number of young people nevertheless do not immediately go on to study at university. The destinations of those leaving in 2016 are summarised in Table 3.

The table shows that while a large proportion of students go on to study at university following year 12, many leaving school seek immediate entry into the workforce and vocational education and training pathways, with very few not undertaking either employment or further education or training (which could include, for example, those taking a gap year and young people with caring responsibilities).

Table 3: Destinations of Students leaving NSW Schools in 2016

	% of NSW Secondary School Students leaving in 2016	
Main Destination[1]	**Year 12 Completers**	**Early leavers**
University	51.2	1.3
Work	21.8	23.6
Apprenticeship / Traineeship	9.8	34.3
VET[2]	9.8	18.7
Looking for work	5.2	15.3
Not in education, employment or training (NEET)	2.8	6.9

Sources and notes:

The Social Research Centre, *NSW Secondary Students Post-School Destinations and Expectations 2016 Annual Report*, Melbourne, pp. 6, 13 - Tables 1 and 9 for columns 2 and 3. This refers to students in all schools – government and non-government. It is worth noting that the DoE Centre for Education Statistics and Evaluation *NSW School Retention Rates by Statistical Areas 2010 – 2016*, NSW Department of Education, Sydney, 2016 reports that year 10 -12 retention rate in public schools in 2016 was 72%.

1. These categories are arranged as a hierarchical classification of 'main destination' (e.g. some people at university may also be working). This is why the list is ordered in the way it is.
2. This includes people involved in Certificates I – IV, Diploma and Advanced Diplomas.

Given that the mainstream curriculum is dominated by academic disciplines, this begs a major question: How well does the current education system serve the needs of the many young people who do not go directly to university?[11]

At some of the workshops that were held for this project, people raised concerns about people who are in the workforce with low-quality or with industry-specific VET qualifications who may struggle to adapt in the workplace of the future. In the engineering

[11] Or to put the question more bluntly, as one teacher noted in field work undertaken in the early 1990s when university participation rates were much lower: 'what do we do with the bottom 80 percent of the student population?'

session, for example, it was pointed out that labourers usually cannot do physical labour forever and currently such workers tend to make lateral shifts (drive trucks, for example) rather than move to higher skilled positions in engineering or project management. Workers who do not take an academic pathway may be more vulnerable in terms of their capacity to continue to engage with education, reskill for non-routine jobs (and jobs with higher cognitive demands) in order to survive in a highly automated workplace.

In policy terms, Australia has sought (and achieved) increasing numbers of young people going on to university. But, in light of the concerns about the need to be highly adaptable in the future workplace, it makes sense for education policy to pay greater attention to the significant number of young people who do not take a university pathway immediately after school, including those progressing straight into employment as well as those who progress into VET.[12]

At one level various initiatives associated with VET in schools have emerged to meet this challenge. At their best, these work exceptionally well to provide a quality, alternative pathway. Most attention in school education, however, is devoted to those students pursuing academic pathways. Particularly significant in this context is the continuing power that the HSC (and equivalent year 12 certificates in other states and territories) provides as the focal point for much educational activity in schools today – especially at the upper secondary level. As Mike Rose (2015) observed, these highly traditional academic instruments are good at identifying students who do well at the abstract application of fundamental skills and excel in terms of the academic curriculum. They are not good diagnostic instruments, however, for identifying the other strengths or qualities less academically inclined students may have.[13]

Equally significant has been the development of a large number of vocationally based courses, many of which are offered by private providers. They have tended to focus learning on matters of immediate relevance to local employers or single organisations. They often neglect the development of systematic underpinning knowledge necessary to grow and innovate in a student's chosen vocational domain (Clarke, 2012, 2014a, 2014b, Clarke and Polesel, 2013)[14]. As large-scale challenges such as those associated with the greater diffusion of AI, labour market fragmentation and global warming intensify, broader, more transferable capabilities will be required of vocational as well as academically talented students. Developing a more appropriate vocationally based stream will require, however, serious rethinking of what vocational education entails.

Rose (2004, 2011, 2015) has spent decades working with, and understanding the nature of, the students and workers who do not go university. One of the many deep insights of his research is that such students (and people) often end up undertaking work that has high cognitive and non-cognitive skilled content – it is just not recognised as such. This is based on close analysis of those working in occupations like waiting staff in hospitality, front line supervision and electricians (Rose, 2004). As he puts it 'there is giftedness in every occupation' (Rose, 2015). He also notes that not everyone desires to obtain a high-status occupation – or even flourishes when they work in one.

Rose is not naive. He realises people in lower status occupations often suffer from living in constrained financial circumstances and he is not romanticising their situation. What he does, however, is take their engagement with education as something important and deserving of more careful attention. Most significantly, he sees that it can be as profoundly exciting and meaningful for them as individuals. As

[12] This and the previous paragraph have benefitted from observations provided by Bronwyn Ledgard of the NSW Department of Education.

[13] The only possible exception to this situation is the inclusion of subjects like drama, fine art and music – but even here these are often designed with academic pathways in mind.

[14] It is important to appreciate that this is not just a problem of VET in schools-it is a problem in Australia's system of vocational education more generally. See, for example, Wheelahan and Moodie, 2011, Wheelahan *et al.*, 2015, Wheelahan, 2018 (forthcoming), Buchanan *et al.*, 2018 (forthcoming).

he notes: '[t]he discovery of moments of possibility also comes for not so good students too. We need to recognise this and take second chance [and vocational] learning seriously' (Rose, 2015).

Writers such as Young and Rose have argued that initiatives directed at students who do not excel in mainstream academic education suffer from one of two problems. The first is a model of remedial education in which foundational skills like English and mathematics are taught in a context-free manner, with emphasis on breaking down the content into more accessible component parts. Rose studied this problem at length. Such an approach to reading, writing and mathematics 'become[s a] narrow, mechanical pursuit…, stripped of fuller meaning' (Rose, 2011: 6 para 232). He argues the challenge should be defined not in terms of how best to 'dumb' material down but rather how to find the right kind of intellectually engaging material and the resources to lift such students up (Rose, 2015). Many teachers endeavour to do just this, but they often do so on the margin of the school system and with very limited resources. The other major response to this problem is to 'teach core skills in context.' As Michael Young notes, this too has serious problems. In reflecting on the UK's Mathematics for the Majority Programme he reports:

> …the emphasis was on mathematics oriented to its use in everyday life. However, [as the evaluation research showed], Maths curricula oriented to everyday contexts made it extremely difficult for students to grasp and use mathematical concepts independently of [the immediate context in which they have been taught and were unable to apply the principles in a different context]. In other words the so-called Majority were excluded from the power of mathematics and the generalising capacities it offers… (Young, 2014: 4).

Things do not need to be this way. A growing group of researchers have suggested that the problems identified by Rose and Young are not the fault of uncreative teachers or the inevitable result of a segment of the population 'just not being up to it'. At its core is the way we think of the divide between 'academic education' and 'vocational training'. Within schools, vocational offerings are invariably defined relative to 'academic' courses – and almost always regarded as 'not as good'. Leesa Wheelahan makes the simple (but significant) point that it is just as appropriate to compare vocational education with professional education (Wheelahan, 2010:126, Wheelahan *et al*., 2015:759). She notes that professional education is different to academic education in how legitimate knowledge is defined. Academic disciplines have legitimacy because they face inwards within the education system toward communities of practice that maintain standards housed in universities. Professional knowledge faces two ways – outwards toward the field of practice and inwards toward underpinning knowledge also housed in universities. Following Bernstein, she notes that the space where the two types of knowledge meet can be defined as 'regions' – and the coherence of such 'regions' is maintained by professional communities of practice (Wheelahan, 2010:128).

In recent years, vocational offerings in countries like Australia and the UK have entrenched their secondary status by defining themselves as 'the other' relative to academic courses. Such an approach has meant that the richer side of vocational development in non-professional work has been neglected. As Rose has noted we need to pay greater attention to advancing 'the humanistic, aesthetic, and ethical dimensions of occupational education' (Rose, 2011: 13 para 533-34). When vocational knowledge is framed in this way it opens up very different possibilities for human development. Mathematics and English, for example, do not become something that has to be broken down into seemingly meaningless components or something that can be only understood in highly specific contexts. Rose gives a detailed case study of a 'second chance' welding class. He devotes particular attention to how the students learnt the underpinning knowledge necessary for effective development and deployment of their metal fabrication skills. None of the students

had previously excelled at maths – but all were highly engaged in grasping abstractions needed to support mastering their craft. He noted that the metal work teacher involved reported that he did not

> ...know maths very well. The ideal, he believes, would be to have a math teacher demonstrating the division of decimal fractions and the calculation of volume, and explaining the why of what the class was doing, the mathematical principles involved. But what the welding instructor does do in that dingy little room adjacent to the welding workshop is bridge the academic-vocational divide and thereby redefine for his students the meaning and function of mathematics (Rose, 2011: 11 para 462-67).

Practical suggestions, based on years of research, have identified how VET in schools in Australia can support the emergence of this kind of learning culture. Such programs should only be supported where they lead to students either going into an apprenticeship or into a higher-level VET qualification. Without this discipline, school-based vocational programs are vulnerable to only meeting short-term needs of employers and schooling systems (Clarke, 2014a; Wheelahan *et al.*, 2015).

* * * *

If we want to nurture productive, flourishing citizens, it is critical to focus on developing quality learning dispositions. Building on such dispositions to develop advanced capabilities in problem solving, collaboration and communication will require nurturing some specific disciplinary or vocational domain of expertise, and learning how to transfer these capabilities to a broader range of situations.

A particularly significant challenge is defining what the domains of specialist expertise are and how mastery of them is achieved. Within the academic realm more attention needs to be devoted to making Keynes's insight about the practical relevance of good theory a reality. This is probably best achieved by increasing levels of work-integrated learning to support more traditional classroom approaches (Boud, 2013). Concerning vocational education, instead of seeing this as 'the other' to the academic mainstream we should define it more on the model of knowledge associated with the professions. This will require defining what the domains of such practice are.

As noted earlier, there is a small but growing literature on job clusters and vocational streams. Such categories help us understand how a specific job can be a gateway into a more general suite of occupations. If vocational development for job clusters is to occur, significant work will need to be undertaken in identifying (a) how to most effectively define what the clusters are and (b) what the nature of the underpinning knowledge is that is needed to support them. This can be done by building on the emerging work associated with job clusters and vocational streams noted in the previous section (Geel and Backes-Gellner, 2009, 2011, Wheelahan *et al.*, 2015, Foundation for Young Australians, 2016, WEF, 2018). It will also require identifying what the underpinning knowledge for these domains is from the established disciplines. Achieving this will also require reform to current approaches to vocational education. Currently VET in schools (like the VET system more generally) is organised around highly specialised fragments of work. For example, in the social and community services sector, instead of focusing on separate specialisms like aged care, disability support, youth work etc. vocational education should be devoted to understanding the underpinning domain common to them all – care work (ACARA, 2013: 7-18). There are encouraging signs that this is already happening in community services with work associated with the emerging job category 'individual support worker'.

Who will facilitate the formation of communities of practice around vocational streams or job clusters? It could well be that part of the school education sector needs take on a new role. At the extreme, schools may have to play a leading role as custodians of underpinning knowledge supporting emerging vocational streams or job clusters. These and broader issues associated with what is taught and by who are taken up in the next chapter.

4. Implications for School Education

While the emergence of AI (and other trends like fragmenting labour markets and climate change) means that major social and economic change is inevitable, it is vital to remember that the precise form it takes is not. Societies have choices. The previous chapter identified how the current narrative about 21st century skills is informed by a tacit objective of nurturing highly flexible labour. Unsurprisingly the achievement of this is held to be in reach if only governments and educators would embrace the current and emerging AI technologies geared to imparting 'generic skills' (WEF/BCG, 2015: 5-21). Our analysis revealed that other objectives – especially ones concerned with nurturing flourishing, productive citizens – are possible. Education in an AI age requires more than increasing levels of coding competence and the acquisition of problem solving, communication and collaborative skills in the abstract. Giving young people the capacity to understand and respond to the covert challenges of AI needs special attention. We call this developing 'digital fluency'. Adaptive capacity more generally will require enriching current models of both academic and vocational education. The former needs closer engagement with the world of practice, the latter needs to broaden its relevance by moving beyond training for specific jobs and instead preparing people for job clusters or more broadly defined vocational streams. It will be hard to achieve these changes in the current education settlement.

Education in an age of artificial intelligence

Preparing students for the overt impact of AI: while analyses differ as to the precise scale of change, it is widely agreed that AI will disrupt established industries and occupations. There is more agreement that there will also be significant changes to the content of jobs throughout the labour market. This is behind the almost universal call to increase levels of 'ICT literacy'. At its most basic this concerns the capacity to touch type and be conversant with the basics of using computers and commonly used software. An appreciation of the basics of coding is also important – but a sense of perspective is needed on this matter. In earlier eras of significant technical change many users and beneficiaries of technology did not need an advanced technical understanding of it in order to flourish. For example, most people benefiting from the emergence of the motor car did not need advanced car maintenance, let alone automotive engineering skills to use the technology. All, however, needed to know how to use a car safely. The challenges of AI do not so much concern the equivalent of having basic car maintenance skills. Important as basic ICT and coding skills are, they are not the prime matter requiring sustained attention at school. A more advanced version of the equivalent to driving skills is what is required.

Preparing students for the covert impact of artificial intelligence: of more importance are areas of personal capability development concerning AI's impact on decision making processes and forms of connectivity. In Section 2 we referred to this as re-conceptualising the challenge of technology. We noted that the current and future need is to ensure that people (and, at a higher level, organisations and governments) understand digital technologies as being something over which they have agency. The pervasive use of technology will require that education and learning in the use of technology supports social goals and digital citizenship. This will require students to attain a degree of digital fluency beyond coding capability so that individuals and the community more broadly understand the values that are incorporated into the use of technology, and are able to respond appropriately. Five challenges arising from the covert impact of AI in particular will need to be addressed:

- *New forms of interaction:* Algorithms that personalise information based on opaque business drivers can influence the way we interpret the world we see. Students will need to be able to understand this, allowing them to make independent and autonomous choices.
- *New power relations between products and consumers:* The business driver for automation is ultimately about maximising the profits of the company that owns the algorithms. This is not always obvious to consumers, who may not even be aware that they are consuming a product (e.g. Gmail) or the way they pay for it (e.g. by sharing their data or by paying attention to products).
- *Provenance:* It is not always obvious who owns an algorithm or who is providing the products consumed. This applies to anything from internet content to shopping. The internet also has the potential to increase the transparency of the provenance of products, as it happens with the tracking of individual objects from factory to consumer, so the consumer can 'connect' to the original producer. This is the case with etsy.com that sells handmade products.
- *Transparency:* Algorithms are increasingly hard to interpret and understand. The inner working of algorithms that rely on deep learning adds an additional layer of complexity and opaqueness concerning machine behaviour. Deep learning trains itself by recognising patterns in data. The resulting 'black box' is thus much more difficult to interrogate, making it hard to monitor and detect undesirable behaviours.
- *Automation of tasks:* Tasks such as monitoring work performance or selecting a person for a job are being increasingly automated. As noted earlier this can often be based on data sets that have themselves been generated over years of implicitly biased decision making processes. Automating processes on such data sets merely entrenches such biases or imperfections. Similarly, automation of processes based on a small number of data points increases the possibility of faulty automated decision making.

Meeting challenges such as these will require education that builds on long standing practices such as the development of critical thinking. Qualities such as those listed below will enable students to understand the changing world around them and how to respond effectively. Four skills in particular deserve attention.

- *Critical thinking around AI-produced content and processes:* this includes understanding that the media we consume has owners, and all technology reflects the values of those who make it.
- *Emotional intelligence in the era of AI:* the need to understand our emotions and how technologies may try to manipulate them. Sometimes this will be for the right reasons and consumers may agree to their use, for example, in systems that detect possible mental or physical health risks using AI (Calvo *et al.*, 2017). Alternatively, individuals may decide not to use a technology in particular circumstances, for example, a smart TV that uses its camera to automatically recognise facial expressions and adapt the advertising material to the mood of the viewers.
- *Meaning:* as noted in Section 2, a key vector shaping economic development that may worsen from the spread of technology is the possibility that meaningful jobs become harder to come by. If this trend continues, it will be more important to help individuals identify the drivers of intrinsic motivation as a means of developing resilience to insecure employment.
- *Healthy technology use:* in the same way that schools promote healthy eating habits through

programs about food and nutrition, healthy technology habits – those that feed the mind – are important. This goes beyond cyber safety. The impact of multitasking on cognitive abilities is well documented (Ophir *et al.*, 2009). This research shows that multi-taskers are more susceptible to distractions and perform worse on many tasks. There is no such thing as a digital native who is able to deploy ICT skills 'naturally' (Kirschner and De Bruyckere, 2017), hence students need to develop technical, critical and cultural literacies with technology. Learning the value of, and ability to, focus on one thing for a sustained period of time, for example, is something that needs to be cultivated.

Other emerging trends, such as rise of the gig economy and decreasing opportunities for permanent employment, may mean that young people will need to be more self-reliant in managing their work and income, as well as having these more broadly defined skills in and understanding of ICT. In addition to an increased need for psychological resilience, this may also include the need for more young people to acquire business and entrepreneurial skills, financial literacy and management skills and skills in collective organisation and collaboration to help define and deliver alternative ways of shaping social and economic development. Social media is potentially a key resource here – but again perspective is needed. As the Arab Spring showed, social media may be able to help mobilise popular concerns; however it is another thing entirely to devise effective modes of collective, open and stable national self-determination. The limits – as well as the strengths – of the new means of communication will need to be understood by young Australians.

Beyond a focus on generic employability skills: reconfiguring 'the academic' and 'the vocational' in schools and the labour market

The core argument in Section 2 was that people need the capacity to adapt to rapidly changing circumstances. Section 3 established that the skills needed for things like problem solving, collaboration and communication are best acquired in the context of mastering specific domains of expertise – academic and/or vocational. That section also highlighted, however, the limits of current approaches to these matters at a school level. This raises the obvious question of how can this situation be improved?

The problems with both the mainstream academic based curriculum and the VET in schools alternatives are not universal. Throughout the system there is much variation in how teachers and their schools manage the challenges of nurturing generally applicable capabilities through the acquisition of specific domains of expertise. There would be considerable value in wider use being made of the experience schools have had in simultaneously deepening disciplinary or vocational domain expertise and using this as the basis for developing more broadly applicable problem solving, collaborative and creativity capabilities. A question of particular interest is: how do we avoid the limitations of narrowly defined 'VET in schools', the vacuousness of a focus on 'generic employability skills', and the perceived excessive academic preoccupation of the mainstream curriculum? And how can this be achieved while maintaining a concern with quality, coherent content knowledge – either disciplinary or vocationally based? Clearly, the quality of the teaching workforce is critical. The mature literatures on curriculum development and especially pedagogy also are powerful assets here. The work in recent decades on 'pedagogical content knowledge' appears to be especially rich (e.g. Shulman, 1986, Harris *et al.*, 2009). We suspect, however, that the

challenges are such that teachers alone cannot solve the problem. While excellent teachers are necessary, they are not sufficient. Given unfolding changes such as AI, labour market fragmentation and global warming, we suspect greater effort will be required to build partnerships with employers and community organisations, with teachers playing the vital role as custodians of educational quality. Box 7 gives some examples of what this might mean in practice. Bergen Academy in New Jersey highlights that the highest standards of academic excellence can be attained in a school that is deeply embedded in its local economy. The example of a college in north-eastern Adelaide reveals vocational education can be expansive and not necessarily confined to a narrow range of limited, low skill jobs.

These experiences highlight the need to broaden the debate about the future of schooling around two key issues. First, is it possible to move beyond the current stark divide between 'the academic' and 'the vocational' in Australian schools by having a commitment to giving all students access to underpinning knowledge as well as opportunities to engage with the world of practice as integral parts of their education? Second, if this is possible, how are the domains or fields of specialised knowledge and domains of practice to be defined?

Underpinning knowledge and practical engagement for academic and vocational excellence. Leesa Wheelahan has noted that 'the purpose of education is to help equip students with the knowledge and capacities they need to make their way in the world.' (Wheelahan, 2010: 70). The nature of that knowledge does not have to be 'dumbed down' for less academically inclined students. In a democracy, everyone should be given the ability to reason independently and act effectively in the world. As we showed in Section 3, this is not some kind of 'generic skill' that can be taught in isolation. Rather, skills like 'problem solving' and 'capacity to collaborate' are only meaningful if an individual has something distinctive to contribute and distinct capabilities to draw on. As Mike Rose (2004) has shown so persuasively, these skills are needed to solve quite challenging situations amongst people working as waitresses, hairdressers, truck drivers and welders – as much as they are amongst stockbrokers, doctors, software engineers and data scientists. A focus on the underpinning knowledge associated with customer service, logistics and materials processing can enrich the lives of people performing the former set of tasks just as business finance, medicine, computer science and statistics are important for the latter cluster of occupations. This could include moving beyond the traditional classroom model of academic schooling.

Underpinning knowledge can be mastered in a host of ways. And attention to it should not be neglected because some students are not academically gifted. Some of Australia's best trades people were not great 'students' but in their working lives often develop deep analytical capabilities. Common examples are often cited from the construction industry for example. So-called 'hopeless students' often become highly respected carpenters – and carpentry today is not just about power tools and wood work. Many carpenters go on to be highly valued project managers (Buchanan *et al*., 2016a and b). As Rose (2011) argues, the challenge when dealing with students who do not thrive on the academic curriculum is not to 'dumb down' knowledge, but rather, education needs to find ways to engage students and support them – that is, to help them rise to obtaining underpinning knowledge that will help them develop the deeper capabilities needed to flourish in life more generally. Examples such as the Bergen County Academies and the north-eastern Adelaide college show that it is possible to do this. We need to make this a systemic concern – not just something that sits on the margins of our schooling network.

Disciplines, vocations and communities of trust. If coherent underpinning knowledge is so important in vocational education, and engagement with the practical world is potentially beneficial for academic stream students, how are the domains of such knowledge and practice to be defined? Traditionally the core of school knowledge, especially in secondary school, has been around the academic disciplines. These domains have their roots in scholarly life – covering realms of knowledge associated with 'mathematics', 'English', 'science', 'history' and 'art'.

Mastery of basic elements in disciplines like Maths and English are and will continue to be absolutely essential for all aspects of human functioning for young Australians (Murphy, 2006). And mastery of other disciplines provides important underpinning knowledge for particular parts of working life. For people working in health and social services, knowledge in particular types of science, such as biology and psychology of human development, is useful. For those working in agriculture other forms of science (especially soil and animal science) are helpful.

The traditional academic disciplines do not, however, have a monopoly on underpinning knowledge. Take the examples just cited. Anyone working in health and social services could benefit from

Box 7: Engaged academic schooling and quality school-based vocational education

The school on the site that is known today as the Bergen County Academies (Hackensack), New Jersey, provides an outstanding example of how excellence in academic and vocational education can be achieved simultaneously. By the late 1980s the technical high school that operated at the site had only 400 students, down from a peak of 1,000 in earlier years. One of the teachers involved in the transformation of education at this site was Richard Panicucci. He notes 'while it did an effective job in providing students with traditional vocational training in areas such as the building trades, interest amongst middle school applicants in these areas was in decline' (Panicucci, 2017). Today it is one of the most prestigious secondary schools in New Jersey. It enjoys a reputation similar to schools like James Ruse High, Sydney Boys and Sydney Girls High. There is high competition for entry. The school only takes about one in ten applicants annually (Finn and Hackett, 2012: 140-144).

What is striking about this success story is that it has achieved this status by staying close to the world of practice. In doing so it has not compromised a commitment to academic standards. The teachers who embarked on transforming the school did so through a renewed focus on engagement with local employers and the community. Initially, change predominantly involved before and after school extension classes for local students interested in more advanced electronics and computing. These courses involved active links with local engineering and ICT firms. This initiative eventually evolved into a standalone Academy for the Advancement of Science and Technology in 1992 (Finn and Hackett, 2012: 141). The Economics Department, as another example, now coordinates curriculum development and work placements with a wide range of local financial services firms, including many on Wall Street. Students are not just enrolled in 'Economics' – they are part of the Academy for Business and Finance. The Science Department has close links with research labs in local teaching hospitals – and these students are part of the Academy for Medical Science Technology. What this case illustrates is that a deep commitment to vocational development does not have to come at the expense of compromising academic standards. Excellence in academic and vocational development can occur simultaneously.

Such an approach is not just something only attainable by top students in the USA. In the early 2000s Norway introduced reforms obliging all students in their final two years of high school to undertake a stream of vocational studies. Cases can also be found in the Australian public school system. Clarke (2012) notes one case involving a government vocational college offering Years 8-12 in north-eastern Adelaide. At this college all Year 11 students – those destined for university as well as those taking other pathways in life – engage in vocational studies. This has been programmed into the timetable where each Thursday all students undertake a vocational stream of some kind. The choices include: Doorways to construction, Skilled metals (engineering), Hospitality kitchen operations and restaurant operations, Community services, Virtual enterprise (business), Multimedia pathway and University pathway (Certificate III in Laboratory Skills) (Clarke, 2012). Researchers have found that this arrangement is valued by a wide range of highly engaged local employers and community members, as well as being appreciated by teachers and students.

having good customer service and basic business skills (e.g. things like emotional intelligence for handling difficult people, including superiors). For those working in agriculture, while basic science is helpful, so too is basic wood work, metal work and equipment maintenance. In these latter domains the underpinning knowledge concerns things like 'customer service' and 'rural operations'.

There is a small but growing literature on how such 'vocational streams' (Wheelahan *et al*., 2015) or 'job clusters' (Foundation for Young Australians, 2016) are defined. The work of Wheelahan and her team has also made the critical observation that defining such domains is not just an abstract, analytical exercise. Researchers can (and in some cases have) identified what they regard as relevant vocational streams or job clusters with common underpinning knowledge. Skills, however, have a social as well as an intellectual dimension. The credibility of academic underpinning knowledge is maintained by global communities of scholars (Murphy, 2006, Wheelahan, 2010: 154 - 156). Vocational underpinning knowledge requires communities of trust, involving users of such knowledge (i.e. employers and workers) as well as those involved in codifying and transmitting it (i.e. educational authorities and educators – both on and off the job).

As we move into the future we need to open up debate about the potential value of greater vocational engagement amongst those mastering traditional academic pursuits (Boud, 2013). Equally, we need to think about raising the quality of underpinning knowledge involved amongst those pursuing less academic – but often cognitively demanding – routes into the labour market. This is not an argument for 'dumbing down' those following academic pursuits to make their knowledge 'industry relevant'. And equally it is not an argument for turning every student more interested in vocational pursuits into a 'down market academic student'. Our point is more significant and draws on Aristotle's distinction between three realms of knowledge: *episteme*, *techne* and *phronesis* (Flyvbjerg, 2001:55-60). Whereas *episteme* concerns abstract reasoning and *techne* relates to the vital knowledge necessary to be competent at every day practice, *phronesis* involves the application of the world of reason to the domain of practice to enrich both. As we move into the future we need to provide ways for all students to find their own balance in how they connect reason with practice. And that will be best achieved if we move beyond the rather confined and confining ways we define the 'academic' and the 'vocational' in schools today.

Time for a new educational settlement?

Schools do not exist in a vacuum. They are part of a wider constellation of social forces that shape the development of a nation's citizens. The key forces cohere into what can be called an 'education settlement'. Such 'settlements' evolve with changing circumstances. AI and associated changes are disruptive and create the potential for a realignment of the key elements of our education system. Any serious change in the way that schools prepare people for the best as well as the worst of times will require engaging with these realities. The broader educational settlement of which they are part will also need to be reconfigured. Two stakeholders in particular need attention – employers and teachers.

The problem of engagement – employers' limited involvement in quality education. Section 3 highlighted that work organisations, including private sector businesses, government agencies and not-for-profits, have a critical role to play in improving individuals' employability – indeed some good ones already do so by actively working with local schools to provide high quality learning experiences. Employer engagement extends well beyond providing work experience. If engagement is to be successful, it needs to be planned around providing quality learning experiences for students. This might, for example, expose students to the application of new technology in selected industries (such as manufacturing or health care) for product design and production, how it is influencing service

delivery models (for example, in tourism and creative industries) and understanding business processes and innovation processes. Greater employer engagement with schools will provide students with a better understanding of how their knowledge can be applied to solving practical real-world problems, expand their understanding of the career options open to them, and generally facilitate the school to work transition. Quality employers also have a vital role to play in helping revitalise the nature of and connections between the academic and vocational streams of education.

Drawing more employers into school education has, however, one major problem: quality control. This would be best managed by limiting the number of employers and organisations involved to only those capable of delivering high-quality learning experiences. Just as every hospital is not a teaching hospital, neither should every workplace be regarded as a teaching workplace. The key challenge here is employer initiative. While schools are keen to engage with the outside world, many employers – especially quality ones – have limited capacity to so engage. There is, potentially, a role for government to identify, engage and support quality employers in education. Just how this is done and what level of public funds is provided to help make it happen requires extensive and careful reflection and debate.

Trusting and valuing teaching as a profession. Suggesting that a broader range of players, such as employers, should be involved in education could be taken to imply we think that anyone can teach. Nothing could be further from the truth. Teaching is a highly skilled profession, and one which will continue to require teachers to demonstrate mastery in sharing understanding in specific subject domains and their associated pedagogies. As a country, we need to give teaching as a profession more status and respect; and our education systems need to ensure that teachers have the skills, development opportunities and ongoing support to take up the issues we have raised in this report. Particular support should be provided for AI related activities, reworking the academic-vocational knowledge divide (e.g. industry placement programs for teaching and practitioner placement programs in schools) and helping them ensure that education in specialised domains provides a solid foundation for developing more generally applicable skills - especially problem solving, communication and collaboration.

Conclusion

Australian education is very good. The weaknesses are often highlighted, but we have good bones to work with. Equally, a good legacy is not enough – it needs to be constantly evaluated and debated. AI may be a challenge, but there is no need to approach it with trepidation. We have solid foundations to build on, but we must seriously upgrade them. This paper has identified priority questions to consider, especially concerning the objectives, the role of specialised expertise and rethinking the nature of both academic and vocational streams within education. Involving the best employers and other vocational and community players more actively in school education will be vital. And valuing teaching as a profession will be critical. Teachers are – and will remain – the anchor of coherence in the system. But we cannot continue with business as usual. We owe the five year olds entering school this year a better deal. This paper has identified what some of the key features of that deal should be.

Appendix 1 : The research process - scenario for the future of work

The nature of the future of work cannot be specified with any degree of precision. As part of the background work undertaken for this report, a wide range of literature across a number of disciplines was scanned to identify key areas of agreement and disagreement on predictions for the future, and key debates are summarised in the body of this report. As a generalisation, however, across the body of research that we scanned, it is clear that while there is broad agreement on key trends, there is little agreement about how specifically they may play out. On the one hand, it is clear that developments in AI are occurring at an exponential rate, and the scale, scope and complexity of developments have been argued to constitute the 'fourth industrial revolution'. There are other large-scale trends facing the world on a global scale, including demographic changes, shortages in critical resources, climate change and globalisation. The combined potential effect of some of these changes leads to some alarming predictions about the future of work and jobs.

Other theorists have suggested that the pace of change has been exaggerated, that automated machines and robots will need human augmentation and intervention for some time to come, and that automation (along with the amplifying effect of other mega-trends) is as likely to create new jobs as it is to replace them. What became clear through the course of examining the literature, is that while it is certain that the future will be very different, a range of scenarios are possible for the trajectory of change. The exact nature of the future will be dependent on choices that are made now, by individuals, communities and policy makers at local, national and international levels.

Understanding uncertainty about the future led the project team to examine existing publications that set out possible futures based on scenario planning methodologies. In particular, we looked for common features across a range of different scenario planning processes to establish what skills and capabilities might be required by workers of the future, irrespective of what that future might be.

Consideration of scenarios

The value of scenario planning for the current project was founded in the fact that while we cannot predict with any certainty what skills and capabilities may need to be developed amongst students of today for the workforce of the future, it does provide us with a sense of the range of plausible futures that we need to prepare them for. The smaller the range of possible futures, the more specific we can be about the skills and capabilities that they may need. Conversely, if the range of possible futures is wide and uncertain, then the stronger the argument for them learning skills and developing capabilities that will facilitate their successful adaptation to this.

Futures scenarios can focus on different topics of interest, and have been employed by governments, private companies and business consultancies. For the purposes of this project, we considered several scenario planning exercises undertaken over the last decade that were focussed on general economic trends, particularly with respect to business, labour market and skills issues. Eight of these exercises were considered in total[15], with five used for the purposes of this report. Two of these are global in nature (Shell Global scenarios (2005), The Millennium Project (2016a)), and two are focussed specifically on Australia (CSIRO, 2016, AWPA, 2012). One, from the UK Commission for Employment and Skills (2014) was included for its very specific focus on the future of work in 2030, and assessment of the skills that will be required irrespective of the scenarios that were developed.

[15] AWPA (2012), CSIRO (2016), Hajkowicz *et al.* (2016), OECD (2001b), PWC (2015), Shell (2005), UKCES (2014), Millennium Project (2016a).

The five scenario exercises were summarised for University of Sydney academics as the basis for workshops that asked them to respond to questions about what those plausible futures might mean for the skills and capabilities needed for the 5-6 year olds of today to thrive and not just survive after finishing school in 2030.

Despite having slightly different foci, across the scenarios that were considered there is a substantial degree of convergence in key economic, social and technological trends. Some of the most significant trends (although by no means the only ones) include:

- *The rate of technological development*: This is increasing exponentially, and includes automation and machine learning, 3D/4D printing, use of big data, biometrics, nanotechnology and many others. Pervasiveness is facilitated by faster mobile internet access and larger storage space.
- *Issues related to natural resources and their use:* Global economic growth has in large part occurred through exploiting the earth's natural resources. While climate change is the best known of these effects, there are others. They include an increase in the extraction of natural resources, including a serious risk of water and food shortages in some areas and for some populations.
- *Globalisation:* Increased globalisation has made a major contribution to the growth of the world economy, including the creation of new markets and the opening up of new opportunities in developing economies. It has also contributed in significant ways to the freer movement of people and skills across national boundaries. There is a paradox, however, in that while global inequality has declined, within countries it has increased (and in some nations, significantly). The future of globalisation, especially in its current neoliberal form, is now under question in light of a rise in nationalism in a number of developed countries.
- *Demography:* The variety of changes occurring in this area include population ageing (in part a result of improved health of older people and in part a feature of declining birth rates in younger cohorts); changing family structures; the suggestion that generational cohorts have different values and attitudes (e.g. baby-boomers versus Gen X and Gen Y); and changing patterns of migration (with many developed countries dependent on migration to remedy skill shortages).
- *Changes in the nature of organisations:* Business structures are changing in response to technological developments, in the quest for innovation, and the power balance in the employment relationship has shifted in favour of business, especially big business. This has resulted in a reduction in secure and continuing employment, the development of the 'gig' economy, an increase in government and big business initiatives in favour of self-employment and business start-ups; and a fundamental change from work as being location-based to mobile forms of working.
- *Structural changes in employment and income shares:* Over the past few decades in Australia and many other countries, employment has shifted away from the manufacturing sector to the service sector. These changes are forecast to continue, although with a difference. While technology and automation have until now mostly affected low skilled work, it is likely that in the future it will have an impact on higher level skills, leading to a 'hollowing out' of the labour market. This will exacerbate inequality and the increasing gap in income shares between the

rich and the poor; and has the potential to lead to major social unrest. The work of Piketty (2014) has highlighted the inherent tendency of the market economy to deepen inequality unless strong countervailing measures are adopted.

- *The nature of innovation*: Converging technologies mean that the traditional boundaries between disciplines, geographic boundaries and sectors are becoming blurred. In the 21st century, innovation is characterised by multi-disciplinarity, collaborations across national borders and partnerships between business, governments, not-for-profits and consumers.

Of particular significance to the trends that are occurring is that they are happening on a global scale, making it extremely difficult for any single country to take action to mitigate their worst effects. In addition, changes in some of these specific areas are inter-dependent, thus compounding their effects.

Workshops and interviews

A summary of the findings from examination of the variety of scenario planning processes was provided to academics from the University of Sydney in workshops and one-to-one interviews. Workshops were also attended by representatives of the NSW Department of Education. In addition to seeking their views on the credibility and relevance of scenarios for Australia, workshop participants were asked about how they saw the future in relation to:

- The potential implications for work and the labour market in NSW
- The capabilities (cognitive and affective) that people would need in the future to thrive in a changing labour market, and how those capabilities could be developed
- The implications for schools and education in NSW.

Altogether, 17 academics and 4 professional staff members from the University of Sydney participated in workshops or interviews. Views were also sought from international colleagues in areas of their expertise.

The findings of the University of Sydney academic research team are incorporated in the body of this report.

Appendix 2: How the 21st century skills framework compares with other human development frameworks

Table 2 in Section 3 provides a very concise account of how most frameworks for generic employability skills, including the latest variant of 21st century skills, take a relatively narrow view of the key matters concerning human development. The table below and accompanying notes provide a little more detail on how Table 2 was derived.

Appendix 2 Table 1 – Characteristics of human development – key elements and how they are neglected or narrowed down in the 21st Century Skills Framework of the World Economic Forum / Boston Consulting Group[1]

Characteristic of human development		Comment of how these matters are handled in most generic employability skills frameworks (e.g. WEF, 21st Century Skills)	Relevant authorities and examples of alternative/ additional framing[5]
Categories of functioning[2]/ Flourishing[3].	Physical -Body structure/ function	Overlooked completely	These matters are fundamental to Health + Medical Science (see International Classification of Functioning)
	Psycho-social : Mental - cognitive	Half of the 16 21st century skills fall in this category (i.e. 1 – 8). Often very narrow definition provided (e.g. 'critical thinking')	Compare with Nussbaum on critical thinking for capabilities approach – a far more expansive notion.
	- affect	Overlooked completely	
	: Social	Skill 9, 10, 13 + 15 cover engagement/ flow/activity, communication, interpersonal relations social functioning and positive relationships. Overlooks Learning + applying knowledge and self-care in ICF	Compare this with positive psychology notion of 'positive emotion' and capabilities notions of 'world citizenship' and 'imaginative understanding' - i.e. the latter are far more expansive.
	: Meaning	Overlooked completely	This is a key part of PERMA, along with Accomplishment/ Achievement.
Categories of character/ Personality[4].	**O**penness **C**onscientious-ness **E**xtraversion **A**greeableness **N**euroticism/ mental stability	Strong on openness to experiences and conscientiousness Neglects extraversion, agreeableness and mental stability	All five identified by Heckman *et al.* as critical to future labour market success.

Notes:

1. The categorical system used for comparison here is the account of 21st century skills provided by the WEF/BCG (2015)
2. The key categories here are the defining elements of the International Classification of Human Functioning (ICF). See WHO (2001) for more details.
3. Flourishing is really high order functioning. The ICF categories have been combined with PERMA framework from the positive psychology movement: Positive emotions, Engagement, Relationships, Meaning and Accomplishments. See Seligman (2011) for more details.
4. The categories here come from the OCEAN framework: Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism (or mental stability). See Kautz *et al.* (2015) for a good summary.
5. Note some 21st century skills are not easily mapped to these frameworks. These include skills 11 and 12 (i.e. curiosity and initiative). Skill 14 'Adaptability' is really an end result of the above.

Abbreviations and glossary

Academic curriculum/Competitive academic curriculum – Mass, comprehensive secondary schooling has only emerged in the last half century or so. The curriculum for this system has primarily been built upon one that was previously designed for specialised schools that focused on University entrance. (See Connell *et al*., 1982: 20, 171)

ACARA – Australian Curriculum, Assessment and Reporting Authority

ACT21S – Assessment and Teaching of 21st Century Skills

AI – Artificial Intelligence

ASD – Autism Spectrum Disorder

BCG – Boston Consulting Group

Capabilities approach/Human capabilities approach – 'In recent decades there has been increasing questioning of the core assumptions underpinning mainstream economic reasoning and policy objectives. … Researchers working in the 'capabilities approach' tradition have cogently identified the problem of assuming economic growth is the self-evident paramount goal of economic and social life. As they put it: what is the utility of growth if large segments of the population do not flourish? Bryson notes the capabilities approach "puts people at the centre of analysis" (Bryson, 2015, 556). In particular it is about people's 'ability to lead lives [they] value and have reason to value'. (Bryson, 2015, 556)[16]

CERTI – Collegiate Employment Research Institute, Michigan State University

Domain expertise – This refers to a situation where a person is highly competent in an area of work. Theories differ as to whether this is determined by what a person does or what they know. This paper is informed by the tradition that defines expertise as involving a complex relationship between doing and knowing as developed in the work of Winch (2010) and Kotzee (2012). A useful summary is provided in Leah (2017).

ELLI – Effective Lifelong Learning Inventory

EY – Ernst and Young

FYA – Foundation for Young Australians

Generic Employability Skills – Interest in this way of approaching skills builds on longstanding concerns of educators. The current formulation dates from the 1980s. Curtis and McKenzie (2001: vii) define it as follows '*Generic* implies that what is learned in one context can be applied in others. *Employability* signals a connection to the world of work that is dynamic and long-term in nature. Employability implies qualities of resourcefulness, adaptability and flexibility, and therefore also signals some of the qualities needed for success in work and life as a whole. *Skills* can be taken to subsume the other potential nouns….' Other terms covering this concept include 'soft', 'enterprise' or '21st century skills'. See also entry on 21st century skills below.

HCT – Human Capital Theory

HSC – Higher School Certificate (Certificate awarded to students who complete six years of secondary schooling in NSW)

ICF – International Classification of Human Functioning (See WHO, 2001)

ICT – Information and Communication Technologies

IEEE – Institute of Electrical and Electronic Engineers

ILO – International Labour Organisation

IMF – International Monetary Fund

ML - Machine learning

NAPLAN – National Assessment Program – Literacy and Numeracy (Basic skills test undertaken by most year 3, 5, 7 and 9 students in Australia)

[16] This definition is taken from Oliver *et al*., forthcoming 2018.

NEET – Not in Employment, Education or Training

NSW – New South Wales

OCEAN – Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism (or mental stability). See Kautz *et al*. (2015) for a good summary.

OECD – Organisation for Economic Cooperation and Development

PERMA – Positive emotions, Engagement, Relationships, Meaning and Accomplishments. See Seligman (2011) for more details.

PWC – Price Waterhouse Coopers

SDT – Social Determination Theory

21st century skills – is the latest manifestation of the recent narrative about the importance of generic employability skills commonly advocated by many policy agencies and peak employer bodies since the mid-1980s. Suto (2013) notes the work of an international collaboration involving governments, academic researchers and three major tech companies has been particularly important in developing this most recent framing of the idea. This is the so-called Assessment and Teaching of 21st Century Skills venture (ATC21S). According to Binkley *et al*. (2012) 21st century skills can be grouped into four categories: '(i) ways of thinking; (ii) ways of working; (iii) tools for working; and (iv) skills for living in the world' (Suto 2013: 5 provides a good summary of recent developments).

VET – Vocational Education and Training. In Australia this term emerged in the mid 1980's to describe the realm of skill development that sits (a) in the education system between schools and universities and (b) in the labour market between low skill entry level jobs and higher skills professional and managerial work. In Australia this domain used to be called technical and further education and was guided by a commitment to quality education. Since the 1980s the primary units of organisation have been highly disaggregated units of competence derived from close analysis of the tasks it takes to undertake current jobs.

Vocations/Vocational Streams – Historically the notion of vocation referred to the Christian notion of 'God's call to men and women to serve him.' Since the reformation theologians have reflected on how a 'person might have several "callings" in [their] work, at home, in the church, and so on' (Moynagh, 1995: 882). In the realm of mass education it has referred to education concerned with work and usually been defined as a more practically relevant curriculum that provides an alternative to 'academic' education. In recent Australian research on the link between qualifications and work the notion of 'vocations' has been used as a term 'to refer to the nature of practice, that is, what people do in occupations and the knowledge, skills and attributes they need to work in those fields. Vocational streams refer to the structure of occupations and the way they are linked horizontally and vertically in related occupations in which common practices and with similar requirements for knowledge, skills and attributes are shared.' (Wheelahan *et al*., 2015: 19-20). For example, the notion of 'care work' is proposed as a vocational stream that encompassed related occupations such as personal care attendant, assistant in nursing, aged care work, drugs and alcohol support work, youth work etc. Vocational streams are similar in nature to the notions of 'skill clusters' as used by Geel *et al*. (2009, 2011) and 'job clusters' as used by AFY (2016) and 'job transition pathways' (WEF, 2018).

WEF – World Economic Forum

WHO – World Health Organisation.

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