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White Paper

Widening the talent pipeline: Facilitating STEM careers in New-Collar jobs in Australia

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Abstract

This White Paper highlights the changes required to resolve structural problems in the labour market that hinder the rapid creation of new digital work roles. Demand for scarce digital skills constantly outstrips the supply of qualified candidates, creating a persistent shortage of talent, depriving organisations of the talent they need to deliver innovation and operational performance, driving up the cost of labour, increasing the risk of cybersecurity attacks, and reinforcing Australia's dependence on foreign technology and expertise. To resolve this problem, this paper argues for advancing educational solutions beyond traditional 3 or 4 year STEM degree courses that unnecessarily delay the delivery of the talent required to drive economic growth and fail to stimulate the cross-disciplinary study or human capabilities required in future work. The paper proposes that supply-side solutions from educators and government must be complemented by employers' efforts to create entry-level jobs and hire candidates for their capabilities rather than for their technical qualifications. To illustrate this point, the paper advances models that are effective in ensuring STEM professionals are able to earn while they learn. Through a combination of formal learning, experience, and credentials that stack into formal qualifications, the talent pipeline can open up STEM careers to a broader range of candidates and strengthen the supply of human capital required by businesses to transform our economy during and after the COVID-19 pandemic.

Introduction

Over the last decade, the economic success of nations has increasingly been tied to the link between student achievement in science and math tests and the growth in per capita gross domestic product (GDP).[1] This has perpetuated the widely held belief that graduating students from science, technology, engineering, and maths (STEM) degree courses will lift a nation's global competitiveness, the idea being that this pool of human capital will lead to scientific research and technological innovations.

The hope has always been that a significant number of jobs for STEM graduates with computing and digital skills and knowledge – so called 'new-collar' jobs – would be created as digital transformation and industry 4.0 strategies reinvigorated the competitiveness of industries such as manufacturing, health, agriculture, banking, logistics and transport, and mining in Australia.[2] However, responses to the coronavirus have brought the future forward. Australia has not only seen the employment of nearly 780,000 citizens disrupted, but, paradoxically, the pandemic has resulted in humans' work roles and tasks being replaced by technology earlier than predicted. Five-year automation and workforce reform plans made in 2019 have been recalibrated in the first 6 months of the pandemic to now be ready for execution in 2021. Consequently, automation and digital disruption will trigger further loss of employment well before digital transformation can create demand for new work roles (jobs).

The advancement of the digital transformation of business and automation does not respect the boundaries between blue- and white-collar jobs. The work physical and routine work roles of traditionally blue-collar jobs are not the only ones being automated. In a world disrupted by COVID-19, it is the higher-cost professional and managerial roles performed by white-collar workers that are equally vulnerable to automation. This is being accentuated as powerful computing technologies and advances in Artificial Intelligence (AI), machine learning and cognitive computing replicate human activities such as analytical thinking, knowledge processing, and decision analysis.

Although prospects for white- and blue-collar jobs may be restricted due to automation and digital transformation, they are being increased for those seeking to access new-collar jobs. Unfortunately, the pandemic has accentuated the failure of educational institutions to appreciate the full extent of the shift in demand for expertise, and few employers are able to

clearly express their demand for this new category of workers in a manner that presents a coherent market signal to educators and students to develop new technical skills.

In economic terms this is referred to as a 'market failure' – "When a market left to itself does not allocate resources efficiently".[3] This paper examines several key aspects of the misalignment or failure in the market to supply sufficient new-collar workers. As an indicative study, the focus is on two of the largest areas of talent misalignment in the Australian market: cybersecurity and data science. In this context, evidence of supply-side market failure includes:

a. The proliferation of alternative credentialling standards – driven by the rapid adoption of non-traditional, work-based, short, and vendor courses - has resulted in a confusing array of training options of varying quality and relevance.
b. Concurrent federal and state government curriculum reviews have complicated and delayed efforts to standardise and reform the supply of digital skills from the school–level and vocational STEM curriculum.
c. Paradoxically, political attention to STEM skills has reduced the attention schools have given to the development of critical professional and human capabilities ("soft-skills" or "enduring skills") needed in the new-collar workforce.[4]
d. The lack of ongoing professional development and mentoring for practitioners in these new professions manifests itself in variable levels of professional development, high stress, and burnout, leading to the high turnover of staff and a lack of career progression, which then leads to an underdeveloped and transient workforce.

On the demand side, employers' talent management strategies lack vision and common problems remain, such as the:

a. Absence of a consolidated employment marketplace where graduates can access the majority of immediate employment opportunities provided by the major vendors and financial institutions. Although there is large and growing demand in the public sector, wages and professional development prospects are not competitive with the private sector.
b. Lack of reliable market data due to the variability of job definitions and how skills are described, the proliferation of niche security and data technologies and vendors, rapid changes in the threat environment, and how organisations set workforce priorities and budgets, and conduct pre-hire assessments.
c. Lack of ongoing professional development and career support for practitioners which is leading to perceived uncertainty over the viability of a new-collar 'career', abnormally high levels of stress, and staff turnover which is leading to consequentially high comparative costs associated with new-collar staff.
d. Lack of entry level roles (and consequential lack of diversity) in the data science and cybersecurity workforce due to the way the work is organised by major employers and the preference given to traditional hiring requirements based on academic qualifications and years of service as opposed to capability (human and technical) or competence.
e. Most major specialist data and security organisations are still operating at low levels of efficiency with fragmented organisational structures, redundant tooling, and low levels of integration and automation in their security operations processes. This is leading to systemic difficulties in providing well-rounded development and mentoring for new employees. Consequently, women and other minority groups are being discouraged from seeking new-collar roles.
f. Many employers have turned to contract workforces to improve access to scarce digital skills. However, the matching of freelance workers to what an employer needs in a team or projects has been fraught with problems. For instance, it is hard for employers using divergent ways of describing new-collar work roles and personal skills to then use the freelance and contract worker portals to not only find the right technical skills but also a person who has the human capabilities to 'fit' their organisation's culture and strategic vision.

Let's move on to explore the backdrop to these issues.

New-Collar Workers

New-collar workers, as originally framed by IBM, are individuals who work in the emerging digital jobs that don't conform to traditional blue- and white-collar distinctions. According to this framing, the education to acquire these jobs does not fit the usual college degree models. In a letter to President Trump, IBM CEO Ginni Rometty argued that new-collar workers are far more likely to develop the human, digital, and specialist technical capabilities through non-traditional education pathways.[5] This propels them into emerging digital jobs in high demand areas where too few skilled graduates exist to meet employer requirements. As the gap between supply and demand widens, many global employers do not have time to wait for people to graduate from traditional diploma or bachelor degrees.[6]

Typical non-traditional pathways into new-collar roles involve a seamless mix of working, learning, and earning. A non-traditional pathway, for example, may commence with a vocational or vendor certificate acquired over three to 12 months. It may then segue into an internship or entry-level role where, through further learning and experience, the participant acquires certain digital credentials that grant entry to more advanced roles.

Examples of fast growing new-collar roles include those associated with digital activities such as:

- Cloud and data
- Data science
- Cybersecurity
- Software development
- Data analysis, machine learning, AI
- Privacy and trust

New-collar roles are found in many other industries besides computing and IT, including banking and finance, health, education, agriculture, media and communications, manufacturing, supply chain, mining, and creative arts. Moreover, new-collar roles, by definition, are not exclusive to blue-collar (labourer) or white-collar (professional) domains. Consider, for instance, the current new-collar jobs with skill gaps, such as agile project manager, service delivery analyst, systems accountant, market data modeller, crop hydrologist, or transport systems technician.

The Talent Challenge: The Demand Side

Over the five years from May 2019 to 2024 the Department of Education, Skills & Employment (DESE) estimate the STEM workforce will grow by 303,200 people.[7] However, these jobs will exist and be created as part of a massive structural transformation of the Australian workforce.

By 2028, analysis indicates that, whereas 3.9 million jobs in Australia will be irrevocably changed due to automation, this digital tsunami will also create an estimated 2.4 million new jobs, half a million of which will be digital jobs.[8] These new-collar roles will emerge at all levels of the workforce, i.e., technical and trade (pre-degree) and professional (bachelor degree).

Certain new-collar jobs will be in more demand than others. For example, global estimates by IBM suggest cybersecurity architects will have a talent acquisition shortfall of 1.8m by 2022.[9] The demand for data scientists follows a similar path. Estimates suggest that in 2022, even if all graduates from all relevant courses stayed in Australia and were hired as a data scientist, employers will still require another 8,000 new entrants.[10]

Post-COVID, economic and social recovery will rely very heavily on building sovereign capability in our workforce. This is where the nation has to build human capital within its jurisdiction to solve the challenging problems that affect economic growth and global competitiveness. To this effect, we must solve the new-collar talent pipeline if we intend to:

- Meet national security demands whereby we must develop and control the capacity to perform certain security roles.
- Develop local talent able to drive and sustain healthy cybersecurity and data science industry capabilities.
- Revitalise businesses or accelerate transformation, as the post-pandemic recovery will be driven by the more flexible and responsive digital and online systems and services.[11]
- Remove or manage risk in digital activities that rely heavily on data to make informed decisions and security operations that shouldn't be solely dependent on offshore resourcing.

Demand for cybersecurity talent

The severity of the cybersecurity skill gaps was confirmed when Cyber Seek, which estimated that nearly 716,000 cybersecurity professionals were employed in the US in early 2020, announced an additional 500,000 would be required by the end of by 2021.[12] In Australia, AustCyber predicted graduates from cybersecurity and related degrees in Australia would total just 2,000 per annum in 2019, but another 17,000 people would be required by 2026 to keep up with demand.[13]

Currently, there are some 73,000 security professionals[14] working in the Australian and New Zealand (A/NZ) talent pool.[15] Employment is growing at a compounded annual growth rate of 16 percent. The movement of staff between employers is very high. Some 24 percent of all staff (17,551) have changed jobs in the past 12 months, and 12 percent have changed employers. The movement of staff is not due to the profession finding sourcing new talent, but from employers 'poaching' existing staff from competitors. As a result of recycling existing workers and the persistent failure to recruit for human capabilities (e.g., ability to collaborate, show empathy, or 'fit' with the culture or team), attrition and the cost of recruiting cybersecurity staff is an ever increasing business expense.[16]

Information Technology (IT) vendors and banks are the biggest employers in the cybersecurity talent pool. Hiring by banks increased substantially in 2019-20, whereas most IT vendors lost talent.

Table 1 - Employers cybersecurity talent, fulltime workers, Australian and New Zealand, Oct. 2020

Company	Est. Cyber Workforce	Attrition
Telstra	1,094 (-8%)	19%
Commonwealth Bank	619 (4%)	16%
ANZ	595 (5%)	11%
NAB	574 (8%)	19%
AWS	460 (28%)	9%
Westpac	415 (2%)	16%
IBM	413 (-7%)	14%
DXC	388 (-9%)	28%
Datacom	379 (-3%)	23%
Cisco	351 (-6%)	16%

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Demand for data science talent

As early as 2017, it was predicted that the United States would create 364,000 job openings by 2020 for data and analytics talent, yet the supply of graduates would only meet half that number.[17] Furthermore, some 61,799 of those job openings would be for data scientists and graduates with advanced analytical skills. In 2020, you do not have to convince business, government, or decision makers of the value that data and the resulting insights can provide. The demand for data scientists and related data engineering, data architecture, data analysis, and business intelligence talent has increased as companies automate data collection and processing, advance big data programs, harness machine learning, deploy sensors, attempt to measure the success of their new digital and online business models, and respond rapidly to new digital revenue opportunities triggered by ever changing customer expectations in a world turned upside down by COVID-19.

In Australia, data analytics and data science jobs underpin improve decision making and the digital transformation of business. With a survey of CIOs confirming 76 percent of businesses intended increased investment in analytics capabilities, it is no surprise job advertisements for data scientists and data analysts have, respectively, increased by 60 and 78 percent from 2018 to 2020.[18] Nor is this growth in demand only in the IT sector; it is across all industries. Organisations in finance, retail, agriculture, health, and transport all compete for data science capabilities to improve customer experience, accelerate transformation, or increase productivity.

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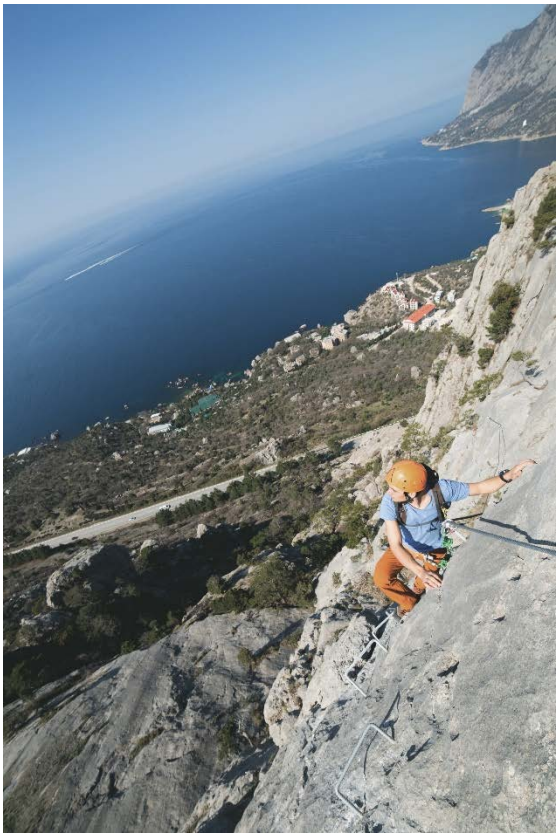
The Talent Challenge: The Supply Side

Universities are rewarded for their ability to attract and graduate more science, technology, engineering and mathematics (STEM) students. This is because STEM students are deemed to be worth comparatively more to the economy and to an institution than, say, a humanities student in terms of income from the students' contribution and grants for Commonwealth supported places. The Commonwealth has actively used funding to "incentivise" students to take up courses in education, nursing, allied health, clinical psychology, agriculture, mathematics, engineering, science, environmental studies, and medical science. For instance, reforms announced in June 2020 will see a domestic Australian student currently on a three year bachelor receive a $1,100 Commonwealth annual contribution alongside the $14,500 the student must contribute when enrolled in business and commerce, but a student enrolled in a STEM course such as mathematics will receive $13,500 from the government while paying only $3,700 themselves.[19]

The Commonwealth government argues that funding reflects the fact that STEM courses generating graduates who are more immediately employable. Certainly, in Australia, STEM-related jobs grew at least twice the rate of non-STEM jobs between 2014 and 2020.[20] However, the growth of STEM jobs is dominated by new-collar jobs that require new approaches to higher education: in terms of both the duration of study and how well most universities can deliver curricula that move beyond professional knowledge to encompass skills training.

The solutions required to service the demand for new-collar jobs demand non-traditional approaches to curriculum design. Moreover, the approach needs to balance the transfer of a technical body of knowledge with the acquisition of the digital and human skills required in the future workforce. Whereas employers may seek to access talent prior to the of 3 or 4 year degrees, and students may embrace entering the workforce earlier and earning while they learn, this is anathema to the very foundations of the traditional approach, whereby a university must be an autonomous institution driven by the individual pursuit of knowledge.[21] Many academics even struggle to accommodate the concept of offering select units of study with micro-credentials, as this provides the opportunity for the students to 'cherry pick' what they want rather than enrol in the full course. This is a debate that has echoes back to other content industries, for instance musicians decrying the digitisation of assets that allowed users to choose songs rather than buy the full album.



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Solution 1: Apprenticeship-by-Degrees

Just as new-collar jobs do not respect the divisions between blue-collar technical jobs and white-collar professionals, so we need new-collar apprenticeships that traverse both vocational education and training (VET) and higher education sectors.

The change accelerant that is COVID-19 is reshaping the workforce so rapidly that neither a competency-based approach by VET providers nor traditionally designed university courses are adequately equipping students for the jobs that will remain or be created.

Let us examine an apprenticeship-by-degrees model that highlights the features of good curriculum design.[22]

Vocations tied to traditional trades customarily use apprentices. Typical examples are the 'tradies' (building, construction, mechanical, mining, etc). Over the past few decades, they have expanded to include service industries and

traineeship models based on vocational training tied to national competency standards. Australia has also trialled higher apprenticeships as a superficial fix to bridge formal vocational education with structured on-the-job training. This raises participants beyond trade certificates to diplomas that open entry to semi-professional, associate, and technical roles.

Whereas professions such as accounting, medicine, engineering, teaching, nursing, etc. have strong roots in vocational education, we do not call their participants apprentices. Instead, we rely on formal university-based study accompanied by internships, placements, and supervised workplace experiences, all wrapped up in a bachelor or post-graduate degree.

Evidence-based research surrounding applied projects with a number of large corporations reveals that a combination of vocational training *and* vocational education will achieve excellent results. However, it requires non-traditional learning models, because the participants can undertake technical skills in the vocational training elements within a higher education degree.

The projects with larger companies and professional bodies appear to seek four common outcomes:

a) Fill roles where substantial deficiencies exist in the talent supply pipeline.
b) Create a workforce that is both work-ready and able to transfer learning into an employer's context.
c) Reskill to rapidly overcome skill misalignments where new recruits from school or the existing talent pool hold skills appropriate for jobs that are being augmented or replaced by technology.
d) Ensure those in the programs acquire capabilities that prepare them for a career, not a specific job.

Rather than prepare workers for a discipline or narrow vocation, apprenticeships-by-degrees model focuses on filling work roles that do not conform to existing professional or occupational boundaries.

Applied in some of Australia's largest wholesale, retail, business services, and mining companies, the model challenges our concept of a 'traditional' curriculum.

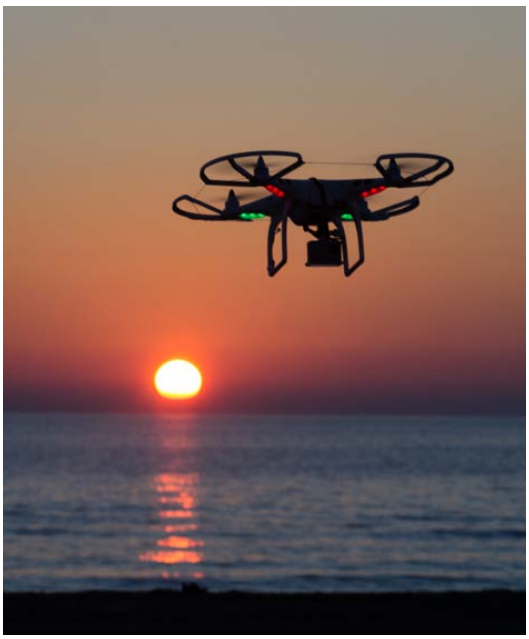
Solution 2: Digital Credential Stacks

The apprenticeships-by-degrees model fundamentally challenges vocational and higher education institutions to develop the capabilities required by graduates to be employable across multiple jobs or occupations. This means the biggest potential failure of this approach could be a failure to develop and recognise capability, whereby the individual cannot use credentials to study or work beyond one employer or a specific vendor technology. To overcome this, all capabilities should carry a mix of highly transferable and employable human capability standards (related to soft skills and enduring common competencies)[23] as well as the specific new-collar technical capabilities.

As with skill sets in vocational training, capability clusters are capabilities related and stacked together because they have a known relationship with certain types of job roles or activities. Capability clusters allow course designers to prepare students to work in growing or emerging areas where the 'job' doesn't exist yet but the majority of the capability requirements are known. Using this model, the design of apprenticeships-by-degrees in new-collar areas can allow learners to stack and package a few critical capabilities that will open what have been termed job neighbourhoods or job corridors.

Job neighbourhoods are role clusters where work activities[24] are underpinned by common capability requirements. A person wishing to transition to a new career or to emerging work opportunities can use a **job corridor** to move from a declining job neighbourhood to one with a positive growth outlook.

Capability profiles allow staff to match their own profiles to a preferred career or job neighbourhood. For employers, they can find staff where capabilities beyond their current role were invisible, underappreciated, or underused and align them towards a skill gap.[25] For instance, a major bank discovered that rather than upskill data analysts to fill the talent shortfall in data scientists, the better option was to target those in business intelligence (BI) roles. In particular, it was the possession of cognitive and business-centred problem-solving capabilities that made the significant difference. The job corridor established consisted of a stack of four capabilities the bank used to rapidly realign 120 internal BI staff to fill the shortage of data scientists.[26]



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Solution 3: Vendor Certification

There are various vendors' proprietary technology credentials, and private credentialling systems can help a person improve their potential for employment.

However, certifications can be very vendor-centric (e.g. Microsoft, Cisco, IBM, Google). Their purpose is to validate a person's skill level and quantify them to work on products, processes, or functionality related to a vendor's product. The problem is that they can ignore the human capabilities and the wider customer, system, or contextual needs an employer may seek.

The certification, digital badges, or credentials are against criteria set by the vendor. These lack comparability in terms of standards or levels of proficiency. What one vendor thinks is important can and will vary with another, as do the learning requirements and outcomes. This is evidenced in the major certifications in the global field of information security:

1. From EC-Council the Certified Ethical Hacker (CEH)
2. From CompTIA Security+ (CySA+) or Advanced Security Practitioner (CASP+)
3. From $(ISC)^2$, such awards as the Certified Information Systems Security Professional (CISSP), Systems Security Certified Practitioner (SSCP) or Certified Cloud Security Professional (CCSP)
4. From ISACA, the Certified Information Security Auditor (CISA) or Certified Information Security Manager (CISM)
5. GIAC Security Essentials (GSEC)

Solution 4: School-based initiatives

A number of innovative solutions to expand the Talent supply pipeline have involved working with demand owners (employers) who are prepared to cast their talent net wider, beyond traditional academic ecosystems. This includes solutions that focus on skills development in long-underappreciated talent pools.

One such solution is IBM's P–TECH program.[27] This is a public-education model that provides high school students from underserved backgrounds with the academic, technical, and professional skills and credentials they need for competitive STEM jobs. The focus is on working with groups such as high school or college students. The approach provides a learning journey that seamlessly connects coursework with workplace experiences that include industry mentoring, worksite visits, paid internships, and early access to employment opportunities with companies partnering the school.

Another exemplar initiative is a program by Beenleigh State High School in Queensland.[28] It issues a comprehensive learner profile that includes micro-credentials (badges), the aim being to future-proof students and ensure they have a comprehensive capability profile including general capabilities, endorsed by local employers. By doing this in high school, students and employers can get a clearer sense of each person's potential beyond a curriculum outcome.

Not all doors to employment in the future workforce will be opened by the ATAR score awarded to tertiary aspirants, or the myriad of degrees, diplomas and certificates graduates may later obtain. Less than one quarter of our students actually go for a university pathway. The rest of our students are looking for jobs.

Mr Matt O'Hanlon, Principal, Beenleigh State High School

Solution 5 Immersive learning

Another very successful approach to developing the next generation of successful data analysts and scientists has been to design learning as an immersive experience.

Many employers are now laud the role of immersive programs such as run by the Data School in supplying potential new hires.[29] Established in London, it now has academies worldwide. The program centres. Students enrol on a 4-month initial training course in technologies such as Tableau and Alteryx, and coverage of essential soft skills. They then do four placements of 6 months with partner organisations.[30] We now have employers that will create entry level roles in functions such as Business Intelligence so Data School students from across the globe can be placed with them. This is because every intern is seen as a potential recruit. However, the uplift of the business capability isn't just about technical knowledge or skills; the data workers to are hired must demonstrate their ability to collaborate and adapt.[31] As with existing employees, this encourages continuous learning by creating opportunities for interns or new hires to undertake personalised work experiences, mentoring, or training programs. The associated costs are considered an investment by the business in talent development and future productivity. [32]

Conclusion

The concentration of the cybersecurity and data scientist workforce among the major employers (i.e., security vendors and banks) indicates that, when combined with the supply and demand imbalances, Australia is set to endure a persistent shortage in new-collar talent. In data science and cybersecurity, alongside other in-demand digital capabilities, the shortage is likely to produce a number of undesirable outcomes including greater dependence on offshore resources, increased cybersecurity and data management risk, and the 'poaching' and recycling of existing talent at ever increasing salaries, instead of investing in the development of a pipeline supplying new entrants.

The increasing integration of security and analytics capabilities across all business operations indicates that the demand for new-collar capabilities will extend across all sectors of the economy. This suggests that the growth of Australia's digital economy is heavily reliant on how well all stakeholders can collaborate to better align supply and demand. Even in microcosm, resolving issues in cyber and data science areas suggests a need for graduates to develop technical, digital, and human capabilities that not only make them job ready for these roles but prepare them for a career where they can pivot towards emerging new-collar roles that are yet to be named.

The talent gap will continue to widen unless the supply- and demand-side challenges are addressed in a holistic manner. To widen the talent pipeline, three immediate actions are recommended:

1. Employers should commit to restructuring work to make more roles available to entry level candidates. This can be facilitated by standardising capability definitions tied to levels and work roles and focusing on hiring for technical and non-technical capabilities instead of just qualifications.
2. Employers need to aggregate and better report future demand for new-collar skills. Beyond recruiting STEM degree graduates, this includes strengthening their efforts to make these employment opportunities more accessible to people with diverse backgrounds, including women, disadvantaged groups, and indigenous and culturally diverse people.
3. Educators need to work towards using credentials to consistently recognise skills and capabilities obtained from diverse experiences including work, life, formal and informal learning within higher education, and vocational training programs.

Before we can address the shared challenge of creating and filling new digital work roles, we must create a national, cross-sectorial collaborative structure to resolving long-term supply and demand imbalances. This national approach must also include recalibrating our understanding that not all STEM roles either require nor will benefit from employees first completing a 3 or 4 year bachelor degree that may not place equal emphasis on technical and non-technical, human capabilities.

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[22] This section follows an earlier paper: Bowles, M. (July 2020). *The New Normal: When non-traditional education becomes normal*, The Institute for Working Futures. Retrieved 20 October 2020 at https://www.workingfutures.com.au/new-normal-part-3-why-non-traditional-education-is-part-of-the-new-normal/.

[23] The Human Capability Standards reference framework can be accessed at https://www.workingfutures.com.au/human-capability/.

[24] Job neighbourhoods or clusters of capability can aggregate, sort, and filter jobs and associated tasks and activities as classified in frameworks such as the Australian & New Zealand Standard Classification of Occupations (https://www.abs.gov.au/ANZSCO), or the International Standard Classification of Occupations (ISCO) as deployed by the US Department of Labour as the SOC in their O*NET online database (https://www.onetonline.org/).

[25] This principle underpins the Chartered Accountants ANZ Capability+ member profiling tool, see https://www.charteredaccountantsanz.com/learning-and-events/learning/ca-capability

[26] Bowles, M. & Lanyon, S. (March 2020). Review of data literacy capabilities, internal document DeakinCo., Melbourne.

[27] See https://www.ibm.org/initiatives/p-tech.

[28] Interview with Matt O'Hanlon, Principal Beenleigh State High School, Queensland, Australia (October 2020)

[29] Interview with Fiona Gordon, Global Director of Business Intelligence Strategy, JLL, 28 October 2020

[30] Data School Australia structure, journey and curriculum can be accessed at https://www.thedataschool.com.au.

[31] Interview with Fiona Gordon, 2020.

[32] Beaumont, S. & Gordon, F. (October 2020). Your Data Culture - A 20:20 Vision. Tableau Conference 2020