



FUTURE SKILLS

To adapt to the future of work, Australians will undertake a third more education and training and change what, when and how we learn.

Prepared by AlphaBeta
for Google Australia

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strategy x economics

Important Notice on Contents – Estimations and Reporting

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The future of work in Australia...



Australians will need **new skills** to adjust to the future of work. **By 2040** the average Australian will spend an additional

 **3 hours** per week on education and training –

a **33%** increase

across their lifetime.



The most valuable skills will be those that **complement, rather than compete** with automation and artificial intelligence.

The fastest growing skills are the **uniquely human traits** that machines cannot easily replicate such as:

adaptability



creativity



team work



integrity



Much of this additional learning will occur later in life as workers:



Reskill

in response to job changes



Upskill

in response to changes in the tasks within their jobs

Australians will need to **double the share of learning they do after the age of 21** from



For most people the extra learning won't be all about more years at university or TAFE.

Most of the extra learning will occur at work through

on-the job training & **short flexible courses**



aimed at mid-career workers.

EXECUTIVE SUMMARY

By 2040, the way we work and learn will look vastly different from today. Advances in technologies like robotics and artificial intelligence are automating a growing number of tasks previously performed manually by human workers. Automation is sweeping through customer service, from supermarket checkouts to personal banking. Robots are mastering ever more complex tasks on factory floors. Satellites and drones are helping farmers grow their crops.

While Australians know the way they work is changing, they are less clear on the skills they need to adapt to new kinds of automation. Does every Australian need to be proficient in a coding language? What will older workers need to know to remain employable? Is it more important for early career workers to develop a technical specialisation or to develop enterprise skills such as communication and leadership?

This report helps Australians navigate the major shifts in the future of work by answering three critical questions:

- **What** skills do we need to succeed in the future?
- **When** during our working lives will we need to learn these skills?
- **How** can we adjust work and learning practices to acquire the skills we need?

To understand how skill requirements for the Australian workforce are shifting, the report analyses recent changes in more than 300 jobs, more than 2,000 work tasks and more than 500 skills required to complete these tasks. We examine how tasks are changing in our economy, and the skills workers are using more often in response.

More importantly, this report translates what we know about the jobs of the future into what it means for the skills of the future. It assesses in detail how much time, in hours, every worker in this country has spent on education and training over their lifetime – and how much these investments in skills will likely need to change by 2040.

This approach offers unique insights into the amount of training and education required for each Australian occupation today and in the future. The result is a comprehensive picture of the actual size of the reskilling challenge in this country.

Australians will spend 33% more time on education and training across their lifetime by 2040

By 2040, Australians will need to invest significantly more time in education and training, as skills become a worker's greatest asset in more complex, machine-assisted workplaces. Growing demand for skills will be driven by three groups of workers: people requiring additional training as they switch jobs or careers ('reskilling'), people requiring additional training as their job tasks change ('upskilling'), and future workers – those who haven't yet joined the labour force and are expected to spend more time in education and training than any generation before them.

- **Reskilling demand:** the average Australian worker will likely change jobs 2.4 times over the next two decades. By 2040, 9 out of 10 Australians between 21 to 65 years are expected to have changed occupations at least once. Most of these people will require some reskilling to successfully switch from one job to the next.
- **Upskilling demand:** Workers who stay in their roles will need to frequently refresh their skills to navigate changes in the way they do their jobs. Automation and globalisation are causing tasks across all Australian occupations to change by an average of 18 per cent every decade.¹
- **Future worker skills demand:** Some of the strongest demand for additional education and training will come from younger people, who will need to be much better prepared than their parents to keep up with a highly dynamic work environment. Compared with today's workers, Australia's future generation of workers will need to spend an additional 3 hours per week on education and training until retirement.

The scale of the reskilling revolution that needs to occur because of these three trends is immense. An additional 3 hours per week of education and training for future workers might not sound like a huge effort, but across a lifetime it means an additional 8,000 hours of training – 33 per cent more than what workers undertake today.

In addition to this increase, Australians will need to change what, when and how they learn.

Today the average working-aged Australian completes a total of 24,000 hours of education and training, which includes all their time spent in school, post-secondary, formal training and on-the-job learning. Across the whole Australian population this equals a total stock of education and training of 300 billion hours.

Demand for reskilling, upskilling and the new skills for new workers will double the total stock of education and training required to **600 billion hours by 2040.**

¹ This finding is in line with past research showing that, for the average Australian worker, machines have already taken on two hours per week of repetitive and routine tasks since the start of the millennium, and they are set to replace another two hours per week by 2030. AlphaBeta (2017), *The Automation Advantage. How Australia can seize a \$2 trillion opportunity from automation and create millions of safer, more meaningful and more valuable jobs.* Available at: <http://www.alphabeta.com/wp-content/uploads/2017/08/The-Automation-Advantage.pdf>.

WHAT WE LEARN: Australians need to acquire skills that complement, rather than compete with, automation

What skills will workers need to succeed in the jobs of the future? This report analyses more than 500 skills and maps them to tasks to identify which skills are required to support future human work. We categorise those skills into three groups:

- **Knowledge** refers to the body of information that can be directly applied to the performance of a task, such as medicine, maths, language, architecture, and accounting.
- **Abilities** refer to an observable physical or mental competence, such as strength, design, listening, driving, time management or programming.
- **Characteristics** relate to the way we execute tasks, and include creativity, integrity, leadership, persistence, empathy, and attention to detail.

The data shows that the fastest-growing skills are 'characteristics'. This is not surprising because these are the hardest skills for machines to replicate. As more knowledge and abilities become codified they can be mastered by machines, leaving workers to focus on more uniquely human skills.

However, humans will always require a broad education because it takes a range of skills to complete a job task. While 'characteristics' like leadership, empathy and creativity will become increasingly important, they are only valuable when combined with general skills.² It takes more than just one type of skill to complete a job task. This means humans will continue to use a broad mix of skills in the future, even if some of these skills can be mastered by a machine.

WHEN WE LEARN: Australians will do much more learning later in life, doubling the share of education and training that occurs after the age of 21

Today, more than 80 per cent of the time we spend in education and training occurs before the age of 21. But the idea that a post-secondary qualification will set us up for life is no longer a reality. In the future, workers will not be able to rely solely on what they learned as a teenager. To remain employable, workers will need to make a habit of refreshing existing skills and adding new ones throughout their career.

Three trends are driving the shift towards lifelong learning: longevity, automation and less predictable career paths. Our analysis shows that Australians will need to more than double the time they spend on learning after the age of 21 compared to today. This will lead an average worker's share of training after the age of 21 to increase from 19 per cent today to 41 per cent in 2040.

HOW WE LEARN: Rather than accumulating more qualifications, most of the new learning will be targeted, flexible, work-based training

As Australians learn more later in life, we will need to change how we learn. For many people seeking to update their skills during their career, the traditional models of university and TAFE qualifications are neither necessary nor compatible with their work and family lives.

Rather than accumulate additional degrees, workers will learn through short courses and on-the-job training which focusses directly on the specific skills

² See Appendix for a detailed list of skills analysed in this report.

they require. To navigate rapid job and task changes in the future, Australians will need to seek more opportunities to improve their skills while at work. Our analysis suggests formal workplace training and informal on-the-job learning together would need to make up nearly 42 per cent of an average Australian's total lifetime skills training by 2040, twice as much as today (21 per cent).

More people will be working and studying at the same time. Some will seek to free up time during work hours to acquire new skills, while others will try to fulfil their growing learning needs outside of their work routine by taking evening, weekend or online courses. Education will need to become a lifelong journey that extends beyond formal institutional learning.

Lessons from the skills shift

Millions of individuals will need to learn new skills over the next two decades, including through reskilling and upskilling, to be ready for more frequent changes in jobs and the tasks within jobs. This skill shift will put the education and training system into the spotlight. Australians will only be able to satisfy the additional skills requirement if education and training providers keep up with the expected surge in demand.

In the future, there will be a growing need for flexible, bite-sized courses that allow workers young and old to quickly acquire the exact additional skills they need at a certain point in their careers. Demand for online courses will likely increase. Australia's education and training providers will need to adjust their teaching models to the era of 'fit-for-purpose' learning.³

Dealing well with skills shifts will require significant national reform. The challenge is substantial, and business as usual is not an option. Governments need to ensure funding and accreditation systems provide the right incentives for the necessary shift towards learning flexibly and later in life. Businesses

will need to prioritise formal training for their workforce, and make more mentoring and on-the-job learning opportunities available.

For Australia to succeed, governments and community leaders will need to drive community skills awareness and enable public participation in human-skills education. Many of these uniquely human skills are developed outside of the formal education environment, which means broader society will need to be mobilised. Parents and other family members, community organisations, sports clubs and social media role models should understand and embrace their roles in teaching children skills that make us uniquely human: empathy, ingenuity, cooperation, resilience, ethics and integrity. Having these skills will allow future Australians to succeed in a world where human work will continue to be as indispensable as the machines that enable our society to function.

³ The Australian Productivity Commission, in a recent report, listed several barriers to upskilling and retraining that Australia would need to overcome. It recommended governments provide easier access to information, create improved VET pathways for upskilling, establishing 'lifelong learning accounts' and creating an independent assessment system to stimulate upskilling and retraining. See: Australian Government Productivity Commission (2017), *5-year productivity review. Supporting paper no. 8: upskilling and retraining*. Available at: <https://www.pc.gov.au/inquiries/completed/productivity-review/report/productivity-review-supporting8.pdf>

1

AUSTRALIA NEEDS
A SURGE OF
INVESTMENT IN
SKILLS TO PREPARE
FOR THE FUTURE
OF WORK



Automation is only one of the powerful trends making the future of work less predictable. Most Australians will in future change jobs multiple times over the course of their careers. Even people who don't switch employers will have to cope with change in the mix of tasks that their jobs involve. To navigate these shifts, Australians will need to make learning new skills a lifelong habit.

An average Australian will increase learning by a third over their lifetime

Over the next two decades, Australians will need to invest in new skills if they are to succeed in the future of work. Australian jobs are being reshaped by automation, globalisation and demographic change. Factory labourers are now working alongside robots just as office and field workers have begun to rely on data analysis and smarter software to complete jobs faster and more efficiently. Outsourcing and digital platforms have created a truly global workforce in many industries. And people are living longer and demanding more flexible working arrangements.

The scale of workforce change in Australia was described in AlphaBeta's *Automation Advantage* report, commissioned by Google in 2017. The report showed that Australian jobs are changing at a rapid rate with machines taking on more tasks that were once done by humans. In particular, machines are taking on tasks that are routine, administrative and physical and leaving humans to focus more on tasks that are interpersonal, cognitive and creative.

As Australians change our jobs, and the tasks within our jobs, we will need to update our skills accordingly. The future of work will increase demand for three types of learning:

- **Reskilling:** More people will require additional training, as job and career switches become more common than in the past.
- **Upskilling:** Every worker's requirement for learning new skills at work will increase, as job tasks continuously change.
- **Future workers:** Young Australians who haven't yet joined the labour force will likely spend more time learning than any generation before them, as they need to keep up with an increasingly complex and demanding work environment.

Australians will need to ‘reskill’ as they change jobs 2.4 times by 2040

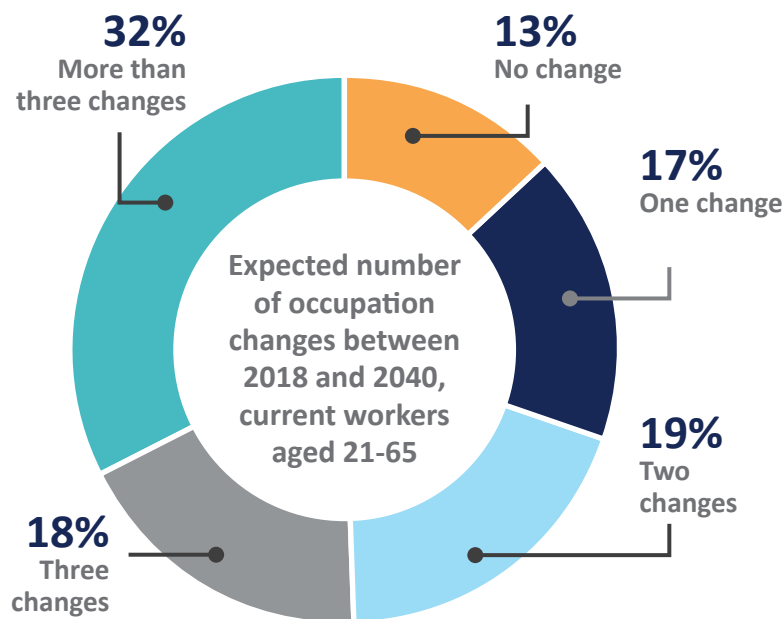
Every year, 2.1 million Australians, or 18 per cent of the country’s workforce, switch jobs.⁴ This report uses a simulation, based on data from the Household, Income and Labour Dynamics in Australia (HILDA) Survey, to estimate how frequently Australian workers will likely change jobs in the future.⁵ The result suggests that the Australian labour market will remain highly dynamic, as most Australians are expected to

change jobs multiple times throughout their careers. By 2040, 87 per cent of all Australian workers between 21 and 65 will have changed occupations at least once (see Exhibit 1). On average, every Australian will change occupations 2.4 times over the next two decades.

When workers change jobs, they need to learn new tasks. An average job change in Australia involves a worker changing more than one fifth of the tasks they complete (22 per cent). To master these new tasks, workers usually need new skills, which creates demand for education and training.

EXHIBIT 1

By 2040, most Australians will have changed jobs multiple times



- 87% of workers will have changed their job at least once by 2040
- The average Australian will have changed occupations **2.4 times** by 2040
- Around **88%** of people under 50 and **33%** of people over 50 will have changed occupations more than once
- With every job change, a workers tasks change on average by **22%**, which may create a need for **reskilling**

⁴ AlphaBeta (2018), unpublished research.

⁵ See Appendix for further details on methodology

Workers will need to ‘upskill’ as their job tasks change by 18% every decade

Even workers who stay in their existing jobs need to adapt and learn new skills to keep up with changes in technology and business processes. For this report, we analysed the change in ‘tasks’ within each Australian job by dividing each occupation into up to 2,000 tasks using data from the US jobs database O*NET.⁶ This analysis reveals that across all 348 occupations in the Australian economy, the

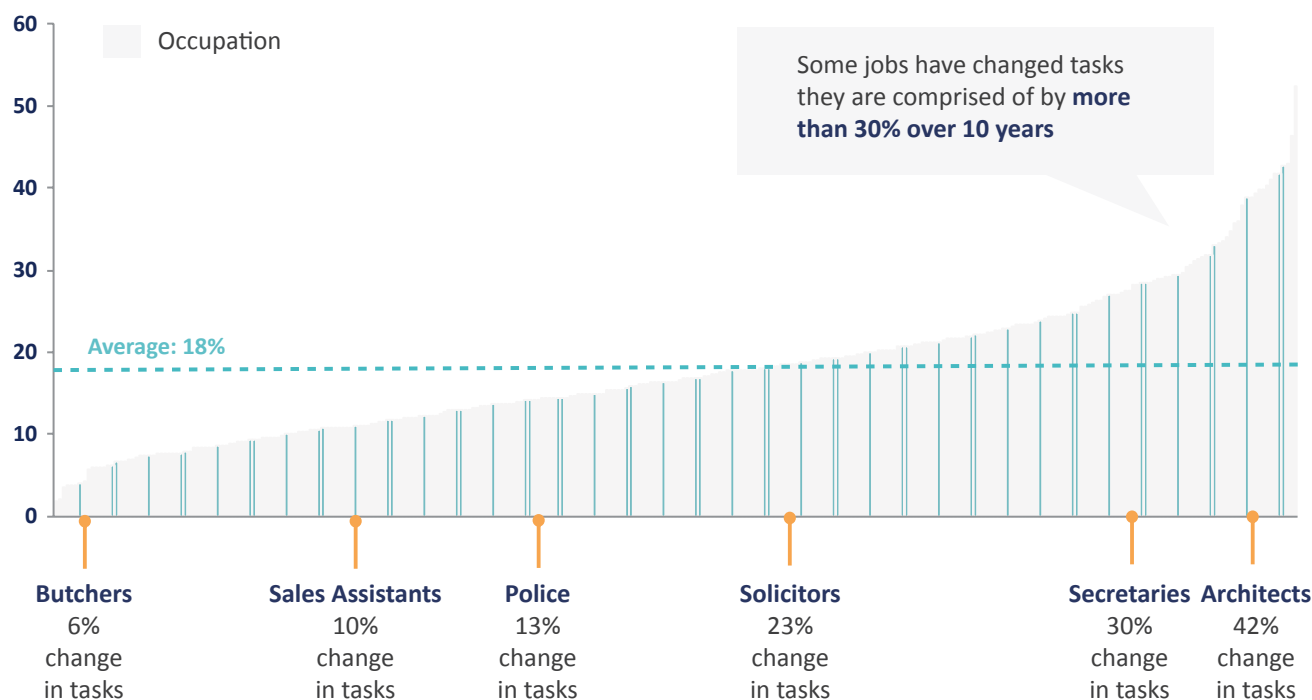
average change in tasks in a ten year period was 18 per cent (Exhibit 2), which means that nearly a fifth of all tasks in a job are redundant and replaced with new tasks each decade.

Of course the level of task change varies substantially around this average. For example, a butcher’s tasks have changed only 6 per cent since 2006, while an architect’s work routine has changed more dramatically, by 42 per cent, over the same period. Computer software now helps architects create drawings faster than in the past, which frees them up to spend more time with clients or on design.

EXHIBIT 2

Tasks in Australian jobs change on average by 18% every decade

Total change in tasks for each Australian occupation
in %, 2006-2016



Note: Task change was measured by taking the absolute value of the per cent change in time spent on over 2,000 activities across occupations (to capture both positive and negative task change) and then halving this value to arrive at a proxy for average task change.

Source: O*NET, AlphaBeta analysis

⁶ See Appendix for detailed methodology

Future workers will spend more time learning than any previous generation

Another factor which is increasing the demand for skills is the increase in investment in education and training among young people. Young Australians are spending more time learning over the course of their working lives than any other generation before them and this is forecast to increase.

Part of this increase will come from rising school completion rates and rising enrolment in post-secondary education. Already, record numbers of Australians are pursuing higher education today.⁷ In 2016, 56 per cent of Australians aged 15 years and

over had attained a post-school qualification, up from 46 per cent a decade earlier.

However, the future increase in education and training doesn't mean that all workers will need to spend more time accumulating university and vocational qualifications. Much of the increase in learning will occur in the workplace – a young Australian in 2040 will spend three times as much time learning on the job throughout their working lives compared with a young worker today (see Exhibit 3).

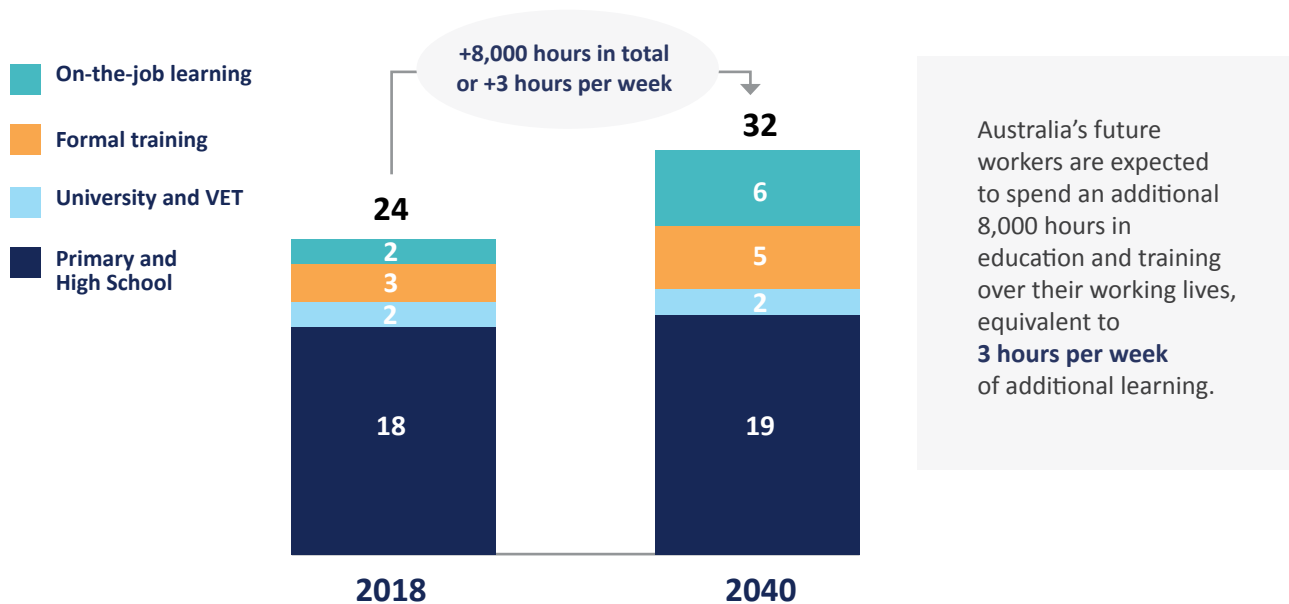
Overall, the average future worker will need to spend an extra 8,000 hours learning over a lifetime, which is equivalent to 3 additional hours of learning per week.

EXHIBIT 3

Australia's future workers will need to spend 3 additional hours per week learning new skills compared to today's workers

Time future workers* are required to spend learning over their working lives

Education and training per person, '000 hours



*Future workers are defined as people joining the workforce after 2018. Note: Figures for 2040 exclude retraining of current workers. Source: O*NET, ABS, HILDA, AlphaBeta analysis

⁷ Australian Bureau of Statistics (2017), "Australians pursuing higher education in record numbers". Available at: <http://www.abs.gov.au/AUSSTATS/abs@.nsf/mediareleasesbytitle/1533FE5A8541D66CCA2581BF00362D1D?OpenDocument>.

The total national stock of education and training will rise substantially

An additional 3 hours per week learning might not sound like a huge effort, but across a lifetime it means an additional 8,000 hours of training or an increase of about a third for each worker.

What does this increase mean for the economy as a whole? Today, an average working-aged Australian completes a total of 24,000 hours of education and training, which includes all the time spent in school, post-secondary, formal training and on-the-job learning (see Exhibit 4). Across the whole Australian population this equals a total stock of education and training of 300 billion hours.

New demand for reskilling, upskilling and the new skills for new workers will double the total stock of education and training required to **600 billion hours by 2040** (see Exhibit 4). About 50 billion of these

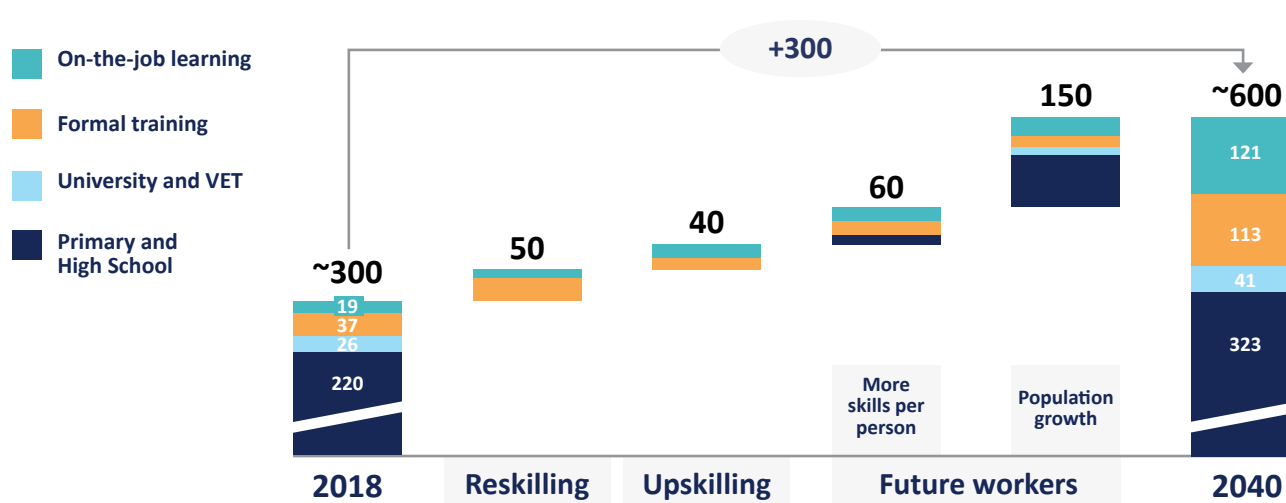
hours will be required to reskill workers moving jobs. Most of this training will likely be delivered through short formal courses and on-the-job training. About 40 billion hours will be required to upskill workers who have to learn new tasks as part of their existing job, of which almost all will be delivered as on-the-job training.

A further 60 billion hours will be required to account for the general increase in education and training levels: workers entering the labour market tend to have more education and training than older workers leaving the labour market. And population growth, including growth in the domestic population and net migration, will increase the total demand for skills by 150 billion hours.⁸ However, skilled migration is expected to significantly alleviate this burden on the education and training system. Over one third of the additional hours driven by population growth (54 billion hours) will be imported via skilled migrants.

EXHIBIT 4

Australia's workforce will need to double the total time spent on learning new skills to 600 billion hours in 2040

Required change in training 2018 to 2040 Total stock for labour force, in billions of hours



Source: O*NET, ABS, HILDA, AlphaBeta analysis

⁸ Australia's workforce participation rate for people aged 15 to 64 is projected to increase from 76.2% in the fiscal year 2015 to 79.1% in the fiscal year 2045, according to the latest Intergenerational Report. See: Australian Government (2015), *Intergenerational Report*. Australia in 2055. Available at: <https://treasury.gov.au/publication/2015-intergenerational-report/>.

**WHAT WE LEARN:
AUSTRALIANS NEED
TO FOCUS ON THE
'SKILL SETS' THAT
MACHINES CAN'T
REPLICATE**

As more manual and routine tasks are taken on by machines, humans will need new skills for the tasks that will comprise the jobs of the future. In the future, the most valuable skills will be uniquely human characteristics, but these will need to be supported by a broad foundation of skills that together constitute the skill set required to perform a specific task.

The most valuable skills will be distinctively human characteristics

Technological progress means that machines are increasingly capable of replicating even sophisticated human skills. Speech-recognition systems are now able to distinguish between hundreds of different human languages, accents and commands. Advances in deep neural networks and other machine learning techniques have led services firms, from banks to travel agents, to use chatbots for initial customer contact before forwarding queries to a human. Technology companies are continuously improving natural language recognition and improving the word error rate of machines when making sense of human communication.⁹

As machines become a more important part of the workplace, how will humans need to change their skills to remain relevant? To answer this question, we begin by grouping skills into three categories.

- **Knowledge** refers to the body of information that can be directly applied to the performance of a task, such as medicine, maths, language, architecture, and accounting.
- **Abilities** refer to an observable physical or mental competence, such as strength, design, listening, driving, time management or programming.
- **Characteristics** refer to character attributes or attitudes that include integrity, leadership, persistence, empathy, and attention to detail, which also form an important part of the skill set needed to perform a task.

⁹ IBM (2017), "Reaching new records in speech recognition". Available at: <https://www.ibm.com/blogs/watson/2017/03/reaching-new-records-in-speech-recognition/>.



2: WHAT WE LEARN

Machines are mastering some of these skills faster than others. Human ‘knowledge’ is easier to codify than ‘abilities’ or ‘characteristics’ and therefore more susceptible to automation (see Exhibit 7). Knowledge is easier to codify because its underlying rules can be written down and explained to a machine. It’s easier to train a machine to understand mathematical rules (knowledge) than it is to teach it to drive (an ability) or be creative (a characteristic). In particular, complex and context-dependent human characteristics like empathy or leadership are challenging to translate into a language that a machine can understand. This means that any skill set comprising even a small share of tacit capability will remain the domain of humans because tacit skills cannot be codified.

Automation has so far been most successful in areas where a task can be converted into explicit instructions that a computer understands. Think of robotic arms in a car factory. Their movements

follow a clear pattern. Robots can identify a car part, lift or lower it into place, and secure it to the chassis. The arm then performs the exact same action to secure an identical part to the following chassis. Such repetitive, routine tasks, and the skills needed to perform them, can be monitored, codified as data, and therefore made open to automation.

However, tasks that require tacit capabilities – ideas and wisdom that are highly subjective, context-specific, and related to intuition and personal experience – are much more difficult to codify for machines.¹⁰ For example, a surgeon can use a robotic arm to perform minimally invasive surgery. But even the most intelligent machine is yet unable to fully replace a surgeon for tasks that rely on uniquely human characteristics to interact with patients, including intuition, empathy, and judgment (see Box 2 – Case study: using uniquely human skills at work).

¹⁰ For background on the concept of ‘tacit knowledge’, see for example: Adler, Paul (2013), The dynamic relationship between tacit and codified knowledge: comments on Ikujiro Nonaka’s “Managing innovation as an organisational knowledge creation process”. Available at: <http://www-bcf.usc.edu/~padler/research/Tacit%20to%20explicit%20draft-1.pdf>.

BOX 1

Methodology: From skills to skill sets

In this report we define ‘skills’ as a set of three different types of capabilities: knowledge, abilities and characteristics. Knowledge, in this context, refers to the body of information that can be directly applied to the performance of a task, such as medicine, maths, language, architecture, and accounting. Abilities refer to an observable physical or mental competence, such as strength, design, listening, driving, time management or programming. Lastly, personal characteristics, character attributes or attitudes – including integrity, leadership, persistence, empathy, and attention to detail – also form an important part of the skill set needed to perform a task. A full list of skills analysed in this report can be found in the Appendix.

Humans never use their skills in isolation. In practice they use a complex interplay of knowledge, abilities and personal characteristics to get work tasks done. For example, the task of creative writing requires a worker to use varying degrees of knowledge (English language), abilities (writing) and specific human characteristics (empathy). Writers can’t do their work by

using just one of these skills, they use all of them together. This report proposes a more nuanced approach to solve the skills conundrum. It recognises that it always takes a combination of knowledge, abilities and characteristics to perform a work task. These skill combinations are summed up under the umbrella term ‘skill set’ in this report. Exhibit 5 gives some examples for skill sets.

Automation only affects a job when a machine can replicate the entire ‘skill set’ – the full combination of knowledge, abilities and characteristics – required to perform a human task. Take ‘vital monitoring’, a critical task in the nursing profession. This task can only be automated when a machine is fully capable of replicating the entire range of capabilities nurses need to complete this task: their knowledge of mathematics and biology, their ability to gain insights quickly just from what they perceive with their senses, their communication skills, their ability to respond quickly to patient needs, as well as their very individual human traits of being persistent and paying attention to detail.



EXHIBIT 5

Humans use ‘skill sets’ – combinations of knowledge, ability and characteristics – to perform a work task

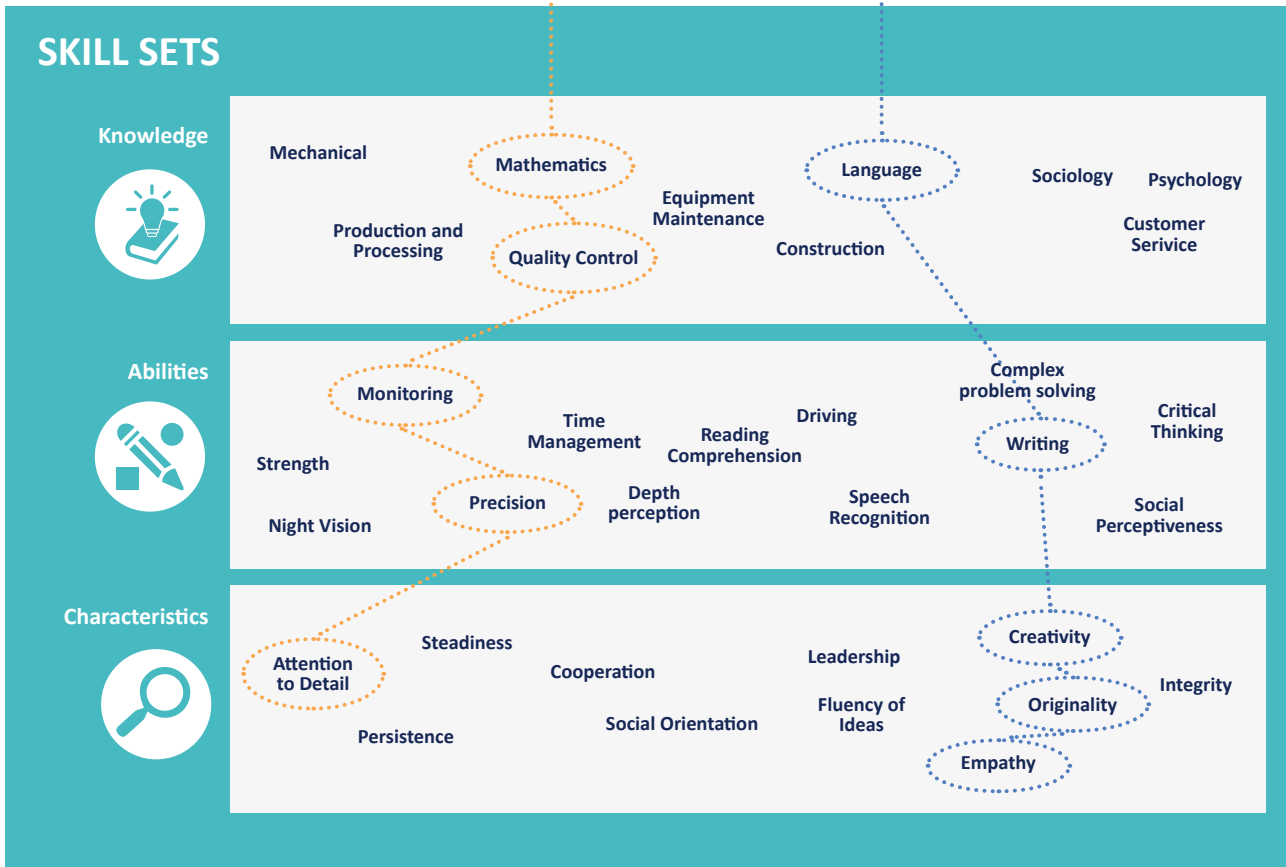
Jobs are made up of **tasks** that can be completed with **skill sets**, which are combinations of knowledge, abilities and characteristics.

EXAMPLE 1:

The **skill set** required to perform **operations monitoring** tasks include a combination of **mathematics, quality control, monitoring, precision** and **attention to detail**.

EXAMPLE 2:

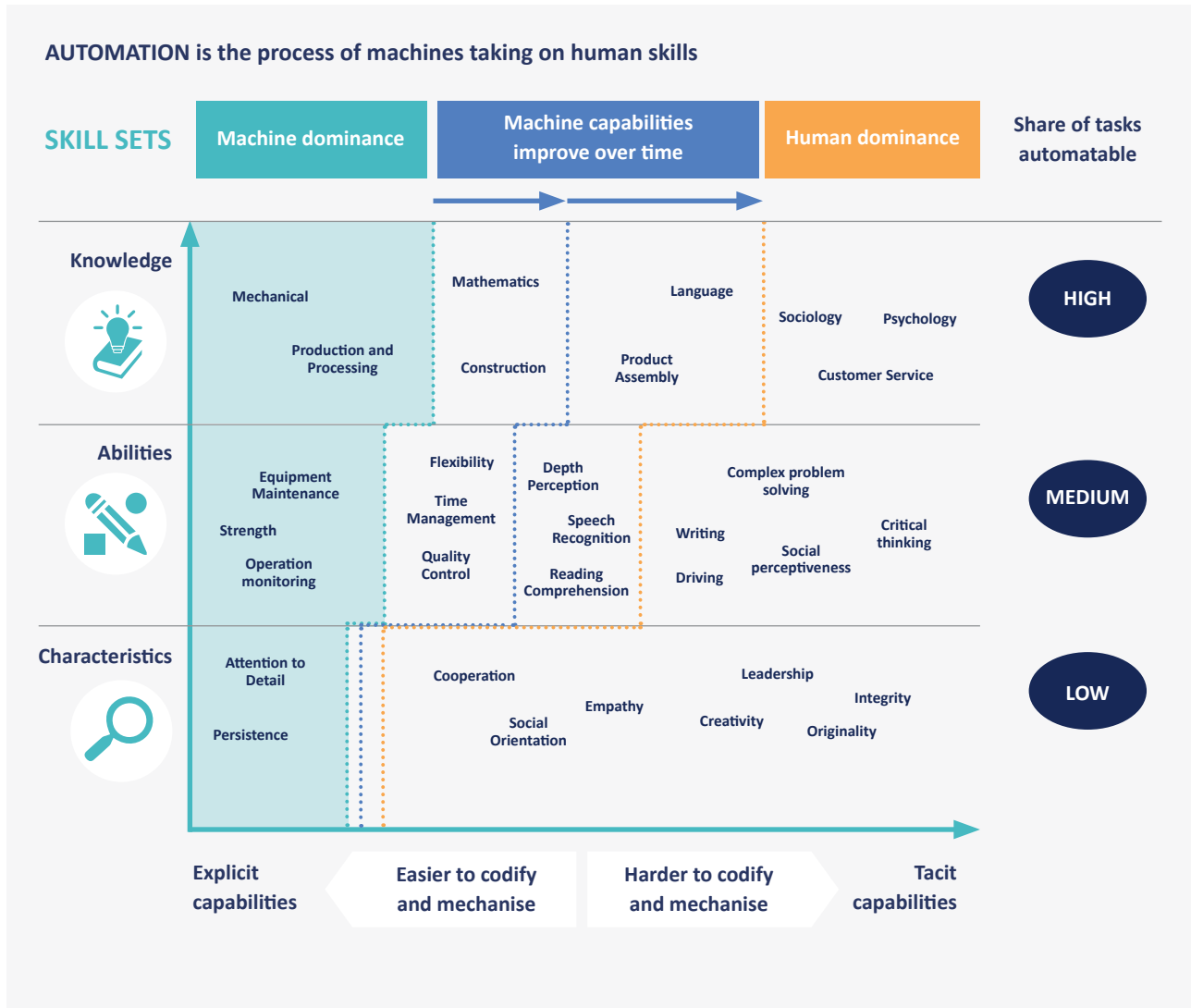
The **skill set** required to perform **creative writing** tasks include a combination of skills including **language, writing, creativity, originality** and **empathy**.



Source: AlphaBeta analysis

EXHIBIT 6

Machines are good at replicating knowledge and getting better at replicating abilities, however still struggle to replicate human characteristics



Source: AlphaBeta analysis

2: WHAT WE LEARN

As machines become more capable, workers will need to shift their learning focus to tasks that are harder to codify and therefore beyond the current ability of machines. In particular, characteristics such as leadership, empathy, creativity, and integrity will become a growing part of the skill sets of humans and set us apart from machines.

But it would be naive to assume that humans will be reduced to using just a few select skills. The reality is that humans never use one skill in isolation. Rather, they use a combination of skills, or

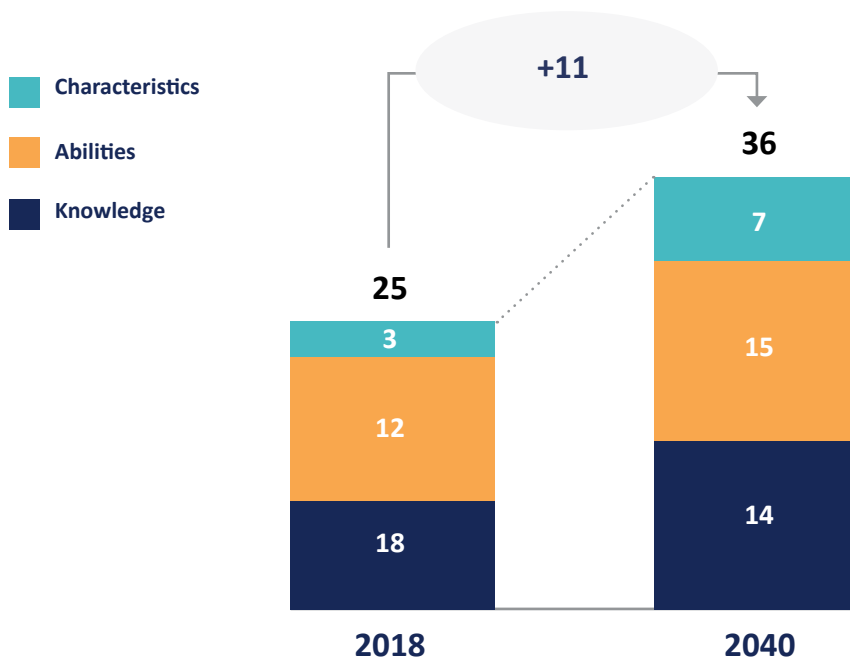
'skill sets', to complete a task. In the future, human workers will increasingly focus on uniquely human skills, but these skills will need to be supported by a broad foundation of skills that together constitute the skill set required to perform a specific task. Exhibit 7 shows the expected increase in different categories of skills by 2040. The relative importance of uniquely human traits in the skill mix will increase and the average Australian worker will need to **spend twice as much time as today on deepening their distinctive human characteristics.**

EXHIBIT 7

Characteristics, the uniquely human part of a worker's skill set, will become more than twice as important by 2040

Required shift in learning by skill type

Education and training per person over a working life, in '000 hours



The importance of characteristics will **more than double** over the next two decades as workers shift into tasks that require uniquely human skills such as empathy, leadership, team work & coordination.

Over their lifetime, Australians will need to spend an additional **3.5 hours per week** developing these uniquely human skills.

Source: O*NET, ABS, HILDA, AlphaBeta analysis

BOX 2

Case study: using uniquely human skills at work

For a surgeon, reassuring patients becomes a major skill as machines take over the operating room.

In many hospitals, surgeons and nurses are learning to work alongside an army of high-tech helpers – computers, robots and other machines. This does not mean that machines are making medical staff obsolete. Rather, they prompt humans to rely on some skills more than others when treating patients.

Plastic surgeon Tim Peltz, who works as a surgical fellow across five hospitals in Sydney, says his workplace has changed substantially since he started his medical career more than 20 years ago. He and his colleagues today use electric scalpels and digital coagulation devices, ultrasonic suction machines, highly computerised ventilation machines and intelligent computer programs that can help to plan an operation and, in some cases, tell them exactly where to cut.

“Almost every little process in our operating room is now affected by machines,” says Dr Peltz. “There are a lot of cables hanging from the ceiling.”

The fully automated robotic surgery remains a rarity, however. While the global market for surgical robots is booming – analysts at BIS Research expect it to grow by 12 per cent per year to reach more than US\$12.6 billion in 2025 – most procedures are still too complex and unpredictable to be managed entirely by futuristic-looking, four-armed machines like the da Vinci Surgical System. Their most common use is in fields like urology and gynaecology,



Surgeon Tim Peltz at work

where a surgeon’s hands prove too large to make tiny, high-precision cuts in a very tight space.

“You need a very repetitive and consistent surgery situation, otherwise the robot has problems recognising what is what,” says Dr Peltz. His patients typically present with injuries from a workplace accident, and such surgical procedures remain a human domain. They require a surgeon like Dr Peltz to rely on his hands, eyes and intelligence to make the right decisions and moves in the operating theatre.

Dr Peltz says he also needs to be stress-resistant and able to improvise quickly when a machine fails, which he says happens frequently. Above all, he learned to use his empathy and communication skills more often in recent years, as many patients feel unsettled by the technological progress in the operating room. “Medicine is becoming a lot more technical and complicated, so I need to communicate better what I’m doing to have the patient on my side,” says Dr Peltz.

There is no 'one-size-fits-all' future skill set

As organisations invest in technology that automates tasks within Australian jobs, every Australian will need to learn new skills to effectively integrate these machines into their work. However, there is no blanket formula to predict which specific skills Australia's workforce will need to thrive in a time of increasing investment in artificial intelligence and robotics. Individual skill requirements will continue to vary significantly across occupations, and it is inaccurate to suggest workers will only need to learn programming or improve their complex problem-solving skills to succeed in the future. It is more instructive to examine which occupations rely on skill sets that machines are unable to replicate, because it is these occupations that will be most resilient in terms of their requirement for uniquely human labour.

Many jobs demand workers with a similar mix of skills. When focusing on such similarities in skills, each occupation in Australia can be assigned to one of seven broad occupational clusters (Exhibit 8).

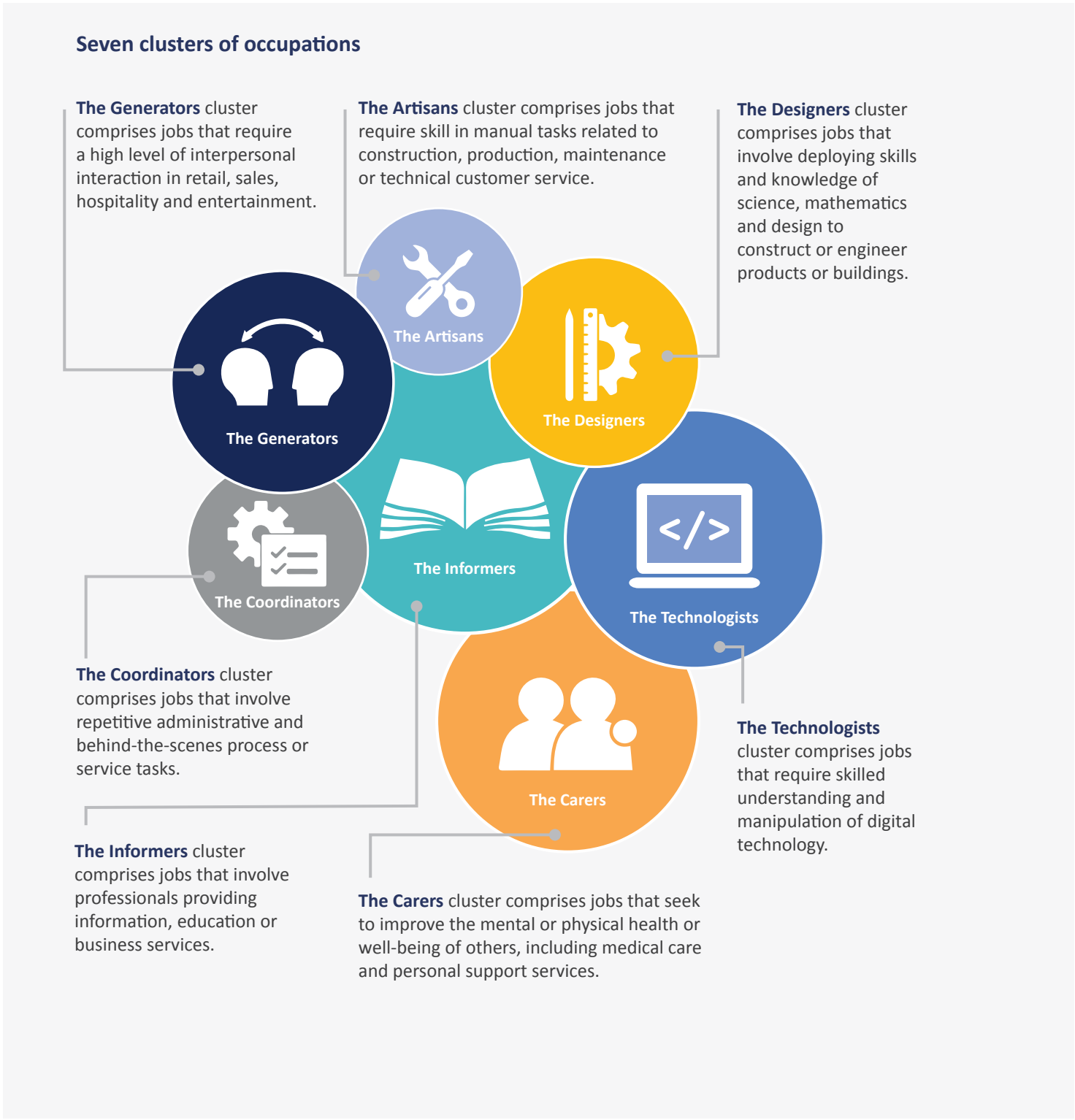
These clusters are:

- **The Generators:** include occupations such as sales representatives, bank managers, entertainers and interpreters, which require a high level of personal interaction.
- **The Artisans:** found in construction, production, maintenance and technical customer service, where workers need to perform many manual tasks. Typical occupations include machinery operators, electricians, plumbers, and farmers.
- **The Designers:** include occupations such as architects, electrical engineers, product testers, geologists and building inspectors, who require good knowledge of science, mathematics, and design for tasks in construction or engineering.
- **The Informers:** need skills to provide information, education and business services. Typical occupations include teachers, economists, accountants, policy analysts, solicitors, journalists, and human resources specialists.
- **The Coordinators:** comprise occupations such as bookkeeper, cook, furniture removalist and receptionist. These professionals typically need to be reliable and have strong time-management skills to perform repetitive administrative tasks, service tasks, and tasks related to behind-the-scenes processes.
- **The Carers:** need to have strong interpersonal communication skills, but also knowledge in biology or psychology, to perform tasks that improve a person's mental or physical health. Key occupations include GP, social worker, childcare worker, fitness instructor, surgeon, and counsellor.
- **The Technologists:** include occupations such as software engineer, database administrator, web designer, and ICT business analyst who need a solid understanding of digital technology to perform their job tasks.










EXHIBIT 8

PART A | The skills of the future vary for different types of work



Source: FYA and AlphaBeta 2017, *The New Work Mindset*. Available at: <https://www.fya.org.au/wp-content/uploads/2016/11/The-New-Work-Mindset.pdf>

PART B | Main occupations & key skills in each job cluster

	Main Occupations	Key Skills
Generators 	<ul style="list-style-type: none"> ▪ Sales reps ▪ Bank Managers ▪ Entertainers ▪ Interpreters 	High level of interpersonal interaction in retail, sales, hospitality and entertainment
Artisans 	<ul style="list-style-type: none"> ▪ Machinery operators ▪ Electricians ▪ Plumbers ▪ Farmers 	Manual tasks related to construction, production, maintenance or technical customer service
Carers 	<ul style="list-style-type: none"> ▪ GPs ▪ Social workers ▪ Childcare workers ▪ Fitness instructors ▪ Surgeons ▪ Counsellors 	Seek to improve the mental or physical health or well-being of others
Coordinators 	<ul style="list-style-type: none"> ▪ Bookkeepers ▪ Fast food workers ▪ Cooks ▪ Furniture removalists ▪ Law clerks ▪ Receptionists 	Involve repetitive administrative and behind-the-scenes process or service tasks
Designers 	<ul style="list-style-type: none"> ▪ Architects ▪ Electrical engineers ▪ Product testers ▪ Geologists ▪ Building inspectors 	Involve deploying skills and knowledge of science, mathematics and design to construct or engineer products or buildings
Informers 	<ul style="list-style-type: none"> ▪ Primary and secondary school teachers ▪ Economists ▪ Accountants ▪ Policy analysts ▪ Solicitors ▪ HR advisers ▪ Organisational psychologists 	Involve professionals providing information, education or business services
Technologists 	<ul style="list-style-type: none"> ▪ Software engineer ▪ Database administrators ▪ Web designers ▪ ICT business analysts 	Require skilled understanding and manipulation of digital technology



Australians in every occupation have already adjusted their job routine to the rise in automation at work. Rapid changes in the tasks required by Australian jobs have forced workers across all clusters to focus more on skill sets that require a distinctively human contribution. This shift can be measured (see Appendix for details on methodology). Our analysis reveals that the use of uniquely human skills is growing faster than the use of more easily codifiable skills, as work tasks continue to change (Exhibit 9). **Workers are increasingly relying on distinctively human characteristics** such as initiative, persistence or originality to do their jobs. In other words, characteristics are overrepresented among the fastest growing skills across all job clusters, and this trend is expected to continue.

Other than that, there is no clear sign that specific skills are in higher demand than others. Each occupation continues to have its own unique skill requirements. For example, while knowledge about computers and electronics is a fast-growing skill for professionals in the Informers and Technologists cluster, people working as Carers, Artisans or








Designers have needed to shift their focus towards entirely different skills in recent years.

Over the next 22 years, people in the Carers cluster – childcare workers, counsellors or GPs – will have most rapidly shifted to using tasks at work that require stress tolerance, empathy, physical endurance, as well as a basic knowledge of biology. People working as Informers – teachers, accountants or solicitors – will have most rapidly increased their use of active listening, influencing, persistence and integrity.

EXHIBIT 9

The shift in skills demand depends on each occupation and its tasks, but characteristics are becoming more relevant across all clusters

Fastest growing skills for each job cluster

	Knowledge	Competencies	Characteristics
Generators 	<ul style="list-style-type: none"> Administration and Management 	<ul style="list-style-type: none"> Communication Strategic planning Written comprehension 	<ul style="list-style-type: none"> Persistence Analytical thinking Leadership
Artisans 	<ul style="list-style-type: none"> Physics Computers and electronics 	<ul style="list-style-type: none"> Judgment and decision making, Reading and oral comprehension 	<ul style="list-style-type: none"> Service orientation Stress tolerance Initiative Analytical thinking Attention to detail
Carers 	<ul style="list-style-type: none"> Biology Medicine 	<ul style="list-style-type: none"> Systems evaluation Multi-tasking Physical endurance 	<ul style="list-style-type: none"> Stress tolerance Empathy Social orientation Adaptability/flexibility
Coordinators 	<ul style="list-style-type: none"> Accounting Human Resources 	<ul style="list-style-type: none"> Social perceptiveness Communication 	<ul style="list-style-type: none"> Integrity Dependability Cooperation Social orientation
Designers 	<ul style="list-style-type: none"> Mechanical Building and Construction 	<ul style="list-style-type: none"> Problem solving 	<ul style="list-style-type: none"> Innovation Attention to detail Initiative Cooperation
Informers 	<ul style="list-style-type: none"> Computers and electronics 	<ul style="list-style-type: none"> Active listening Influencing Written communication 	<ul style="list-style-type: none"> Service orientation Persistence Integrity
Technologists 	<ul style="list-style-type: none"> Computers and electronics 	<ul style="list-style-type: none"> Deductive reasoning Programming Computational thinking 	<ul style="list-style-type: none"> Originality, Adaptability, Analytical thinking Innovation

Source: O*NET, AlphaBeta analysis

3

**WHEN WE LEARN:
AUSTRALIANS NEED
TO DRAMATICALLY
INCREASE LEARNING
LATER IN LIFE**

The average Australian today learns more than 80 per cent of their knowledge and skills before the age of 21. However, as we live longer, retire later, change jobs more frequently, and perform more work with the assistance of machines, learning throughout life becomes more important. In the future, Australians will need to continuously revise and refresh personal skills during a variety of life stages and in different personal circumstances, many of which are our current education system is not optimised to serve. The average worker will need to triple the time spent on learning after the age of 21.

Australians will shift towards lifelong learning

As several major forces reshape the world of work, Australians will need to become more responsive to change within their jobs and in the mix of jobs available. To ensure they remain employable, workers will need to make a habit of refreshing their skills and picking up new ones throughout their careers. Three trends are driving the shift towards lifelong learning: longevity, automation, and more unpredictable career paths.

For one, a **growing number of older workers** in Australia will increase demand for education and training later in life. Rising life expectancy and advances in medical science mean more workers will be healthy enough to work longer. Australians are already working to older ages. Over the decade to 2016, the workforce participation of people aged 65 and over increased from 8 per cent to 13 per cent.¹¹ This rate will likely increase further as more people choose to retire later in life.

Secondly, the **use of technology to automate tasks** at work will lead a growing number of Australians to constantly learn and adjust their skill sets to work productively with the machines that help them do their jobs. Frequent changes in tasks required to do a job will become the norm as companies continue to use technology to improve their productivity. The trend to use machines, rather than humans, for the most dangerous and backbreaking tasks in Australia's economy is also set to continue and will lead more Australians to shift to safer, physically less strenuous tasks.¹² To master these shifts, workers will need to be prepared to learn new skills throughout their entire working lives.

Thirdly, Australia's highly **dynamic labour market** will contribute to the growing need for lifelong learning. In a typical OECD country more than 20 per cent of jobs are created and destroyed each year as firms adjust their labour demand to periods of industry growth and decline.¹³ The rate is similar in Australia, but the number of people changing jobs in our economy has increased slightly from 1.6 million to 2.1 million per year since the early 1990s.¹⁴ This trend is expected to persist as workers and employers continue to respond to the major forces disrupting the economy, including globalisation and urbanisation.

Some workers, especially those in industries affected by offshoring, may need to change jobs involuntarily and even switch careers. However, regardless of whether people change occupations by choice or not, they will likely need some training to perform in a new role. This demand for reskilling will be driven by workers of every age group and strengthen the shift towards lifelong learning.

¹¹ Australian Government (2017), "Older Australia at a glance". Available at: <https://www.aihw.gov.au/reports/older-people/older-australia-at-a-glance/contents/social-and-economic-engagement/employment-and-economic-participation>.

¹² AlphaBeta (2017), *The Automation Advantage*.

¹³ OECD (2016), *Back to work: Australia: improving the re-employment prospects of displaced workers*. Available at: <https://www.oecd.org/employment/emp/Back-to-Work-Australia-AR.pdf>.

¹⁴ AlphaBeta (2018), unpublished analysis.

Australians will need to triple mid-career learning

Much of what we know, we learn in our youth. On average, Australians today acquire more than 80 per cent of their knowledge, abilities and characteristics before the age of 21. The time a typical Australian adult currently dedicates to learning (2 hours per week) pales in comparison to the time spent on learning as a teenager (26 hours per week).

In the future, lifelong learning will need to dramatically increase if workers want to keep pace with the changing economy and progress in their careers. Australians will need to learn more in all stages of their lives. But our analysis shows that the need for training in additional skills is largest

in the later stage of a worker's career. While the average teenager and young adult will likely need to add only one hour of training per week to prepare for the more challenging world of work in 2040, **the time Australians spend between 21 years and retirement will need to triple from 2 hours to 6 hours per week** (see Exhibit 10).

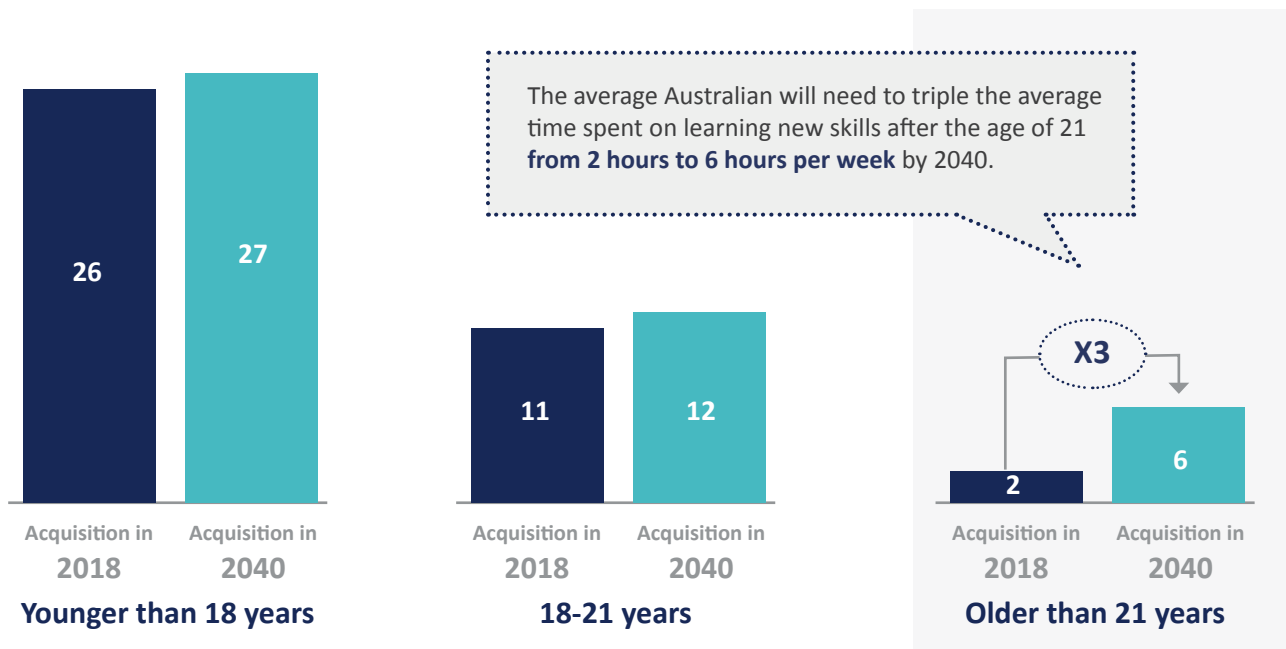
The need to view learning as a continuous process, rather than a mission mostly completed earlier in life, will force workers to reshuffle their priorities. By 2040, 41 per cent of the average worker's total education and training will need to occur after the age of 21, up from 19 per cent today (see Exhibit 11). It means the office, rather than a classroom, will play a much greater role in helping Australians acquire the skills they need in the future.

EXHIBIT 10

Australians will need to learn slightly more in younger years, but the time spent on learning new skills later in life will triple

Skill acquisition over a working life by age

Average weekly hours per person



Source: O*NET, ABS, HILDA, AlphaBeta analysis

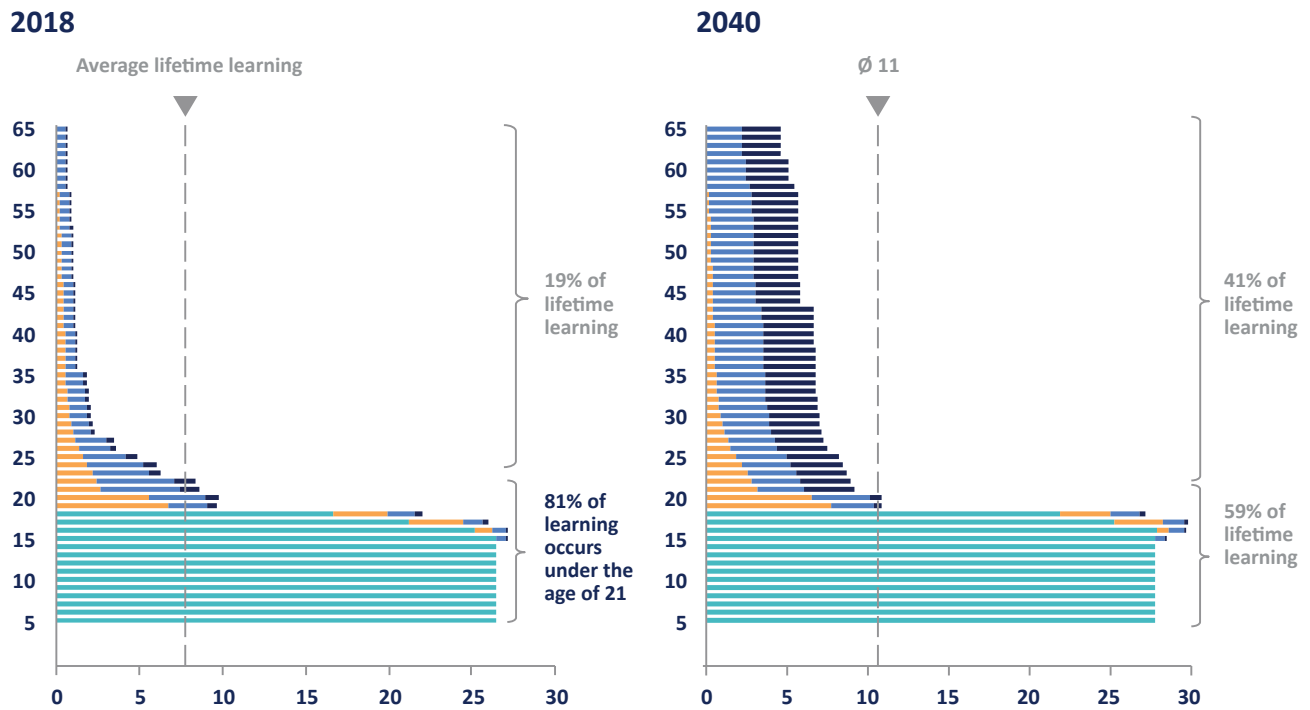
EXHIBIT 11

The shift towards lifetime learning will cause Australians to acquire 41% of their skills later in life in 2040, up from 19% today

Skill acquisition over a working life by age

Average weekly hours per person

- School
- Learning through university/VET (formal education)
- Learning on the job
- Learning through formal training



Source: O*NET, ABS, HILDA, AlphaBeta analysis

BOX 3

Case study: Lifelong learning

New 'Skills Checkpoint' helps older Australians keep abreast of workplace change.

When the Australian Government piloted a new program in late 2015 to help older workers cope with the rapid changes in the labour market, officials soon realised they had tapped into a huge service gap. More than 1,000 people aged between 45 and 54 signed up for the Skills Checkpoint Pilot to find out whether their existing skills are still valued by employers or whether they'd need a refresh.

Some participants felt they'd already reached a dead end in their careers. "It can be very challenging to find new jobs, particularly as you age," one Australian told the organisers. "One can tend to doubt that the skill set already achieved in one's lifetime is sufficient to obtain another job." Others acknowledged their skills "haven't kept up" as they watched their industries decline, businesses close and risk of redundancy increase. One participant said he was getting too old for hard physical work after suffering from repeated injuries, but he lacked direction on what to do next.

A personalised career plan and a boost in confidence for participants

The Skills Checkpoint Pilot proved the missing link. Participants were screened for aptitude, skills and interests. Career advisors helped them explore alternative work paths and highlighted any additional education and training programs that would



facilitate a job or career change. They also offered information about how a worker can present individual skills in job applications and interviews. In the end, participants went home with a personalised career plan and a boost in self-esteem. "My experience with the Skills Checkpoint Service has lifted my confidence in my ability to put myself forward to get a new job," one worker said after the pilot.

The overwhelmingly positive feedback convinced the Australian Government to roll out the *Skills Checkpoint for Older Workers Program* across the country at the end of 2018, with more than \$17 million in funding. It will be available for any employee between 45 and 70 years old "at risk of entering the income support system", as well as eligible older workers who have recently become unemployed. The Government says it will pay for the reskilling and upskilling of up to 20,000 older Australians over a four-year period.

Source: Ministers for the Department of Education and Training (July 2018), "Skills Checkpoint for Older Workers Program tender opens". Media Release: <https://ministers.education.gov.au/andrews/skills-checkpoint-older-workers-program-tender-opens>. Australian Apprenticeship Support Network (2016), Skills Checkpoint Pilot. An overview of the evaluation findings. Available at: https://www.australianapprenticeships.gov.au/sites/ausapps/files/publication-documents/report_-_executive_summary_of_the_skills_checkpoint_pilot_evaluation.pdf



4

**HOW WE LEARN:
MORE LEARNING
WILL BE DELIVERED
FLEXIBLY AND AT
WORK**



Learning at work, instead of in a classroom, will need to become a priority for Australians in the era of artificial intelligence. To keep up with frequent job and task changes, workplace training will account for twice as much of a worker's lifetime investment in skills. By 2040, workers will undertake four times as much formal professional training throughout their working lives. The shift towards lifelong learning will challenge the traditional education system, as millions of Australians will seek to move flexibly between work and training in all stages of their career.

Much of the new learning will be work-based

As technological development and economic incentives result in machines taking on a growing amount of work traditionally done by humans, Australians will need to change not only what and when they learn, but also how they learn. As outlined earlier in this report, Australians will need to shift their focus to tasks that rely

on their distinctively human characteristics. The future world of work also requires them to be highly responsive to ongoing changes at work. Consequently, learning throughout an individual's entire working life will need to become the standard for all Australians.

In practice, this means the workplace will need to become the most important arena for updating and refining a worker's skills. However, our analysis shows that many people focus too little on structured learning at work. The average Australian still acquires the bulk of their skills at school or in higher education. Once people join the workforce, their amount of time spent on training declines dramatically, compared to the hours they spend learning in younger years.

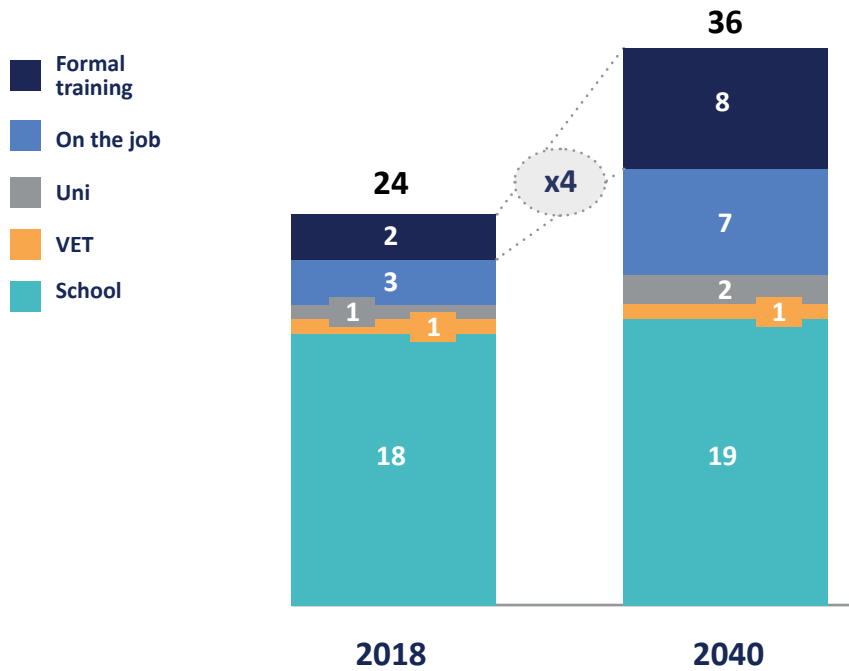
Workplace training – whether through formal professional development courses or informal on-the-job learning – currently only accounts for around one-fifth (21 per cent, or 5,000 hours of training) of the average Australian's total lifetime learning. As seen in Exhibit 14, this amount will need to increase substantially to 42 per cent (15,000 hours) as workplaces become more dynamic. **Formal training alone will need to quadruple by 2040, from a total of 2,000 hours over a worker's life today to 8,000 hours by 2040.** This required increase in formal training is driven by the growing need for reskilling and upskilling.

EXHIBIT 12

By 2040 Australians need to quadruple the total time spent in formal training throughout their working lives

Skill acquisition over a working life by source

Per person, in '000 hours



Learning at work (formal and on the job) as a share of total lifetime learning will need to increase from 21% to 42%. **Formal training** alone will need to **quadruple** by 2040.

This means Australians will need to increase their learning at work by **4 hours per week**.

Note: Excludes population growth, includes retraining of current workers.
 Source: O*NET, ABS, HILDA, AlphaBeta analysis

Learning will need to flexibly cater for mid-career workers

The growing need for lifelong learning will challenge the traditional model of acquiring skills in Australia. Much of the learning Australians undertake today follows a rigid path: at school, children learn foundational skills such as literacy and numeracy, as well as more specific knowledge about science, history and geography. At vocational colleges or at university, young adults acquire more specific knowledge to set them up for a professional career. Once in the workforce, people learn through experience whenever they perform their daily tasks on the job. Many employers also offer formal training opportunities to improve the skills of their staff.

In the future, Australians will need to be more flexible in how they learn, constantly revising and updating their skills to ensure their contribution remains relevant and meaningful as automation affects tasks within their job. More people will be working and studying at the same time. Some will seek to free up time during work hours to acquire new skills, while others will try to fulfil their growing learning needs outside of their work routine by taking evening, weekend or online courses. Education will need to become a lifelong journey that extends beyond formal institutional learning and into the workplace.

The change in how we work will be least noticeable during primary and high school years. Of course, schools will need to update curricula frequently to ensure their education remains fit for purpose. But the hours an average Australian will spend at school, and the overall concept of classroom education for children and young adults will change little compared to the sweeping changes that tertiary education providers and businesses are set to experience.

Universities and vocational training providers will need to step up in their role of supporting a skilled workforce by offering more flexible course structures that also cater for working professionals. Learning at university will need to become more accessible for Australians at all stages of their career. But instead of returning to university to enrol in traditional bachelor's or master's degrees that can take several years to complete, working Australians will seek out tertiary education providers that offer an array of short courses to fill a specific skills gap. Time constraints will lead many of them to prefer online tertiary education over courses that require physical attendance.

Employers will play a major role in fostering the shift to more flexible, lifelong learning. Many of the occupation-specific skills Australians need in the era of artificial intelligence are best acquired in the workplace through practice and repetition. Consequently, the way we spend our time at work will change. Learning and working will become increasingly inseparable. Not only will employers need to collaborate more closely with tertiary education providers to offer a growing amount of formal training. They will also provide an environment that fosters informal learning through mentoring and team collaboration, as workers will need to spend double as much time on "learning by doing" on the job (Exhibit 12) by 2040.

BOX 4

Case study: flexible learning at work



How Australia’s largest vocational training provider draws working professionals with flexible online courses and a touch of virtual reality.

More and more education providers in Australia are retooling their curricula to cater for a new type of student: the working professional. However, getting the course design right is critical for attracting business clients in Australia, says Jon Black, managing director at TAFE NSW, Australia’s largest provider of vocational education and training.

Every year TAFE Enterprise, the professional training arm of TAFE NSW, is meeting the skills needs of some 50,000 employees from all industries in Australia, including from blue-chip companies such as Microsoft, Cisco, Lendlease and Harley Davidson. Often, courses are custom-built for every corporation.

“When I talk with business leaders about their training requirements, the answer is always the same,” says Mr Black. “They want training solutions that are consistent enough to roll out across their organisation, but flexible enough to respond to changes in the commercial environment. What this reflects is a constantly evolving world of work where many skills and knowledge are perishable.”

For course co-ordinators at TAFE Enterprise this means a constant search for courses that fit into an employee’s busy schedule and into a company’s budget. The barriers for businesses to invest more in formal staff training are still substantial. In a recent TAFE survey among 400 large businesses in Australia nearly every second manager said it is difficult to motivate employees for training. Almost three quarters said they would struggle to free up employees for the required training time. 54 per cent cited a lack of training budget as a barrier.

Source: John Black (2018): “Meeting the training demands of industry”. Available at: <https://www.afr.com/news/special-reports/training-evolution/afrmar22sindustry-insighttafe-nsw-special-report---20180321-h0xsoe>; AFR/TAFE (2018), “Reskilling in the modern age”. Available at: <https://www.afr.com/news/special-reports/training-evolution/reskilling-in-the-modern-age-20180321-h0xsk2>; TAFE Enterprise (2018): Skills and Australian business report 2018. Available at: <https://www.tafensw.edu.au/documents/60140/86282/TAFE+Enterprise+Training+Report.pdf/bf500d82-3956-2ed5-5b39-b80d9c090dd5>.

TAFE thinks digital learning could be the answer to overcoming such hurdles. TAFE Digital is already offering more than 250 courses online. Some of these are deliberately kept short to help busy working professionals squeeze in evening or weekend studies. A specialist team of education professionals is also partnering with technology start-ups to make courses more engaging by using virtual and augmented reality software, as well as gamification strategies.

In the survey, seven in ten companies said they were willing to explore such high-tech training options to engage weary employees. “Businesses seeking a competitive edge are beginning to acknowledge the urgent need to upskill and reskill their existing workforce,” says Mr Black.

IMPLICATIONS

A massive skill shift is required to prepare Australia's workforce for the automation age. We need to change what, when and how we learn to master the growing unpredictability of work. This has consequences for everyone in Australia, and governments and education providers must take the lead in driving reform.

The skill shift needed to prepare Australia's workforce for the future is enormous, and we need to take action now if we want to succeed as a country. Our analysis suggests that the Australian Government's recent "Gonski 2.0" recommendations are a good start, but schools are just one piece of the puzzle. Post-secondary education and training providers will need new approaches to support workers' lifelong learning needs. And governments can help by providing public funding models and financial incentives to encourage individuals and businesses to invest in education and training.

For the skill shift to be successful, four conditions must be met:

- **Make skills a priority.** Australians need to be willing and able to invest double as much time in new skills by 2040 to prepare our workforce for the future of work.
- **Create more flexible education and training opportunities.** Education providers need to adjust their teaching methods and content to cater for the growing demand in flexible, lifelong learning.
- **Adjust funding and certification models to encourage lifelong learning.** Governments and businesses need to provide incentives for workers to invest more time in learning new skills.
- **Get everyone involved.** Teaching new skills must be a collective effort from the heart of society. It involves schools, universities, TAFEs and employers as much as it draws on parents, sports coaches, and community leaders to act as role models.

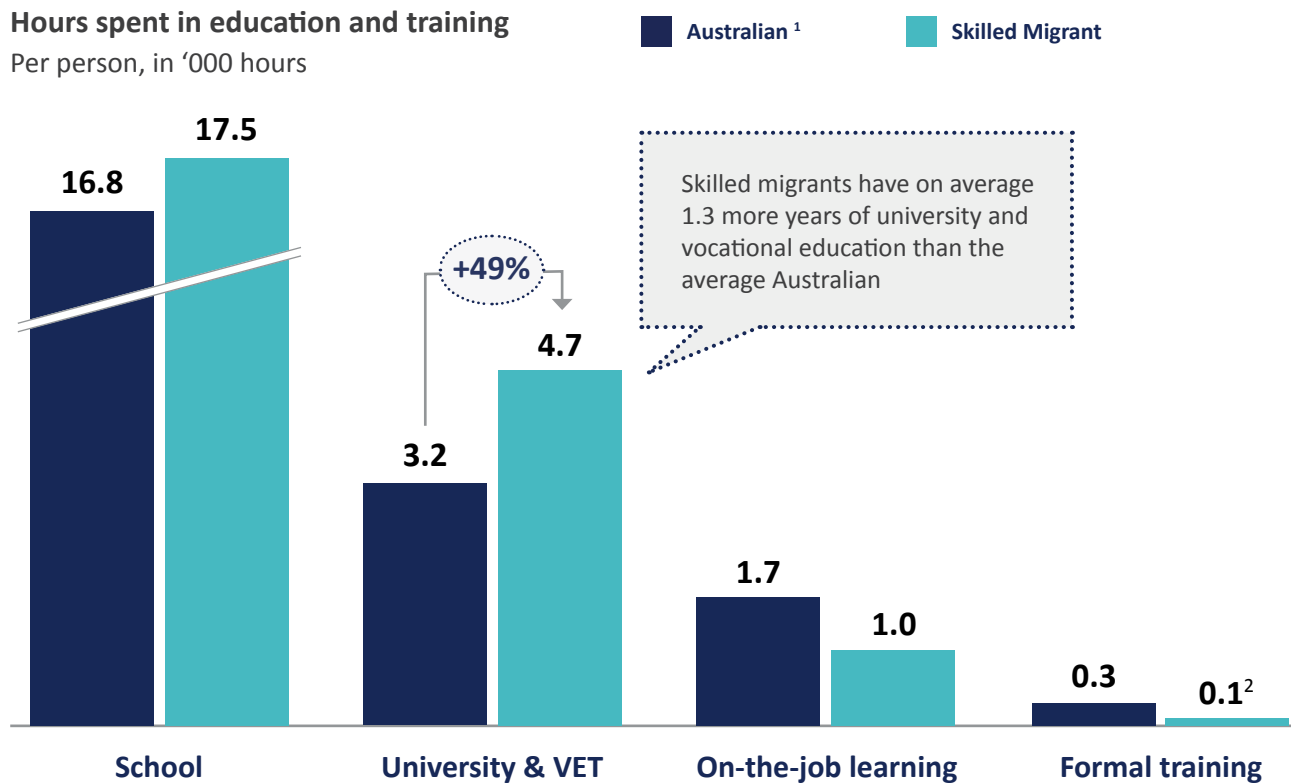
Australia needs to invest dramatically more in skills

This report shows that Australia's workforce needs to urgently focus on what will matter most in the automation age: learning the skills that allow humans to thrive in an environment where they are using machines to perform an increasing number of tasks at work. Over the next two decades to 2040, Australia will need to double its total investment in education and training from a combined 300 billion hours to 600 billion hours.

Part of this immense need for skills is driven by population growth. Further still, one third of the human capital needs driven by population growth will be imported through skilled migrants. Australia's continued intake of skilled migrants will go a long way in lessening the burden on our education and training system, while ensuring the skill demands of a changing economy are met. Skilled migrants extend the depth and breadth of Australia's human capital, with the average skilled migrant spending 49 per cent more time in post-secondary education than the average Australian (Exhibit 13).

EXHIBIT 13

The average skilled migrant has spent 49% more time in post-secondary education compared to the average Australian



¹ This only includes Australians born in Australia to avoid capturing previous intakes of skilled migrants.

² Skilled migrants have spent less time receiving formal training at work due to lower investment in formal training in developing countries. This is based on responses to the question on the extent of staff training ("In your country, to what extent do companies invest in training and employee development?") in the World Economic Forum Global Competitiveness Index, which is used as a proxy for number of hours spent receiving formal training.

SOURCE: ABS, World Economic Form (WEF), AlphaBeta analysis

But even when leaving demographics aside, every Australian will need to invest significantly more time in education and training to keep up with the rapid changes in jobs and job tasks. Together, Australian workers will need to increase their total investment in skills by an additional 150 billion hours by 2040. In other words, the combined 300 billion hours people in Australia's current workforce have already invested in skills over their working lives until today are nowhere near enough to prepare this country for the future. Collectively, Australians need to add another half of what they have already invested in skills to be ready for the changes ahead.

This growing skill requirement is driven by the rising need for reskilling and upskilling. Millions of people will need to retrain as they move from one job to another or completely change careers. Even those who stay in a role will need to be nimble and dedicate more time to learning at work, as machines will continue to take over a growing amount of human work tasks. Every worker in Australia, young and old, will require additional training and education to be ready for the challenges of the future.

Our analysis signals that formal training at work

will need to quadruple and learning after the age of 21 will need to triple over the course of a worker's life. Australia's youth will be particularly affected, as education and training become an even bigger priority. The next generation of workers, those who have not yet entered the labour market, will need to invest more time in skills than any worker generation before them. Our analysis shows that by 2040 young Australians will need to spend 3 more hours per week in education and training over the course of their careers compared to their parents.

Education providers need to adjust teaching methods and content

But it will be a challenge for Australia's education system to keep up with the expected surge in demand for lifelong learning. At present, the system is not fully equipped to deliver the amount of education and training that is required to prepare Australian workers for the future of work.

Schools, universities, TAFEs and private vocational training institutions need to urgently step up in catering for a reskilling and upskilling revolution as they choose what and how education is delivered. For Australia's education system to remain globally competitive and succeed in equipping our workforce with relevant skills, every education provider will need to revise curricula and pedagogy.

In the future, employers will look for workers with specialist as well as cross-disciplinary skills, including the ability to lead and motivate people and communicate effectively. Schools will need to revise their approach, as highlighted recently by the Australian Government's latest Review to Achieve Excellence in Australian Schools, also known as "Gonski 2.0".¹⁵ The review's key recommendation that fostering personal and social capability needs to be at the core of a school's curriculum and

teaching practice is in line with our analysis that human characteristics such as leadership and empathic communication will need to become more than twice as important in a worker's skill set by 2040.

Primary, secondary and tertiary education in Australia will continue to be crucial for developing the foundational, subject and cross-disciplinary skills in young people. But as learning becomes a lifelong journey, educators will need to adopt new approaches of supporting Australia's skilled workforce. In the future, there will be a growing need for flexible, bite-sized courses that allow workers young and old to quickly acquire the exact skills they need at a certain point in their careers. Demand for online courses will increase. Australia's education and training providers will need to adjust their teaching models to the era of 'fit-for-purpose' learning.¹⁶

The Australian education system is certainly aware of these challenges. Many universities have already begun to align current teaching models with a new vision for education – one that involves shorter, more flexible, more specialised courses that target younger and older Australians alike and can be completed online. TAFE Enterprise, now Australia's largest professional training provider, has set up its own unit, dubbed TAFE Digital Lab (see Case study: flexible learning at work) to reinvent vocational education for the 21st century. The Global Innovation Index, an annual survey on the innovative power of 126 countries worldwide, confirmed that Australia's tertiary education system remains one of the country's biggest assets, ranking it seventh on its scorecard.¹⁷

¹⁵ Australian Government (2018), Through growth to achievement. *Report of the review to achieve educational excellence in Australian schools*. Available at: <https://www.education.gov.au/review-achieve-educational-excellence-australian-schools>.

¹⁶ The Australian Productivity Commission, in a recent report, listed several barriers to upskilling and retraining that Australia would need to overcome. It recommended governments provide easier access to information, create improved VET pathways for upskilling, establishing 'lifelong learning accounts' and creating an independent assessment system to stimulate upskilling and retraining. See: *Australian Government Productivity Commission (2017), 5-year productivity review. Supporting paper no. 8: upskilling and retraining*. Available at: <https://www.pc.gov.au/inquiries/completed/productivity-review/report/productivity-review-supporting8.pdf>.

¹⁷ Cornell University, INSEAD, World Intellectual Property Organisation (2018), *Global Innovation Index 2018*. Available at: <https://www.globalinnovationindex.org/home>.

Governments and businesses need to support the shift to lifelong learning

The required shift towards lifelong learning can only occur if Australians are willing to learn more and if the education system moves to supply more and more flexible learning opportunities.¹⁸ However, education providers rely on the support of governments and businesses when creating new course offerings.

Businesses are fundamental in providing insights about the skills they expect human workers to bring, guided in the medium term. To ensure overhauled curricula meet their standards, employers will need to collaborate closely with education and training providers. Employers need to create the space and structures for employees to join formal professional development training, which will need to quadruple by 2040, according to our analysis. They will also need to make more mentoring and on-the-job learning opportunities available, as demand for such informal training will need to double over the course of the average Australian's working life by 2040.

To help workers shift more easily from one role to another, employers should seek to identify as early as possible how technology and other forces will likely impact their workforce in the medium term. Transparent workforce plans would assist workers in identifying skill gaps and training needs that are in line with their next career moves.

Businesses will also need to consider providing early training to employees likely affected by automation and offshoring. This would lift the skills of vulnerable workers and increase their chances of redeployment elsewhere in a company. It would be equally important for employers to strengthen their pipeline of future talent. This may mean collaborating with schools or running community-based workshops – some technology companies

run holiday coding camps for children – to ensure the next worker generation is equipped with critical skills for the automation age.

Businesses in Australia have begun to reflect and develop solutions to respond to these growing training needs. For example, the Business Council of Australia recently launched a discussion paper outlining a vision for a new tertiary education model that would enable workers to more easily retrain and reskill over their lives.¹⁹ Our analysis adds urgency to the responsibility of Australian businesses to support the reskilling revolution.

Governments need to provide the overall framework for the skill shift to succeed. Public funding models and financial incentives are important tools to incentivise individuals and businesses to invest in education and training. Governments need to make sure that existing funding frameworks encourage lifelong learning and ensure a 'funding neutrality' between vocational training providers and universities. This is particularly important as more education providers will need to introduce shorter, more flexible courses that cater for working professionals – a move that will directly pitch vocational training providers against universities and online education providers from the private sector, such as Udacity.

The proliferation of Massive Online Open Courses (MOOCs) shows that the education system is already changing in line with our analysis that shows learning will need to become more flexible in the future. However, recognition of and trust in these new types of learning will require the creation of a certification framework and cultural change.

Micro-credentials could be a way to structure the expected surge in non-traditional education offerings where students gain qualifications in specific areas such as learning how to code, how to use social media, or how to apply management skills such as staff supervision or strategic decision-

¹⁸ The Australian Productivity Commission, in a recent report, listed several barriers to upskilling and retraining that Australia would need to overcome. It recommended governments provide easier access to information, create improved VET pathways for upskilling, establishing 'lifelong learning accounts' and creating an independent assessment system to stimulate upskilling and retraining. See: Australian Government Productivity Commission (2017), *5-year productivity review. Supporting paper no. 8: upskilling and retraining*. Available at: <https://www.pc.gov.au/inquiries/completed/productivity-review/report/productivity-review-supporting8.pdf>.

¹⁹ Business Council of Australia (2017), *Future-proof: protecting Australians through education and skills*. Available at: <http://www.bca.com.au/publications/future-proof-protecting-australians-through-education-and-skills>.

making. Micro-credentials could be a way to recognise specific skill sets. They could be used to recognise classroom learning as well as any informal learning or training on the job. Employees could receive digital certificates or badges as evidence of attaining their new credential. Micro-credentials could be used for one-off qualifications or part of an employer-mandated training pathway.²⁰

Teaching new skills needs to be a whole-of-country effort

Responsibility for training does not rest solely with the education sector. Ultimately, everyone in Australia needs to embrace the required skill shift as a collective effort. Our analysis shows that basic foundational knowledge such as mathematics and English language will remain a pillar of a worker's skill set in 2040. Teaching such knowledge will remain the primary domain of primary and secondary schools.

As the uniquely human part of our skill sets will become more relevant, real-life education will need to play a bigger role. Research shows that tacit skills are typically acquired through experience and collaboration in a community.²¹ This means everyone in society – parents, neighbours, piano teachers, sports coaches - will need to be aware that they are in the best position to teach children the characteristics that will help them succeed in the era of artificial intelligence. The required skill shift in Australia can succeed. But it requires everyone to step up and play their part.

²⁰ Oliver, Beverley (2017), Better 21C credentials. Evaluating the promise, perils and disruptive potential of digital credentials. Available at: http://go.pardot.com/l/135221/2016-04-18/62kb7/135221/10220/Better_21C_Credentials.pdf.

²¹ Psychologist Albert Bandura coined the concept of "social learning" in the 1970s. It recognises that children learn a lot by observing and copying patterns in the behaviour of people around them, including family members, peers, and even characters on TV. Other researchers have found a relationship between social media and tacit knowledge sharing. See for example Research by Panahi S./ Watson J./Partridge H. (2012), *Social media and tacit knowledge sharing: developing a conceptual model*: <https://pdfs.semanticscholar.org/1c40/e4bf2fedd618eb93406e29734ad294e512f4.pdf>.

TECHNICAL APPENDIX

A.1 Key features of our approach

There are many different types of skills

- Not all skills are the same. There are important differences between knowledge, competencies, abilities and characteristics.
- Some of these skills (knowledge and competencies) are easier for machines to master than others (abilities and characteristics).

Skills should be understood in combination as 'skill sets'

- Skills don't get tasks done independently. English language isn't enough to deliver the task of customer service. The worker also needs product information (knowledge), service orientation (ability) and social orientation (characteristic). In other words, workers need a combination of skills, or 'skill set', to complete a task.
- Even if a machine has mastered one codifiable skill, it will only replace a human worker once it has mastered the entire 'skill set' required to complete a task.
- This means humans still need a variety of skills, including skills that might be automatable, because they are always part of a 'skill set' that includes other skills machines cannot replicate.

Skills needed for the future are different for different jobs

- Different workers will need to have different skill sets in the future, depending on their occupation. Workers in care industries may need more physical skills, while workers in professional services may need less. It would be misleading to conclude that certain 'average' skills will be most in demand in the future.

Skills measured in terms of number of hours of training required

- We measure skills in a practical way – in terms of the number of hours of training required to deliver them.

A.2 Estimating the current stock of skills in the economy

The methodology used in this report differs from existing reports, as it provides a quantifiable estimate of the impact of workforce changes including automation on the amount of education and training required for our workforce.

We estimate how many hours have been spent in education and training by workers currently in the labour force and what they have spent their time learning.

A.2.1 How many hours have been spent in education and training by workers currently in the labour force?

The analysis begins by understanding how much time Australians currently in the labour force have spent in school, VET, university, on-the-job learning and formal mid-career training. We derive these estimates using ABS and Census data as described in Exhibit 14.

EXHIBIT 14

How much training do Australians in the labour force currently have?

Training Source		Estimation Method
School	Includes primary and secondary school	Method & assumptions: Typical number of hours for each year in school x number of people who have completed each year of school. Source: Census
Vocational educational	Includes formal post-secondary qualifications including certificates and diplomas	Method & assumptions: Typical number of hours in vocational education by qualification (i.e. diploma) x number of people who have completed vocational education by qualification. Source: Census
University	Includes bachelors, masters and doctorate degrees	Method & assumptions: Typical number of hours in university by degree (i.e. Bachelors) x number of people who have completed university degree. Assumes a pre-requisite education profile by degree type i.e. if a person's highest level of educational attainment is Masters, they must have completed a Bachelor degree as well. Source: Census
On -thejob learning	Includes informal learning on the job	Method & assumptions: Lifetime number of hours worked by labour force status (i.e part-time, full-time) and industry x proportion of time spent learning on the job (5%). Assumes that everyone's labour force status and industry of work remains the same throughout their lifetime. Source: ABS, Census, O*NET
Formal mid-career training	Includes formal work training	Method & assumptions: Lifetime number of hours worked by labour force status (i.e. part-time, full-time) and by industry x proportion of time spent in formal training by industry. Assumes that everyone's labour force status and industry of work remains the same throughout their lifetime. Source: ABS, O*NET

Another question we answer using ABS data is, how much time have we spent acquiring characteristics? These cannot exclusively be assigned to any education and training source. Although we recognise that personality characteristics can indeed be shaped by work experiences, experiences outside of education and training such as playing team sports, are just as important in the development of personal characteristics.²² Therefore, we treat the learning of characteristics as a function of years lived. We assume that of an entire person's life, they spend 1 per cent of their lifetime learning characteristics.

Studies investigating the mean-level change in personality traits across the life course show that the development of personality traits is dynamic: while some traits are more likely to be developed in adolescence, others are developed later in life. For example, while people exhibit increases of certain traits in young adulthood (20 to 40) (such as conscientiousness and emotional stability), people decrease in measures of openness in old age.²³ We believe the best way to deal with this dynamism is to assume each year, on average, a person spends the same amount of time adopting characteristics.

²² Niess, C & Hannes, Z (2015), *Openness to Experience as a Predictor and Outcome of Upward Job Changes into Managerial and Professional Positions*, PLoS One

²³ Roberts, BW, Walton KE & Viechtbauer W (2006), *Patterns of mean-level change in personality traits across the life course: A meta-analysis of longitudinal studies*, Psychological Bulletin 2006

A.2.2 What have we been spending our time learning?

Steps

1. **Collect O*NET data on skills, knowledge, abilities and work styles (hereafter referred to as KSAW) covering 964 US occupations.**²⁴

This data included importance scores for each KSAW, for each occupation, as well as level scores for each KSA. We also collect O*Net data on the required education and training for each occupation.

2. **Assign each KSA a level and training source**

This data on KSAW was used to understand, for each occupation, where a typical worker acquired each of the skills that were relevant to their jobs. This data included level scores for each knowledge, skill and ability. We used these level scores to give each KSA a level rating of low, medium or high. This approach was taken to capture the nuances in education and training requirements for different occupations. For example, electricians may not necessarily

need the same level of mathematics knowledge as scientists, but they will still require some mathematics knowledge. We then assign each KSAW level to a training source (school, university, VET, on-the-job learning and formal training) based on assumptions on where the KSAW would be acquired.

3. **Calculate hours assumptions for each training source**

We use O*NET data on required education and training for each occupation as the starting point for converting skill requirements into hours. O*NET provides data on 41 training categories (school, different types of post-secondary education, as well as time spent in formal training and work experience). We map these to equivalent Australian qualifications, where necessary. We then calculate the typical number of hours for each of O*NET’s 41 training categories. For example, the number of hours assumed to complete a Bachelor degree is calculated as 37.5 hours a week x 32 weeks x 3 years = 2700 hours. This is described in Exhibit 15.

EXHIBIT 15

How much training do Australians in the labour force currently have?

O*NET Category	Mapping to categories in A.2.1	Method
Required Level of Education (1 – 12 sub-categories)	School, university, VET	Map the university and VET qualifications to Australian qualifications
Related Work Experience (1 – 11 sub-categories)	On-the-job learning	Assume 5% of time in work experience was spent learning (same assumption as in A.2.1)
On-site or In-Plant Training (1 – 9 sub-categories)	Formal professional training	Apply the average share of hours per year on formal training (derived from ABS in A.2.1) to the time categories specified in O*NET
On-The-Job Training (1 – 9 sub-categories)	Formal professional training	Apply the average share of hours per year on formal training (derived from ABS in A.2.1) to the time categories specified in O*NET

²⁴ The US Department of Labor’s O*NET database is one of the world’s richest sources for labour data. The database contains information on the importance of over 130 knowledge, skills, abilities and workstyles across 964 US Standard Occupation Classification (SOC) Codes.

4. Create a cumulative training profile for each occupation

Let F be a matrix of shares of training type required, for each occupation, where $F_{i,j}$ corresponds to the frequency of the occupation i that requires the training type j (high school, bachelors, 1-3 months formal training etc). S is a matrix of the amount of time spent on each training source (e.g. s_1 can be the amount of time spent completing a high school degree). The matrix of the weighted average number of hours spent on each training type for every occupation is given by T under the following equation:

$$\begin{bmatrix} f_{1,1} & \cdots & f_{1,s} \\ \vdots & \ddots & \vdots \\ f_{o,1} & \cdots & f_{o,s} \end{bmatrix} \times \begin{pmatrix} I(s) \\ \begin{bmatrix} s_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & s_s \end{bmatrix} \end{pmatrix} = \begin{bmatrix} t_{1,1} & \cdots & t_{1,s} \\ \vdots & \ddots & \vdots \\ t_{o,1} & \cdots & t_{o,s} \end{bmatrix}$$

We redefine S based on groupings of O*NET training sources to consist of 6 training sources: school, university, on-the-job learning and formal professional training. These results are aggregated to calculate, for each occupation, the total number of hours required at each training source.

5. Estimate time training on each relevant skill for each occupation

To estimate, the number of hours each occupation has spent on each relevant skill, we begin with assessing which skills are relevant to each occupation. We create an occupation importance score matrix, which stores O*NET's importance score data for each KSAW, for each occupation. We assume that if a KSAW has an importance score greater than 3, the KSAW is relevant to the occupation (Scale of 1-5, where 3 is the minimum score that O*NET uses to assess relevance of KSAW to occupation). Based on the assignment of KSAWs to training sources, we create a $o \times k$ binary value matrix R_s where o the number of occupations and k is the number of skills.

Elements take a value of 1 over the number of skills learnt at source s if the skill is important to an occupation, and the skill is acquired at that source of education:

$$R_s = \begin{bmatrix} r_{1,1}(s) & \cdots & r_{1,k}(s) \\ \vdots & \ddots & \vdots \\ r_{o,1}(s) & \cdots & r_{o,k}(s) \end{bmatrix}$$

$$\text{where } \begin{cases} r_{k,o}(s) = \frac{z_{k,o,s}}{\sum_{k \in K, o \in O, s \in S} z} \in \{0,1\} & k \in K \text{ where } z = 1 \text{ if } (\text{imp}_{k,o} \geq 3) \ \& \ (\text{source}_k = s)0, \\ r_{k,o}(s) = 0 & \text{if } (\text{imp}_{k,o} < 3) \ \text{or } (\text{source}_k \neq s) \end{cases}$$

The time spent on training for each skill by each occupation by source s for each source is given by:

$$OK_s = \begin{bmatrix} ok_{1,1}(s) & \cdots & ok_{1,k}(s) \\ \vdots & \ddots & \vdots \\ ok_{o,1}(s) & \cdots & ok_{o,k}(s) \end{bmatrix} = \begin{pmatrix} T(s) \\ \begin{bmatrix} t_{1,s} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & t_{o,s} \end{bmatrix} \end{pmatrix} \times \begin{bmatrix} r_{1,1}(s) & \cdots & r_{1,k}(s) \\ \vdots & \ddots & \vdots \\ r_{o,1}(s) & \cdots & r_{o,k}(s) \end{bmatrix}$$

6. We recategorise O*NET data on skills, knowledge, abilities and work styles (KSAW) into three capability clusters: knowledge, abilities and characteristics as shown in Exhibit 16

EXHIBIT 16

How much training do Australians in the labour force currently have?

Skill Groups	Abilities	Knowledge	Skills	Work Styles
Knowledge		✓		
Abilities	✓		✓	
Characteristics				✓

7. We aggregate the results for each cluster based on the recategorisation in Exhibit 16
8. We then apply these 2014 estimates to 2018 occupation data (i.e. the number of people in each occupation) to calculate the total stock of hours for each capability cluster acquired by people in the 2018 labour force
9. We align these estimates with ABS data on total stock from each source estimated in A.2.1

We adopt a different approach to work styles (recategorised characteristics) because we cannot neatly assign a training source to work styles. This is because the development of characteristics can occur outside formal education and training settings. Therefore, we cannot use the change in required education and training for each occupation to imply the changes in time spent learning work styles as we have done for knowledge, skills and abilities.

We use the historical change in O*NET's importance scores for work styles as a proxy for the change in required training time, to derive a growth rate to be applied to our 2018 stock of hours (that is, hours spent acquiring characteristics). We test the significance of applying a different methodology to work styles, by doing a like-for-like comparison in the change in importance scores for all KSAWs over the time period. We observe a significant difference in the change in importance scores for work styles, as compared to all other KSAs. The average historical change was 8 times larger than the change for all other KSAs. Therefore, if we had applied this method to other KSAs, this would have yielded an even larger growth rate for characteristics. Accordingly, there is plausible reason to believe that our estimate of the change in characteristics is conservative. We apply another precaution to avoid overestimating the growth in characteristics by discounting the growth rate for work styles. We apply a conservatism factor of 20% to the growth rates for each work style.

We translate the results of the US data analysis into the Australian context. This report determines how training hours have changed in the Australian economy by matching US occupations with their Australian equivalent using concordance tables. To complete the picture, and determine Australian education and training trends, it combines occupational training data with Census data on

An exception to the above method is how we estimate how much time has been spent learning each KSA in school. Here, we use existing Australian data on school subjects and recommended teaching time for each subject, for each year of school, to calculate the share of time spent learning each subject.²⁵ We then map subjects in the school curriculum to KSAs from O*NET using the level scale anchors. Taking the current stock of hours spent in school estimated in Section A.2.1, we distribute this across these subjects, according to shares for each KSA cluster. Finally, to calculate the total time spent learning each KSA, we apportion the respective time spent on each individual subject to the number of relevant KSAs to calculate the total time spent learning each KSA.

²⁵ *Time allocations and entitlement – Advice on implementing the Australian Curriculum F(P) – 10*, Queensland Studies Authority (QSA), based on information available in 2011

A.3 Estimating the stock of skills required in 2040

To understand how education and training requirements will change over the next 22 years, we take, for each source of education, observations of Occupation/Skill (OK) training hours at different points in time. This allows for a detailed analysis of changes within and between jobs. For example, by taking the difference between OK2006 and OK2014, the total change in hours spent on each skill is given for the elapsed time period. We calculate annual growth rates between 2006 and 2014 and use this to extrapolate our initial 2018 estimates to 2040 to estimate the impact of task changes on required training hours.

There are a few exceptions to this overall approach. As stated in Section A.2, we do not use O*NET data to estimate time spent in school, and therefore the changes associated with learning at school. Instead, we assume an individual's maximum time spent in school will not change but do take into account population growth and rising completion rates using ABS and Census data.

Furthermore, we use historical Australian trends on growth in university completion from the Census, to predict overall change in university hours in the future. We then use the results from the O*NET analysis to distribute the change in hours across knowledge, abilities and characteristics.

To account for the fact that workers who are over the age of 25 are unlikely to return to university, we reappportion the additional training attributable to these workers from university to formal professional training. We assume that the share of the labour force that is over 25 over the period, is constant.

A.3.1 Estimating retraining hours

Steps

1. Project labour force growth to 2040 using ABS data on historical labour force growth rate. Estimate the number of new workers added each year, and the number of remaining current workers.
2. We use annual HILDA data to understand the frequency of job changes in the labour force. We determine the percentage of people who:
 - Stay in the same occupation, and same industry (this includes changes in employer)
 - Move to a different occupation, but stay in the same industry
 - Move to a different industry, but stay in the same occupation
 - Move to a different occupation and different industry
3. Assuming those percentages stay constant, we can calculate the instances of movement across the labour force over the next 22 years for both groups of workers, current and future. That is, for each year, we calculate the number of people who stay in the same job, move to a different occupation but stay in the same industry etc.
4. We assign each scenario a retraining profile (Exhibit 17)

EXHIBIT 17

Scenario	University or VET	Formal training	On-the-job training
Move to a different industry, but stay in the same occupation		✓	
Move to a different occupation, but stay in the same industry		✓	✓
Move to a different occupation and different industry	✓	✓	✓
Retraining hours	Weighted average of university and VET hours for Bachelors or Cert IV qualification	1 year of the average annual time spent in formal professional training	1 year on-the-job learning, learning at 25% of time working

- We aggregate the instances and types of job movement to estimate the overall retraining hours that will need to be undertaken from now to 2040.
- We distribute these total retraining hours across knowledge, abilities and characteristics based on their respective shares of total hours in 2040 determined from analysis in Section A.3

To understand how many hours of training an average person acquires over their working life in 2018, we divide the total training stock in hours by the current number of people in the labour force. For 2040, population growth was removed, and the 2040 stock of skills was divided by the number of workers in 2018 to estimate hours of training per person over their lifetime.

A.4 Measuring how many workers may change jobs by 2040

This report seeks to quantify the need for reskilling by examining the likelihood of occupation change among people who are currently part of the Australian workforce. We use HILDA survey data on occupation change to estimate the probability of a person changing occupation in a given year, and then simulate how many people will likely stay in their existing occupation, and how many might leave, for each year between 2018 and 2040. We also assess how likely these occupation changes are for different age groups. We use a Monte Carlo simulation (a process to model the probability of different outcomes) to evaluate how many people we expect to change occupations never, once, twice, three times, or four times or more by 2040.

A.5 Measuring task change in Australian occupations

The analysis of task change in Australia is based on information from the US government's O*NET database. The O*NET database contains detailed information on more than 2,000 work-related activities for over 1,000 occupations. It includes data on how often a worker performs certain tasks in a job, regardless of whether these tasks require manual work or brain work.

We analysed task-related data for the years 2006 and 2014 and extrapolated the trends we observed into the future to cover the decade between 2006 and 2016. In a first step we converted the data on task frequency into timeshares and fitted it to match the total weekly work hours for each occupation. We then used a unique method to measure how the time workers spend on each task changed per year.

Changes in the time workers spent per task were summed up for each occupation and for the economy as a whole. In a final step, we translated our results into the Australian context by converting American occupations into equivalent Australian occupations using concordance tables mapping US SOC and ANZSCO codes.

A.6 Measuring the fastest growing skills

Steps

1. Undertake analysis in A.2 and A.3, however do not aggregate results into capability clusters (knowledge, abilities and characteristics)
2. Calculate average annual growth rates in hours for each KSAW and level (approximately 500+), for each occupation cluster
3. Rank each KSAW in each occupation cluster based on annual growth rates

A.7 List of skills covered by this analysis

See Exhibit 18

EXHIBIT 18

KNOWLEDGE		
<ul style="list-style-type: none"> ▪ Psychology ▪ Sociology and Anthropology ▪ Geography ▪ Therapy and Counseling ▪ Education and Training ▪ English Language ▪ Foreign Language ▪ Fine Arts ▪ History and Archaeology ▪ Philosophy and Theology ▪ Public Safety and Security ▪ Law and Government 	<ul style="list-style-type: none"> ▪ Administration and Management ▪ Clerical ▪ Customer and Personal Service ▪ Personnel and Human Resources ▪ Transportation ▪ Production and Processing ▪ Food Production ▪ Computers and Electronics ▪ Engineering and Technology ▪ Design ▪ Building and Construction 	<ul style="list-style-type: none"> ▪ Mechanical ▪ Mathematics ▪ Physics ▪ Chemistry ▪ Biology ▪ Medicine and Dentistry ▪ Telecommunications ▪ Communications and Media ▪ Economics and Accounting ▪ Sales and Marketing
ABILITIES		
<ul style="list-style-type: none"> ▪ Arm-Hand Steadiness ▪ Manual Dexterity ▪ Finger Dexterity ▪ Control Precision ▪ Multilimb Coordination ▪ Response Orientation ▪ Rate Control ▪ Reaction Time ▪ Wrist-Finger Speed ▪ Speed of Limb Movement ▪ Static Strength ▪ Explosive Strength ▪ Dynamic Strength ▪ Trunk Strength ▪ Selective Attention ▪ Time Sharing ▪ Monitoring ▪ Time Management ▪ Management of Financial Resources ▪ Management of Material Resources ▪ Management of Personnel Resources ▪ Programming ▪ Perceptual Speed ▪ Spatial Orientation ▪ Visualization 	<ul style="list-style-type: none"> ▪ Stamina ▪ Extent Flexibility ▪ Dynamic Flexibility ▪ Gross Body Coordination ▪ Gross Body Equilibrium ▪ Oral Comprehension ▪ Written Comprehension ▪ Oral Expression ▪ Written Expression ▪ Active Listening ▪ Speaking ▪ Active Learning ▪ Social Perceptiveness ▪ Coordination ▪ Persuasion ▪ Negotiation ▪ Instructing ▪ Service Orientation ▪ Critical Thinking ▪ Learning Strategies ▪ Complex Problem Solving ▪ Judgment and Decision Making ▪ Systems Analysis ▪ Systems Evaluation ▪ Speed of Closure 	<ul style="list-style-type: none"> ▪ Operations Analysis ▪ Technology Design ▪ Equipment Selection ▪ Installation ▪ Operation Monitoring ▪ Operation and Control ▪ Equipment Maintenance ▪ Troubleshooting ▪ Repairing ▪ Quality Control Analysis ▪ Reading Comprehension ▪ Writing ▪ Mathematics ▪ Science ▪ Fluency of Ideas ▪ Originality ▪ Problem Sensitivity ▪ Deductive Reasoning ▪ Inductive Reasoning ▪ Information Ordering ▪ Category Flexibility ▪ Mathematical Reasoning ▪ Number Facility ▪ Memorization ▪ Flexibility of Closure
CHARACTERISTICS		
<ul style="list-style-type: none"> ▪ Achievement/Effort ▪ Persistence ▪ Initiative ▪ Leadership ▪ Cooperation 	<ul style="list-style-type: none"> ▪ Concern for Others ▪ Social Orientation ▪ Self Control ▪ Stress Tolerance ▪ Adaptability/Flexibility 	<ul style="list-style-type: none"> ▪ Dependability ▪ Attention to Detail ▪ Integrity ▪ Independence ▪ Innovation ▪ Analytical Thinking

A.8 Education and training hours assumptions

EXHIBIT 19

Qualification	Hours	Calculation
Certificate III	2,400	37.5 weeks a year x 32 weeks a year x 2 years
Certificate IV	1,200	37.5 weeks a year x 32 weeks a year x 1 year
Diploma	2,400	37.5 weeks a year x 32 weeks a year x 2 years
Associate Degree	2,400	37.5 weeks a year x 32 weeks a year x 2 years
Advanced Diploma	3,600	37.5 weeks a year x 32 weeks a year x 3 years
Bachelor Degree	3,600	37.5 weeks a year x 32 weeks a year x 3 years
Graduate Certificate	600	37.5 weeks a year x 32 weeks a year x 0.5 years
Graduate Diploma	1,200	37.5 weeks a year x 32 weeks a year x 1 year
Master Degree	2,400	37.5 weeks a year x 32 weeks a year x 2 years
Professional Specialist Qualification, Doctoral Level	4,800	37.5 weeks a year x 32 weeks a year x 4 years
Doctoral Degree Level	4,800	37.5 weeks a year x 32 weeks a year x 4 years
Postgraduate Degree Level	3,600	37.5 hours per week x 32 weeks a year x 3 years



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