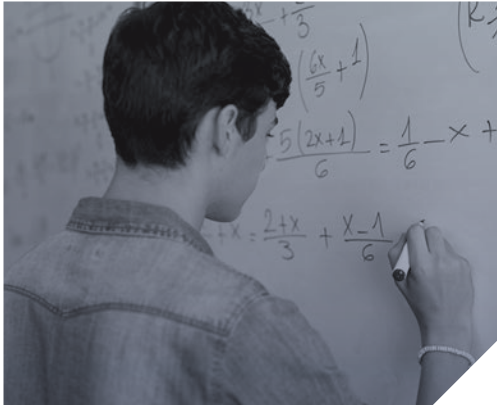
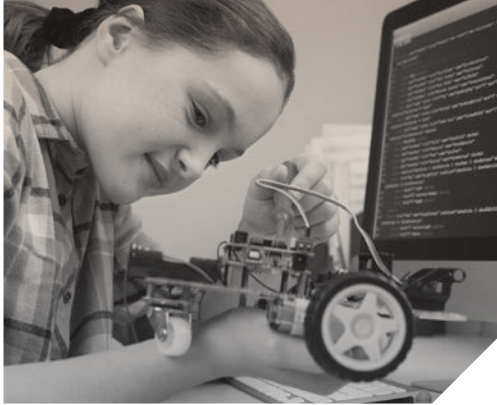


ATSE REPORT



OCTOBER 2022

Our STEM skilled future

An education roadmap for an innovative workforce

Australian Academy of Technological Sciences & Engineering

Our STEM skilled future:

An education roadmap for an innovative workforce

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Executive summary

Australia is faced with a national skills crisis.

Our nation currently lacks the capacity and critical capabilities to be able to deliver on our technology-powered, human-driven potential – both now, and into the future. The impacts of COVID-19 on border closures and impacts on skilled migration, coupled with rapid advances in business digitisation and transformation, have exposed the fact that Australia's workforce needs to be more resilient and responsive if we are to ensure we have enough science, technology, engineering, and mathematics (STEM) workers in the roles where they are needed most, and to prevent us from becoming a global digital and technological laggard.

The Fellows at the Australian Academy of Technological Sciences and Engineering (ATSE) have identified five key areas that require immediate attention if we are to unlock the country's technological potential. These are in the areas of mathematics, digital skills, agricultural technologies, engineering, and entrepreneurship. Expert Fellows in each of these domains highlighted the critical issues in these areas and hosted a series of five roundtables to consult Australia's leading experts across a broad and diverse range of sectors and industries and explore short and medium-term policy solutions to address the pressing challenges identified. Their topic-specific recommendations are presented in this report.

Four themes emerged as overarching recommendations that apply to each domain and to addressing STEM skills shortages more broadly. The recommendations acknowledge key work and initiatives to be learned from and built upon, wherever possible. They are:

Overarching Recommendations

- 1 Establish a National Skills Taxonomy to streamline consistent communication about needs and pathways among Australia's organisations and individuals.
- 2 Prioritise and invest in evidence-based approaches to STEM program development and assessment to ensure education and training is fit-for-purpose and provides value for money.
- 3 Promote and support a culture of lifelong STEM learning in the workforce to ensure Australia has the skills it needs now and into the future.
- 4 Raise the profile of STEM careers in Australia to showcase their accessibility and attractiveness.

An additional clear and resounding message emerged from the roundtables: Australia needs to work together to solve our current skills shortages. This includes all levels of government, industry, unions, peak bodies, educators, and individuals. Increasing diversity and inclusion (D&I) in the workforce was consistently called out as a critical enabler to move the needle on the identified workforce shortages, not just because it is the right thing to do, but because without an increase in workforce participation we will not fill our current capacity and capability gaps without relying on international labour.

Australia needs to design its STEM ecosystem in a manner that ensures we are accounting for the STEM skills we need both now, and into the future. Our national strategy needs to be robust, evidence-based, promote continual learning, and take a holistic, systems-thinking view of both challenges and opportunities. This is key to understanding and managing the factors that will either set us up for success or see us faltering on our potential to fully utilise the technologies we are discovering, developing and implementing.

Our country is not alone in facing STEM workforce shortages. We need swift and decisive action if we are to attract and retain the talented workforce Australia needs to be a strategic and competitive global player, or we otherwise risk losing our workers and technological discoveries to international counterparts. We need to act, and we need to act now. This report provides a roadmap to producing a the resilient, robust, and competitive STEM workforce that is well within our grasp.



Introduction

About ATSE

The Australian Academy of Technological Sciences and Engineering (ATSE) is a Learned Academy of independent, non-political experts supporting Australians to understand and use technology to solve complex problems. Bringing together Australia's leading thinkers in applied science, technology and engineering, ATSE provides impartial, practical and evidence-based advice on how to achieve sustainable solutions and advance prosperity.

ATSE is committed to:

- Exciting and educating young people in STEM
- Enhancing research collaboration, translation, and commercialisation
- Climate change mitigation and adaptation
- Helping Australia get technology ready

About this report

STEM education and skills are front of mind for the Academy as they are critical to Australia reaching its technology-powered, human-driven potential. ATSE's expert Fellowship has identified five key areas for exploration where the current and possible future lack of skilled workers will hold Australia back from reaching its aspirations. These areas are:

- **Mathematics in regional, rural and remote schools**
- **Digital skills: from coding to skills for the entire workforce**
- **Capacity development for a technology-driven agricultural transformation**
- **Addressing the engineering shortages**
- **Promoting entrepreneurial skills in Australia**

Across July and August 2022, ATSE held a series of national roundtables to explore key issues in each of these domains, and potential short and medium-term solutions to solve our skills shortages. The sessions were led by ATSE Fellows and were attended by over 120 individuals across industry, academia, and government (see complete list in the Appendix).

Findings highlight that collaborative national action between government, industry, education, unions, peak bodies, and individuals will be required to drive rapid and sustainable action. The overarching recommendations from the series of five roundtables are provided in this report, along with topic-specific recommendations.

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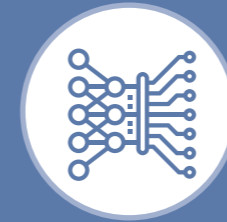
Professor Shaun Coffey FTSE

Director of Capacity Building, Crawford Fund

We particularly acknowledge the role of **Emeritus Professor Robin King FTSE** in developing this report. Robin sadly passed away in July 2022. Robin was renowned for his leadership and passion for addressing engineering education issues. During his retirement from engineering education, he held several senior positions with Engineers Australia and the Australian Council of Engineering Deans, in which he worked tirelessly to advance the engineering sector. We are grateful for his work in chairing the working group and roundtable for the engineering shortages component of this project.

Overarching recommendations

Across all five roundtables held during ATSE's consultations, a common set of themes emerged. These themes have been synthesised into four overarching recommendations that need immediate action if Australia is to unlock its STEM capacity, capability, and innovation potential.



COMMON LANGUAGE

Establish a National Skills Taxonomy to streamline consistent communication about needs and pathways among Australia's organisations and individuals.



EVIDENCE-BASED

Prioritise and invest in evidence-based approaches to STEM program development and assessment to ensure training is fit-for-purpose and provides value for money.



LIFELONG STEM LEARNING

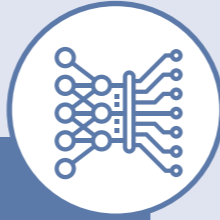
Promote and support a culture of lifelong STEM learning in the workforce to ensure Australia has the skills it needs now and into the future.



MINDSET SHIFT

Raise the profile of STEM careers in Australia to showcase their attractiveness and accessibility.

RECOMMENDATION 1 – COMMON LANGUAGE



Establish a National Skills Taxonomy to streamline consistent communication about needs and pathways among Australia's organisations and individuals.

Australia currently lacks a comprehensive skills taxonomy. This introduces challenges for individuals and organisations to communicate the skills they have – and need – in a shared common language. It also results in a lack of clarity around pathways for upskilling, re-skilling, or transferring skills between comparable roles across sectors. A comprehensive skills vocabulary and taxonomy can help solve this challenge and will enable rapid mobility into areas where capacity and capability are needed most.

A skills vocabulary that builds on or accelerates the work undertaken by the National Skills Commission (NSC) on the Australian Skills Classification (ASC) should be established, prioritising the classification and mapping of priority STEM skills shortages. This should be revised in alignment with an appropriate and agreed schedule and be designed with a view to practical implementation in the workforce. The skills vocabulary should also build on the work by the NSC on Occupation Profiles and the Jobs and Education Data Infrastructure (JEDI) initiative, and generate a taxonomy and training pathways from both traditional training systems and frameworks such as the Australian Qualifications Framework (AQF), and non-traditional systems such as micro-credentialling (Department of Education Skills and Employment, 2022; National Skills Commission, 2022a, 2022c, 2022d). The skills vocabulary and taxonomy should build on experience and lessons learned during labour market trend analysis activities and COVID-resilient career analysis to create robust, reliable, and relevant forecasting for current and future industry jobs and skills needs (National Skills Commission, 2022b). To ensure coherence with the global talent market, this taxonomy should be the starting point for an international skills framework, which could be developed through the International Council of Academies of Engineering and Technological Sciences (CAETS).

Following the Australian Government's Jobs and Skills Summit in September 2022, ATSE welcomes their commitment to reforming the VET qualification framework and establishing a framework that incorporates and recognises work-based learning and micro-credentials (Australian Government, 2022c). The following recommendations will establish a robust and sustainable system for understanding and managing our national skills requirements:

1.1. The Federal Government should continue to expand and define its skills vocabulary, prioritising STEM skills in urgent demand.

This will enable individuals, organisations, and recruiters to articulate the skills they have and need using a standard vocabulary, helping match supply and demand. Education providers should be encouraged and incentivised by governments at all levels to use the vocabulary to articulate skills and competency outcomes. Effective implementation requires close collaboration with state and territory governments, and consultation with industry groups.

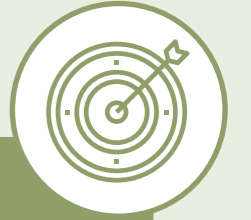
1.2. The Federal Government should use the skills vocabulary to map a taxonomy of roles and highlight adjacent job families.

This should be provided to the public to enable the articulation of pathways to support career transition, upskilling and reskilling. Organisations, particularly small and medium enterprises (SMEs), should use the resource to create learning and development strategies for their employees.

1.3. The Federal Government should provide industry-specific skill demand forecast information to all Australians.

This will enable employers and employees to ensure they develop the skills they need to remain competitive, permit government to better track and manage trends and develop strategy, and ensure education providers can develop timely and relevant training programs.

RECOMMENDATION 2 – EVIDENCE-BASED



Prioritise and invest in evidence-based approaches to STEM program development and assessment to ensure education and training is fit-for-purpose and provides value for money.

There is a proliferation of STEM resources and training programs, especially online, but little curation and evaluation of quality and effectiveness. This raises challenges for businesses seeking to find appropriate, value-for-money learning pathways to up-skill and re-skill their workforces, and for would-be students to make informed choices about the training they select. It also raises challenges for time-poor educators, particularly those teaching out of their professional field or who are looking to strengthen and build their own knowledge and skills.

Australia has a wealth of resources and initiatives to draw from to fast-track the establishment of the curated resources recommended in this report. Inspiration and lessons learned can be found in initiatives such as Scootle, FUSE, STARportal, the Women & Girls in STEM Map, and the Guide to Evaluating STEM Gender Equity Programs. These should be built upon as a starting point and inspiration for the following recommendations (Department of Education and Training, 2022; Department of Jobs Precincts and Regions, 2021; Kingsley, 2020; Office of the Chief Scientist, 2022; Scootle, 2022):

2.1. The Federal Government should establish a self-assessment and quality framework for evaluating STEM training skills (based on a skills taxonomy), assessing skills imparted and competency level.

The Federal Government should lead the establishment of a self-assessment tool and quality framework for education providers and organisations to self-assess their STEM training programs. The tool should also enable individuals to assess training programs on offer, or provide guidance on how to request an assessment from a training provider. Training programs should be listed on a publicly available central register to provide a comprehensive overview of the education landscape.

2.2. The Federal Government should establish a centralised directory of quality-assessed STEM training programs to support selection of appropriate training pathways and programs.

This would enable organisations to develop trusted learning and development pathways for their staff, and individuals to select programs aligned with their required skills and competency level. Multiple online collections of STEM training and resources should be consolidated into a central, maintained, curated, and trusted database for learners, educators, and organisations. This would provide 'one front door' for STEM education, training and resource needs.

2.3. The Federal Government should support education providers to establish priority STEM training programs, quality assessed against the framework.

Funding should be prioritised in alignment with current and anticipated future demand, with a view to attracting diverse talent and generating inclusive workforces. Training programs for STEM skills in high demand should be supported to highlight pathways into a range of STEM careers to attract students to programs. Programs should impart priority technical and non-technical skills.

2.4. The Federal Government should establish a centralised resource of self-serve STEM resources, quality assessed against the framework.

Previous initiatives to build central repositories should be strengthened, and fragmented initiatives should be connected. This will enable businesses, employees, and teachers, particularly those teaching out-of-field (i.e., teaching a subject outside of their profession or area of qualification), to be supported with quality resources in STEM and pedagogy resources to supplement their knowledge and skills. Individuals should self-serve from the resources to supplement their learning.

RECOMMENDATION 3 – LIFELONG STEM LEARNING



Promote and support a culture of lifelong STEM learning in the workforce to ensure Australia has the skills it needs now and into the future.

With the rapid progress of innovation and changes in careers, especially technology-focused roles, there is a need to instil a culture of lifelong STEM learning in the Australian workforce. This will allow our current workforce to be retrained and upskilled, teachers to be given the necessary support for their professional learning, and expert educators to provide support across the sector.

In addition to creating high-quality, evidence-based STEM training programs, there is a need to incentivise organisations to enable their workforces to participate in learning initiatives, linking skills acquisition back to business value and organisational resilience. And there is a need to highlight to individuals, the value of ongoing learning to build capability and career prospects. Providing opportunities for individuals to see what success looks like in engineering, technology and entrepreneurship, and opportunities for professionals to learn from peers, are key to making STEM education attractive and attainable.

3.1. STEM peak bodies to establish Communities of Practice (CoP) between educators and industry to advise on skills gaps and required standards for education and training programs, with the support of state and federal governments.

STEM peak bodies should be supported to encourage and facilitate connections and knowledge-sharing between educators and industry professionals. Key challenges raised in these sessions, including emerging and forecasted skills gaps and required standards for education and training programs, should be regularly fed into governments. Governments should develop short, medium and long-term solutions in response to current and emerging issues.

3.2. Federal and state governments should support education and industry peak bodies to establish targeted mentoring programs.

These should be developed within sectors to support continuous upskilling of technical and non-technical skills, and between educators and industry, to ensure educators are aware of the needs of the relevant sectors and to provide case studies for use in instructional settings.

3.3. State government education departments should support comprehensive employment of teacher assistants in primary and secondary education to alleviate teacher time pressure and support teachers' continual learning and development.

Governments should support teacher assistant roles, particularly for STEM educators. Education peak bodies should work with educators to undertake job role profiling to separate teaching activities from administrative activities. Schools should be funded to recruit teacher assistants to both relieve administrative burden from, and provide support to, educators. This would provide educators with the capacity to re-skill and up-skill. This additional support may also encourage career changers from STEM fields to consider entering the teaching profession.

3.4. The Federal Government should invest in workplace learning incentives for businesses.

Initiatives such as fee-relief and tax incentives should be provided to develop and deliver training for priority STEM skills. This will help incentivise businesses to encourage their employees to participate in relevant, value-adding workplace training, re-training and up-skilling.

RECOMMENDATION 4 – MINDSET SHIFT



Raise the profile of STEM careers in Australia to showcase their accessibility and attractiveness.

Careers in STEM, or those where STEM skills are required, can seem inaccessible or opaque to those outside of the STEM workforce. Children, and even adults, can find it difficult to imagine a day in the life of an engineer or entrepreneur, or envisage the places a math degree or digital skills course can take you. Equal representation has also been lacking in STEM careers, particularly of women, Aboriginal and Torres Strait Islander people, those living with disabilities and neurodiverse individuals. This can make it hard to imagine a STEM career is attainable.

Role-modelling and story-telling can change understanding and perception of STEM skills and careers, showing the breadth of opportunities available, and that diverse people are welcome and successful in STEM. Australia also needs to not just attract and develop diverse local and international STEM professionals, but also retain them. Internationally, Australia currently markets itself as a lifestyle destination rather than a country to come to if you want to have a cutting-edge career. There are opportunities to change these perceptions to bolster and maintain our nation's STEM workforce.

ATSE acknowledges the Australian Government's commitment to promoting equal opportunities and reducing barriers for employment following the Jobs and Skills Summit. In particular, the requirement for businesses with 100 employees or more to report their gender pay gap statistics, additional support for disability employment outcomes, and the call for the public service to set targets to improve gender equity and Aboriginal and Torres Strait Islander employment in its workforce (Australian Government, 2022c).

4.1. The Federal Government should establish a central resource highlighting practical case studies and diverse role models and career profiles of STEM professionals.

A central, trusted, quality resource should be established to bring together existing resources, and to identify and fill gaps. Peak bodies and organisations should be invited to provide diverse role models, career profiles and community impact of STEM professionals, and staff profiles to the resource. Educators could draw from the database for case-study-based learning and to highlight role models and career pathways. Individuals could consult the database when considering career pathways.

4.2. Federal and state governments should support the delivery of quality, independent paid internship programs in priority STEM areas.

Quality paid internships in priority STEM areas provide exposure to the opportunities in STEM careers and develop early linkages between education and industry. They highlight the roles and career prospects of STEM careers to individuals, open up job opportunities, build a collaborative STEM culture, and bridge the gap between theoretical learning obtained from education and training, and real-world application of skills and experience to uplift capability. Organisations hosting interns should be supported with best practice guidelines to maximise the value for all parties.

4.3. STEM employers should showcase their Diversity and Inclusion (D&I) initiatives to attract more diverse workforces.

STEM employers should highlight the for-purpose, impactful nature of their sectors, organisations, and roles. In promoting roles, organisations should be transparent in actions taken to create an inclusive culture and showcase the ways the organisation addresses, tracks and reports on D&I matters. Individuals should request organisational D&I information from organisations at the commencement of, and during employment.



4.4. The Federal Government should conduct regular whole-of-workforce foresight studies to identify emerging skills gaps and establish a unified National Strategy for STEM capability to uplift, and support state and territory governments and industries with their unique needs.

A National STEM Strategy based on regular systematic whole-of-workforce foresight studies should be developed to drive a coordinated approach to STEM capability uplift to enable consistency and amplify impact of current and future STEM initiatives. The Federal Government should work closely with state and territory governments to ensure the strategy employs place-based and industry-appropriate approaches to meet the unique needs of the different industries and communities in each state and territory.

4.5. Governments, industry and academia should coordinate to develop clear messaging and actions to attract and retain STEM professionals.

National messaging on STEM careers should highlight the multiple pathways to acquiring STEM skills, and the coveted nature of these skillsets across a range of sectors. Messaging should highlight that STEM skills are for everyone, particularly under-represented groups and individuals who may perceive such roles are not accessible to them. And that careers in STEM can be equally diverse and go beyond the stereotypes of scientists working at lab benches. Peak bodies, academia and industry should be encouraged to communicate about STEM careers as purpose-driven, future-focused, and meaningful career choices. Governments should also ensure international marketing campaigns highlight Australia as a country to have both a desirable lifestyle and a cutting-edge career to attract skilled STEM workers and retain our STEM qualified workforce.

Sector-specific recommendations

In addition to the overarching recommendations previously outlined in this report, the topic-focused roundtables highlighted several sector-specific recommendations required to address those domains' unique challenges. The key challenges identified by the expert working groups, and solutions identified in the roundtable sessions, are outlined in subsequent sections of this report.

Sector-specific recommendations related to ATSE's overarching recommendations are highlighted by the following recommendation key:



Mathematics in regional, rural and remote schools

The status of mathematics education is an issue of national concern. The requirement for general numeracy in the community, as well as the training of those with advanced mathematical skills, both need to be addressed. Despite the centrality of school-level mathematics to STEM careers, many of which are anticipated to be in increased demand in the coming years, there are challenges associated with early high school mathematics and limited uptake of senior secondary mathematics subjects. ATSE's consultations focused on the compounded challenges for mathematics education in regional, rural and remote (RRR) schools where the issue is particularly acute, noting that this is a nationwide challenge including metropolitan schools.

Students at RRR schools do not have access to the same resources, opportunities, infrastructure, and teaching quality as their metropolitan peers. This is reflected in national statistics, where 10.7% of remote students and 35% of very remote students, scored below the minimum standard (Australian Mathematical Sciences Institute, 2020). By comparison, for year nine students in major cities, 3.8% are below the minimal standard (Australian Mathematical Sciences Institute, 2020). At a senior secondary level, fewer RRR students enrol in advanced mathematics subjects compared to other regions. These issues carry through to RRR students' engagement with STEM at a tertiary level. Students at RRR schools experience barriers to considering higher education including lack of knowledge, financial concerns, living too far from university campuses, and not being interested in the limited course offerings of regional campuses (Stone et al., 2022).

The shortage of mathematics teachers is a national concern underlying students' engagement, enrolment, and achievement in mathematics. Mathematics teacher vacancies are typically challenging to fill. For example, in Victoria, 19% of advertised secondary mathematics teaching vacancies go unfilled (Department





of Education and Training, 2021). Consequently, much mathematics teaching is delivered by out-of-field teachers, with less than one quarter of year seven to year ten students having an in-field maths teacher every year; remoteness is particularly linked to out-of-field mathematics teaching compared to other subjects (Australian Mathematical Sciences Institute, 2018; Shah et al., 2020).

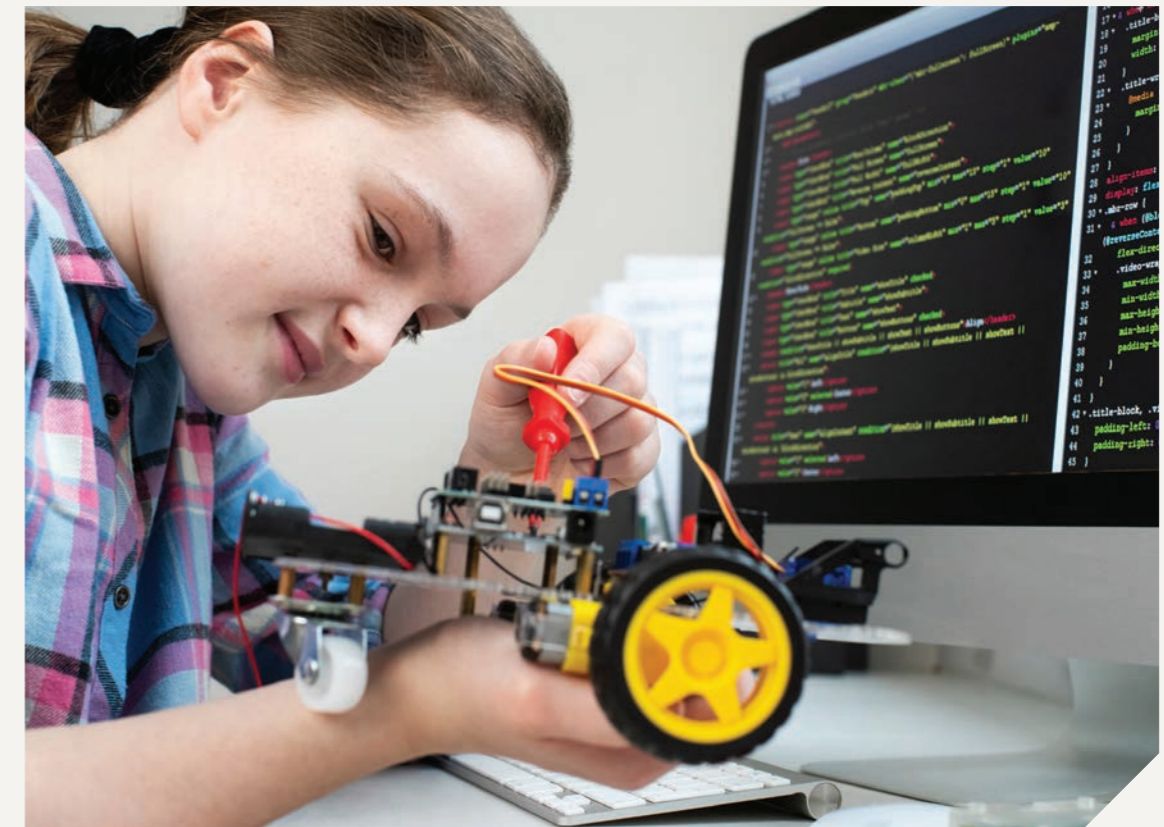
Action is also required in the area of supporting and encouraging Aboriginal and Torres Strait Islander students to study and pursue mathematics. Numeracy results from National Assessment Program - Literacy and Numeracy (NAPLAN) show a sizable gap in mathematics achievement between Aboriginal and Torres Strait Islander and non-Indigenous students - 14.2% of Aboriginal and Torres Strait Islander Year Nine students did not achieve the minimum numeracy standard (as compared to 1.9% of non-Indigenous students) and only 0.9% achieved the highest band (as compared to 9.6%) (Australian Mathematical Sciences Institute, 2020). Aboriginal and Torres Strait Islander students in remote communities have lower NAPLAN attainment than Aboriginal and Torres Strait Islander students in metropolitan and inner-regional schools (Australian Mathematical Sciences Institute, 2020). Aboriginal and Torres Strait Islander primary school students for whom Standard Australian English is a second dialect are learning both new vocabulary and mathematical concepts simultaneously, but this process is not explicitly accounted for in teaching (Watts et al., 2019). Aboriginal and Torres Strait Islander girls additionally face a lack of female role models, receive less classroom help than their male peers, and engage less within mixed-sex classrooms (YouthInsight, 2021).

There is a dire need to address the systemic teacher shortage, and the pressing need to support teachers with relevant, high-quality training and educational materials to assist their ability to inspire, empower and educate students to acquire this fundamental and critical skillset. Mathematics education needs to be relevant and appropriate for the context in which it is delivered, and diverse and representative role models are critical to it being viewed as a conduit to achievable and desirable career pathways.

Recommendations

In addition to the overarching recommendations in this report, the following sector-specific recommendations should be adopted to overcome barriers in this domain.

	<p>Government education departments should invest in programs to improve and provide culturally appropriate and engaging delivery of STEM education for Aboriginal and Torres Strait Islander students, particularly acknowledging Traditional knowledge, and including mathematics instruction 'in language'. These should be developed in consultation with Aboriginal and Torres Strait Islander communities.</p>
	<p>Government education departments should work with peak bodies and educators to develop strategies to facilitate and enable appropriate up-skilling for teachers, particularly in RRR Australia. This should include education and training (e.g., by online learning, at nearby universities and Vocational Education and Training (VET) providers, or by visiting educators) with appropriate time-release for teachers in the public system to enable participation.</p>
	<p>Peak bodies, educators, and government education departments should work to develop and support implementation of collaborative teaching practices. Strategies should leverage virtual mechanisms such as online synchronous teaching from subject matter experts for multiple classes that allows both the students and teachers to learn. They should also consider group/co-marking of student work, collaborative lesson planning, sharing of established lesson plans and team teaching, where appropriate. This cultural change needs to be championed by school leadership and departments of education.</p>
	<p>Government education departments should develop and fund a targeted paid internship program for undergraduate tertiary mathematics students to expose them to RRR teaching career options that they may not have otherwise considered. This includes programs that target metropolitan students to attract them to RRR settings, and RRR students to support their retention in RRR communities.</p>



Digital skills: from coding, to skills for the entire workforce

The demand for digital skills - the skills we need to produce and to use digital technologies - has been increasing at an unprecedented rate. As the COVID-19 pandemic has fast-tracked digital transformation across a range of industries, it has resulted in a rapid adoption of new technologies as organisations and individuals have adapted to a new way of remote working. At the same time, the pandemic has hampered skilled migration to address key skills shortages, leaving Australia with critical and growing shortages.

It is predicted that one in four jobs created by 2025 in Australia will be for digital technology workers (Australian Government, 2020). An analysis of Australia's current workforce has found that 87% of jobs now require digital skills, and there is a need for 156,000 new technology workers to keep pace with the rapid transformation of businesses (RMIT, 2021).






As Australia and the rest of the world become increasingly digitised, we need to increase the depth and breadth of digital skills we have available to us in order to stay competitive and internationally relevant. Australia is currently ranked #20 in the 2021 IMD World Digital Competitiveness Ranking, slipping five spots from the previous year in rank (IMD World Competitiveness Center, 2021). Across the same period, countries such as China have bounded ahead, gaining fifteen places to go from #30 to #15. This highlights the pace at which a country can become a digital leader or laggard, and Australia risks being left behind if urgent and decisive action is not taken.

There is an immediate need to improve digital skills in the Australian workforce to both ensure economic recovery from COVID-19, and to avoid jeopardising an AU\$10 billion growth in the technology, media, and communications industries by 2025 (RMIT, 2021). Digital skills are key to unlocking business productivity. As well as providing a commercial edge, there is a social responsibility perspective at play in the upskilling of our workforce. With digital skills becoming a near-requirement for most roles in our increasingly digital economy, having digital skills enables full workforce participation, and jobs requiring digital skills generally attract a higher salary (UK Department for Digital Culture Media & Sport, 2019).

Australia's Digital Economy Strategy 2030 highlights our ambition to be a leading digital economy and society by 2030. It highlights the aims of all businesses being 'born' as digital businesses, and all Australians having access to digital skills and technology, focusing on integrated data and technologies. The strategy simultaneously highlights what the government must do in its 'own backyard' to achieve this, striving for frictionless government service delivery and smart regulation that builds citizen trust (Australian Government, 2020). This sees the demand for digital skills set to continue to increase in coming years. Considering the rate of technological change, and the pace at which a country can become a digital leader or laggard, these long-term building blocks need to be balanced against short and medium-term initiatives that continue to support all digital users and producers.

Recommendations

In addition to the overarching recommendations in this report, the following sector-specific recommendations should be adopted to overcome barriers in this domain.

	Industry, academia and governments should use the taxonomy outlined in recommendation one to map and highlight the multiple pathways into the rapidly moving digital technology space, and its inclusivity of - and accessibility to - non-university educated professionals.
	Industry peak bodies should work with the Federal Government to establish simple industry standards for digital skills (e.g., cybersecurity, artificial intelligence, data analysis, etc) to enable the acknowledgement of skills acquired through diverse educational mechanisms such as micro-credentialling (i.e., small, focused courses that rapidly upskill individuals), on-the-job training and vendor-provided training.
	Digital employers should showcase their willingness to attract, retain and promote candidates from diverse educational, experiential, and cultural backgrounds, and embrace continuous workplace learning via diverse educational mechanisms.
	Peak bodies, educators, industry, and all levels of government need to highlight the presence and value of all forms of diversity in the tech sector, and the positive employment and pay prospects associated with digital and technology-focused roles.
	All levels of government should lead activities to explicitly link policies and strategies that have a digital component (e.g., strategies for digital cities, climate change, energy, health, etc) to enable coordinated impact.

Capacity development for a technology-driven agricultural transformation

In Australia, the agriculture sector comprises some 87,000 farm businesses, employing around 325,000 workers, with the gross production value for 2022-2023 forecast at over AU\$80 billion (Australian Bureau of Statistics, 2022; Cameron, 2022; DAFF, 2021). However, there are still far more jobs vacancies in the agriculture sector than there are graduates, trades people and unskilled workers to fill them - even with current and planned seasonal worker programs (Young, 2021).

The Australian agricultural and food sector is on the cusp of a major technology-driven growth and transformation period. This will be accelerated in part by technology-based solutions to maintain resilience to climate change events such as the increased severity and periodicity of droughts, heat waves, and floods. Consequently, the challenge is not simply to meet current skills but to re-build and modernise the educational and training capacities of universities and VET institutions so they can provide the graduates, professionals and trades people required in future decades.

As technology transforms the agriculture and food sector over coming decades, the lack of adequately skilled labour is expected to become an even more critical constraint than it is at present, putting Australia's food security and economic stability at risk. Issues around ownership and access to data, particularly that generated on-farm and by farmers, will also need to be addressed by multidisciplinary teams with STEM and legal expertise as the use of advanced technologies continues to rise in this sector.

Agriculture sector narratives that focus on its technology-driven, sustainability-focused future need to be developed to attract more workers into this sector. It is essential to attract unskilled labour (e.g., to bring in horticultural harvesters), as well as skilled and educated workers to manage and transform food production and supply chains. With suitable capacity, it would be feasible to build robust and just data management frameworks to accelerate the sector's continued modernisation and transformation.

Recommendations

In addition to the overarching recommendations in this report, the following sector-specific recommendations should be adopted to overcome barriers in this domain.

	Peak bodies, industry and the Federal Government should work to encourage and facilitate the establishment of mentorship and capability uplift programs for farmers, farm workers and service providers to ensure they are conversant with technology-specific trends and development opportunities.
	Universities and the VET sector should coordinate with all levels of government to invest in and rebuild and modernise agricultural educational and training, enabling systems-analytical, digital, and practice-based applied training. Agricultural and food related educational material should be provided to educators by industry and peak bodies to enable primary and secondary school students to improve understanding of technology-enabled, sustainable food systems, and healthy nutrition.
	Peak bodies and industry should link roles in the sector to purpose, highlighting the important role the agriculture and food sector plays in sustainability and societal wellbeing. They should tell the story of current agricultural technologies, highlight diverse career profiles, and use case studies to articulate the future of the sector. This will help re-write the narrative of work in this sector and attract more skilled workers.
	Peak bodies, industry and the Federal Government should create clear, comprehensive, and comprehensible data sharing and use requirements that incorporate ethical considerations and focus on mutual benefit creation. This will assist with overcoming barriers to adoption of new technologies in this space.

Addressing the engineering shortages

Engineers are essential to building and maintaining Australia's critical infrastructure and ensuring Australia has the physical assets it requires, such as bridges, schools, and skyscrapers, as well as designing the systems and software we need to power a modern and efficient society. However, our country continually operates with significant shortfalls of engineering tradespeople and professional engineers (i.e., chemical, civil, electrical, mechanical, structural, software, etc).

These shortages increase the risks in engineering project completion and performance and constrain Australia's ability to grasp new engineering opportunities. Infrastructure Australia has estimated the need for 41,000 more engineering professionals by 2025. The Australian Space Agency is aiming to build an industry with 20,000 additional jobs by 2030, with many, if not the majority, in engineering (Australian Government, 2022a; Infrastructure Australia, 2021). Other initiatives with a manufacturing emphasis and for the decarbonisation and electrification of the economy also imply jobs growth and the need for new engineering capabilities.

Australia's engineer supply comes from two sources – skilled migrants who completed engineering qualifications abroad and graduates of Australian universities. The closure of Australia's borders during COVID-19 resulted in a loss of migrant engineers from our workforce. It has also exposed the long-standing problem of Australian universities not producing enough engineering graduates, currently only meeting around one-third of the annual engineer demand.

Each year from 2010 to 2019, the higher education system produced approximately 7,500 domestic and 6,500 international graduates from programs accredited by Engineers Australia at the Professional Engineer level (Australian Council of Engineering Deans, 2022). There is a trend of declining commencing student numbers in engineering and related technologies degrees (Australian Council of Engineering Deans, 2022). In 2020, 61.7% of domestic engineering students commenced their study in an accredited bachelor degree for the Professional Engineer occupation directly from secondary school on the basis of their Australian Tertiary Admission Rank (ATAR) result (Australian Council of Engineering Deans, 2022).

As entry to higher education is driven from demand by qualified and motivated students, it is clear that the number of students seeking to study engineering is below the tertiary education sector's capacity. There is a need to encourage and inspire more school leavers into engineering to bolster Australia's graduate levels, as well as to facilitate mechanisms for engineering students to gain meaningful industry experience.

One mechanism to increase the number of engineers is to target participation in currently under-represented groups. The commencing national participation rates for female engineering students have shown only slow growth, from 14% in 2010 to 20% in 2020, despite many outreach programs and initiatives. Aboriginal and Torres Strait Islander student participation in engineering has doubled over the past five years but from a low base, supported by outreach initiatives by engineering faculties, employers, and the profession. In 2020, Aboriginal and Torres Strait Islander students comprised 1.2% of commencing undergraduate engineering students (Australian Council of Engineering Deans, 2022). D&I across the entire workforce needs to be viewed as a critical lever to move the needle on shortages of engineers, while at the same time the myriad sectoral and systemic issues that have contributed to, and continue to drive, our skills shortages in this domain need strong interventions and leadership.

ATSE acknowledges the Australian Government's commitment to addressing skills shortages and strengthening the migration system following the Jobs and Skills Summit, particularly considering the high numbers of international engineers currently waiting for visa application outcomes (Australian Government, 2022c; Knaus & Hurst, 2022). This is a positive first step towards improving the skilled migrant pathway into engineering in Australia in the short term. However, looking forward, governments' and employers' net additional demand projections of some 50,000 more engineers by 2025 (in addition to unmet demand for technology workers), and further increases beyond, will exceed the pre-COVID immigration and local graduate supply (Tech Council of Australia, 2021). Extensive work remains to be done on removing the barriers migrant engineers currently face in participating in the Australian engineering workforce. Yet the problem of our engineering shortages will not be solved by improving and increasing the skilled migration





pathway alone. In addition to training more engineers domestically and increasing skilled migration, there is a need to improve retention of engineers in the workforce. Migrant engineers in particular face barriers to working as engineers in Australia, with only around 40% working in engineering roles. A report published by Engineers Australia has highlighted key barriers to engineering workforce participation of skilled migrant engineers including: a lack of local knowledge and experiences, perceived cultural differences (including in non-technical skills), visa or sponsorship issues, a lack of local referees who can vouch for their work, certification queries, 'flight risk' concerns, and a tendency to hire from networks for senior roles (Engineers Australia, 2021).

Of Australian-born qualified engineers, only two-thirds are employed in engineering occupations (Engineers Australia, 2019). Withdrawal from the engineering workforce is due to a range of factors including working conditions, pay rates (as compared to trades and non-technical roles), and discrimination. Greater information sharing and cohesion within the engineering sector could make consolidated efforts to address these issues.

While there are many small-scale programs to increase engineering enrolments and provide students with industry experience, there is a lack of cohesion across the different sectors within engineering as these different sectors do not communicate with one another about workforce needs, challenges, and strategies. There are opportunities for engineers in sectors with low demand to re-train into other adjacent sectors, as well as for tradespeople to re-train, but this is currently difficult to do. A unified engineering council, as recently posited by the Group of Eight, would be well-placed to address the multifaceted causes of engineering shortages and ensure the different sectors are working in alignment (Group of Eight, 2022).

Recommendations

In addition to the overarching recommendations in this report, the following sector-specific recommendations should be adopted to overcome barriers in this domain.

	Engineering industry employers should establish industry placements and cadetships, potentially also supported by governments. Programs should be designed for students at all stages in their degree, and individuals working in engineering-adjacent professions (e.g., building and construction) to drive upskilling, career mobility and introduce organisational efficiencies.
	Employers and education providers should highlight to groups with low engineering enrolment numbers (particularly women and others from diverse backgrounds) the benefits to them of an engineering career, how engineering solves problems and supports communities, and the skills needed. Programs to increase enrolments of diverse students, and diversity in the workforce, should be evaluated and results reported publicly.
	Employers should develop flexible work arrangements and robust parental leave policies to improve retention for people with caring responsibilities in engineering careers. Employers should conduct genuine and regular audits of their structural and cultural impediments to genuine diversity at all levels.
	The engineering sector and Federal Government should collaborate to establish a National Engineering Council to address fragmented sectoral issues. The purpose and terms of reference of this body need to be developed through a collaborative process. This Council should also work with all levels of government and relevant groups to co-design and support programs to address barriers faced by skilled migrant engineers.

Promoting entrepreneurial skills in Australia

With the push for Australian industry and academia to translate innovative ideas into developed products, entrepreneurial education has the power to transform this ideal into reality. Ensuring these entrepreneurial skills are embedded in STEM programs in schools provides students with crucial future-ready skills and an array of new career possibilities.

According to the European Commission's 'New Skills Agenda' for Europe, entrepreneurship is described as a crossing key competency across all sectors of life, encompassing knowledge, skills, and attitudes (Bacigalupo et al., 2016). Entrepreneurship, according to this vision, relates to all elements of life: personal, civic society, and the workplace and can offer cultural, social, and economic value.

Entrepreneurship skills aid in the translation of new ideas into products and services. They instil abilities such as critical and creative thinking, problem-solving, adaptability, resilience, a growth mindset, and the capacity to manage risk and uncertainty – all of which are essential for STEM endeavours, especially in this era of unparalleled technological change.

A report from Australia's Chief Scientist argues that Australia needs to strengthen its education system for more students to become creative, innovative, and literate in scientific and technological areas that support entrepreneurship (Office of the Chief Scientist, 2014). A recent study has also pointed to the same need to enliven STEM subjects by relating them to the student's surrounding world and introducing elements of entrepreneurial thinking (Fraser et al., 2021). This is particularly important for Aboriginal and Torres Strait Islander people, and those from RRR communities (Shirodkar et al., 2018).



Entrepreneurial learning is a distinct instructional method that has the potential to develop student talent. It has a strong focus on identifying real-world problems and identifying solutions, iterative experimentation, the development of a tolerance of risk and resilience to failure, and a strong focus on teamwork. These attributes are comparable to pedagogical techniques such as project and problem-based learning and service learning which combine classroom and community involvement, particularly in their emphasis on problem-solving, authenticity, and teamwork.

The Foundation for Young Australians' (FYA) 'New Work Order' report argues that young people will require entrepreneurial attitudes, skills, and talents to flourish (Foundation for Young Australians (FYA), 2017, 2018). According to FYA research, young people are likely to work in more jobs and vocations than in the past and will need to be more entrepreneurial than ever before, claiming enterprise skills will become the 'new basics'.

Countries such as the United States, Japan and Germany have established programs to expose their STEM school students to an entrepreneurial culture. The International Institute for Management Development's World Competitiveness Yearbook, released by CEDA, ranked Australia 61st on entrepreneurship (Sadler, 2022). If Australia doesn't act to upskill its workforce in entrepreneurial skills, it is missing a golden opportunity to capitalise on its research commercialisation and translation potential, and to develop the critical non-technical skills required across multiple STEM careers. It is critical and timely to closely explore how a national approach can be developed that delivers an introduction to entrepreneurial thinking at the school level.

Recommendations

In addition to the overarching recommendations in this report, the following sector-specific recommendations should be adopted to overcome barriers in this domain.

	<p>Industry and the Federal Government should establish and define the key skills cluster required for entrepreneurship (e.g., creativity, enquiry, communication, resilience, perseverance, problem-solving, leadership, ethics, collaboration, risk-tolerance, etc). Education peak bodies should work with educators to map the entrepreneurial skills cluster to the current curricula and highlight any gaps requiring resolution.</p>
	<p>Peak bodies and industry should highlight diverse case studies and role models of entrepreneurs and entrepreneurial skills to showcase the diversity in the field. The value and transferability of the entrepreneurial skills cluster should be highlighted, particularly to parents, to help overcome concerns around their children engaging in entrepreneurial studies.</p>
	<p>State government education departments should lead the integration of entrepreneurship education into the curriculum so it is introduced to students at an early age. The government and school leadership must provide support teachers to integrate entrepreneurial education as a critical skill cluster that supports student learning and provides values across a range of career pathways.</p>

Appendix

List of participants

The Academy sincerely thanks all chairs, working group members and roundtable participants for their contributions to this project.

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- Professor Tisha Morrell, Head of School of Education, University of Queensland

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