OPTIMISING STEM INDUSTRY-SCHOOL PARTNERSHIPS: INSPIRING AUSTRALIA'S NEXT GENERATION

FINAL REPORT APRIL 2018

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Education Council

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Note from the Chair

Every school day, close to 4 million students and a quarter of a million teachers pass through the school gates and engage in the activity we call education for approximately seven hours.

When the bell rings for home time, their education continues: around the kitchen table, on the sports-field, at the computer. It is an enormous investment of individual and community resources, so firmly embedded in our lives that we rarely question why we do it.

But though we all agree on the “why” of education, we argue passionately about the “how” – and increasingly, we worry about the “how well”.

What does it mean to provide our children in 2018 with a fit for purpose twenty-first century education in science and mathematics? Who has access to that education today, and why are we failing to provide access to others? How can we learn to do better?

In the course of preparing this report I have met with many people – business leaders, parents, teachers, education ministers and more – who care deeply about the answers to these questions. They care because they are anticipating the future, and they understand that, unless we change course, we will fall short of the incredible promise of our times.

Science and mathematics education in Australian schools is far from broken but it is clearly not where it should be.

Australian students should be performing in the top quartile of Organisation for Economic Cooperation and Development (OECD) countries. Gaps between the richest and poorest, urban and regional, and Indigenous and non-Indigenous students should be closing. Students should be excited about the future, hungry to learn, and equipped with the skills to leave the problems of our generation behind.

Instead, international testing shows our students performing at about the middle of the OECD pack. Across the board, results in science, numeracy and literacy are slipping; and achievement gaps are stubbornly entrenched.

We are a wealthy, privileged country, enjoying 27 years of continuous economic growth. Unfortunately, success breeds complacency and complacency erodes the aspirations on which our prosperity is based.

Employers want to help, not just by exhortation but by practical action. And they do help. In fact, businesses have been helping schools for more than 100 years. In March 2018, there were more than 500 registered STEM activities on the STARportal website to connect parents, students and teachers to opportunities for learning.[1] The majority of these activities are delivered or sponsored by Australian businesses.

Industry can help to build the enthusiasm of students, teachers and parents by providing examples of real world problems that young people would love to solve. Businesses can contribute content and context to the principals, lead teachers and academics who are developing contemporary curriculum resources. They can offer their staff to help teachers directly or indirectly, as preferred by the teachers. They can work with intermediaries such as universities and TAFEs to supply contemporary content or technology that can be incorporated into teacher professional learning.

Industry's motivation in all of these initiatives is clear: it wants to elevate the skills and aspirations of the future workforce. This should not be misinterpreted as a desire to replace the broad goals of education with a narrow set of job-specific skills.

Employers with the vision to invest in the future have the insight to look for T-shaped individuals, those who have deep specialty skills (the vertical pole of the T) and broad enterprise skills (the horizontal bar of the T).[2] Take away the horizontal bar and you are left with an 'I' – lots of discipline knowledge but lacking the collaborative skills to contribute that knowledge effectively. Take away the vertical pole and you are left with a dash – possibly smart but always rushing off for the answers instead of being able to contribute to the discussion.

Employers expect the education system to deliver students who are work capable, not necessarily job-ready. They recognise that they have the critical role in the education continuum, to provide on the job training to graduates and school leavers.

The challenge for interested CEOs is that, given that they are not education experts, they don't know how to prioritise their resources. The world of industry-school partnerships is awash with output and input metrics, but starved for data on outcomes – let alone robust studies of impact.

Further, as our consultations revealed, there are systemic challenges that counteract the messages we are trying to convey.

Foremost amongst them is the breaking of the continuum from primary to secondary to tertiary education – at the point where Year 10 students sit down and choose their subjects for Years 11 and 12.

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1 www.starportal.edu.au
2 IBM's Role in Creating the Workforce of the Future, 2009, in Beyond IT.

Think about the nexus between primary and secondary education. Primary school teachers know exactly what content knowledge and skills will be expected of their students at Year 7. Year 7 teachers know where they ought to begin. Compare that well-developed bridge to the chasm that students approaching tertiary studies need to jump.

In the past, universities sent signals to students through course prerequisites, particularly for mathematics. Principals knew that mathematics must be learned sequentially – each lesson builds on the next, layering fundamental skill on fundamental skill, in primary school and right through secondary school. Those foundations are difficult to retrofit at university if a student has opted out of mathematics, or studied it at a level where it might be easy to pass but hard to excel.

Today there are far fewer prerequisites, even in courses where an advanced knowledge of mathematics is essential. Those important signals – to students, that they need to strive; and to schools, that they need to give students the encouragement and resources – are failing. Students select their courses with an eye to a number: the ATAR to enter a particular course. Rightly or wrongly, they absorb the message that the way to boost their ATAR is to drop down a level in mathematics.

ATAR as a driver of aspirations is further complicated by the common misconception that the range of the percentile ranking is 0 to 99.95 with a median score of 50.

However, because the ranking is relative to the starting Year 7 cohort, in practice the range is closer to 40 to 99.95 with a median score nearer to 70.

Teachers, parents and businesses agree: we need a better conversation about the purpose of the ATAR; with an emphasis not just on getting into university, but getting in prepared to do well.

That conversation would go a long way to lifting the impact of industry-school partnerships.

Alongside an emphasis on aspirations, some of the principles that have guided our work include an appreciation for the role of principals and other school leaders, the centrality of teachers, and the importance of clear objectives and measurable impact.

Useful impact studies need to look at data over many years. But integrated comprehensive data is not available because there is no way to track what students choose or achieve as they move across system boundaries between government, Catholic and independent schools; or cross state and territory boundaries with their families; or transition from pre-school to primary to secondary to tertiary.

The solution is to implement a national unique student identifier that ensures absolute privacy and allows students or their guardians to choose when and to whom to release information, allows students to determine what information to share from their personal records, and permits approved research on aggregated, de-identified data. The benefit to the student is to enable them to access and share their own education history and digital portfolio as a more comprehensive picture of their achievement.

How is effectiveness in STEM education and industry-school partnerships measured at the national level? From our consultations we concluded that single measures such as the international Programme for International Student Assessment (PISA) test, while valuable, are not sufficient in themselves. Good as these tests are at measuring science, numeracy and literacy, and acknowledging that they are modernising to measure enterprise skills, it is not clear that they measure student ability in newer subjects such as Digital Technologies or Work Studies. It is difficult to determine what fraction of our declining performance is due to a mismatch between what is measured and what we teach. For this reason, we need a broader set of measures. Our recommendation is for a one-page ‘Dashboard’.

These observations are offered in the firm belief that industry-school partnerships have important, even life-changing impacts. We found many examples of excellent programs, treasured by students and praised by schools, some of which we have profiled here. Our key unsolicited advice to governments is to learn from what is working well, invest in successful programs and avoid starting anything new unless there is a clear gap to be filled.

In that, we acknowledge the important work of the Review to Achieve Educational Excellence in Australian Schools (Gonski 2.0 Review) and we further draw the reader's attention to the schools and VET recommendations in the Innovation and Science Australia Prosperity through Innovation 2030 strategy plan.

Producing this report was a non-trivial effort. As Chair of the Forum I thank my Deputy Chair and my fellow Forum Members, as well as the highly capable members of the secretariat. We benefited greatly from the submissions, the public consultations and the consultations with education ministers and department heads. I humbly thank each person who contributed to a submission, participated in a consultation or answered my personal calls for help.

Education ministers, I commend this report to you.

Dr Alan Finkel AO
Australia's Chief Scientist
Forum Chair

Executive Summary

Australia's education system has served us well but must continue to evolve to ensure our competitiveness in a world racing towards the future. The report recommendations seek to optimise the ways industry partnerships can assist in the provision of contemporary, internationally competitive STEM education in schools.

Australian businesses have a long history of contributing to STEM education in schools. Their aspiration is to support their communities as well as the education of a highly capable future workforce at a national scale.

From the schools' perspective, they benefit from the emerging technology context inherent in industry partnerships, and avenues for teachers to maintain contemporary STEM knowledge and practices that energise teaching and learning in STEM. Industry can also help schools by providing personnel, financial and physical resources.

Further, it is clear that industry is well placed to work with governments to better understand future workforce needs.

From our consultations it is clear that principals and teachers appreciate support from industry. However, to be effective, partnerships have to address issues related to commitment, personnel, bridging different contexts and language, and recognise the primary role that principals and teachers have in defining the pedagogy and teaching in their schools. Intermediaries such as universities, TAFEs and subject associations provide expertise and accredited training capabilities.

Early in the preparation of this report it became clear that the ambiguous and extreme interpretations of phrases such as *STEM skills* confuses the discussion. In this report, we use *STEM skills* to refer to the capabilities that support professional STEM careers. We use the term *digital proficiency* to refer to technology capabilities that nearly every child and adult needs in order to maximise their participation in our increasingly technological world. *Digital proficiencies* are equally important to those working in non-STEM disciplines across the humanities, social sciences and trades.

Enterprise skills such as communication, clear thinking, creativity and problem solving were identified by industry as being increasingly important now and in the future. These skills are universal, taught as much through the humanities and other non-STEM pathways as they are through STEM pathways.

When students make subject decisions in secondary school, they are more likely to make choices that will be consistent with ultimately undertaking STEM related tertiary studies and careers if they understand the kinds of real world problems those careers might help them solve as adults. Industry is well placed to share real world problems with students, teachers, career advisers and parents.

There is a broad perception from industry and school educators that **the decline in the number of Australian students selecting advanced subjects in upper secondary to maximise their tertiary career choices is occurring because they are receiving the wrong signals from the tertiary sector**. One such unclear signal is the ATAR, used by universities as a tool to simplify their selection processes but perceived, rightly or wrongly, by students, parents and educators in the school system as a driver of subject choices, often towards less challenging and less appropriate subjects.

The other unhelpful signal is the erosion of mathematics prerequisites over the years. The submissions and consultations did not recommend compulsory mathematics, nor did they recommend that prerequisites for physics and chemistry be reinstated. They did, however, consistently recommend that mathematics prerequisites be applied to courses and specialisations that require mathematics, on the basis that mathematics is the language of science and that mathematics skills need constant development and cannot be acquired effectively in a short bridging course.

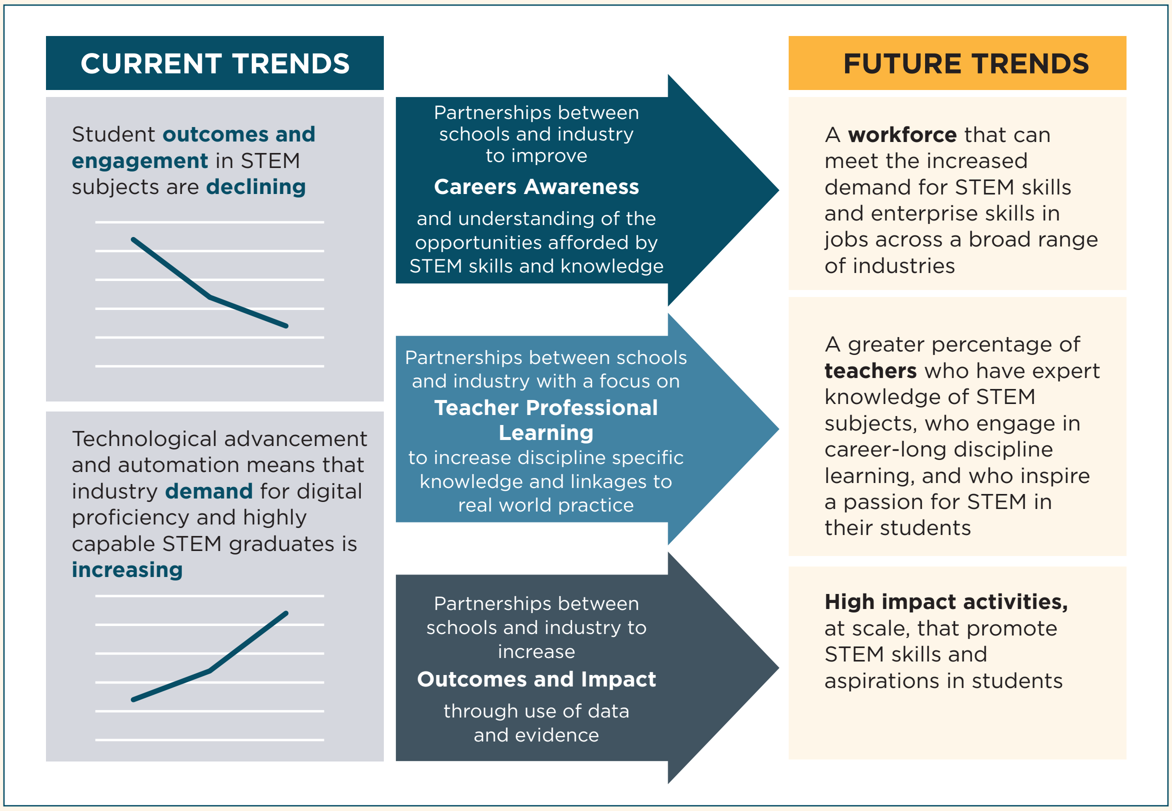
Education and industry members of the Forum were unanimous in their **recognition of the central role of teachers, principals and other school leaders in achieving better student outcomes**.

The Forum concluded that **minimum national requirements for teacher professional learning are needed** that include relevant, discipline specific professional learning from an accredited provider such as a university or a TAFE, to ensure ongoing high quality teaching in STEM disciplines.

Industry and other partners such as professional associations can assist principals and lead teachers in the development of high quality, contemporary professional learning materials. These materials should be broadly applicable and relevant for teachers working outside their main discipline, and accessible to teachers in rural and remote communities with limited travel and broadband access.

School teachers delivering STEM related Vocational Education and Training (VET) in secondary schools face ongoing challenges to gain and maintain the required credentials. **There is an opportunity for education authorities to collaborate closely with industry to help teachers acquire and maintain VET industry currency requirements** in line with national standards, including providing industry placements and other professional learning opportunities.

The Forum acknowledges that a range of partnership models exist nationally and within states and territories. It encourages education authorities to consider and promote identified **best practice approaches**. These **include designing for scale, integrating teacher professional learning** into the programs, **and alignment with the Australian Curriculum**.



For schools and industry, the **Forum recommends the establishment of a national online resource and toolkit** with information on the elements of successful partnerships, the important role of intermediaries, and advice to support schools and industry in designing, implementing and evaluating partnerships.

Understanding the impact of these partnerships requires high quality data. Whilst Australia has a number of useful data assets, they are at present stranded assets because they are disconnected from each other. This makes the evaluation of the impact of any partnerships or policies on student outcomes expensive or unviable.

The Forum is of the view that **the lack of a national lifelong Unique Student Identifier is inhibiting the development of national STEM education data sets** and our understanding of the impact of STEM policies and programs. This has a flow on effect for industry which finds it challenging to assess both need and impact to target their resources effectively. The Forum recommends that Education Council should prioritise and accelerate the introduction by 2020 of a national lifelong Unique Student Identifier, with strong privacy protections built in, to promote a more sophisticated analysis and understanding of student pathways and progress in Australia. Students will benefit as they are able to access richer records of their schooling and have these records follow them as they transition between schools.

On student outcomes, Forum members recommend that a more comprehensive set of measures be adopted than the oft cited PISA and NAPLAN scores. Notwithstanding the success of these metrics, they are not able to capture the breadth of Australia's educational performance in STEM disciplines. An overreliance on these measures alone risks students not being equipped with the full set of skills required to succeed in the workplace and broader economy.

The Forum proposes a dashboard of STEM educational performance that is concise and utilises existing data and evidence. It includes indicators such as STEM participation and attainment including for underrepresented cohorts, VET and higher education enrolments, and graduate and employment outcomes.

The ten recommendations of the STEM Partnerships Forum have been developed by drawing on the experience of Forum members as well as insights provided by extensive consultation with education and industry experts from across Australia. The Forum believes that adoption and implementation of these recommendations, over the next two to three years, will have a constructive impact on STEM engagement and performance in Australia over the long term, increasing individual opportunities and contributing to the future prosperity of this nation.

Recommendations

Understanding workforce needs

A large quantity of data and research on industry demand for STEM skills and knowledge exists, but it does not present a clear or consistent picture of demand. To ensure efforts are targeted appropriately, Australia needs clear definitions of STEM skills and a better understanding of future workforce needs.

Recommendation 1

The Australian Government, in partnership with state and territory governments and industry associations should collaborate to develop a more detailed understanding of future workforce needs, including vacancies and the skills required of employees both in STEM specific areas and areas where STEM skills are valued. The research should:

a. **consolidate and validate existing work and labour market data and identify information gaps,**
b. **have the potential to be regularly updated as a time series to identify trends,**
c. **identify the role of employers in contributing to on the job training of graduates, and**
d. **clarify the optimum balance between enterprise skills, digital proficiency and the need for STEM discipline specific content knowledge in the present and future workforce.**

Signals to senior secondary students

Industry is concerned about the capability of graduates and has identified the need for school students to receive the right signals about the importance of studying enabling subjects in years 11 and 12.

Recommendation 2

Education Council should review:

a. **how the senior secondary system, including the ATAR, can incentivise students to study the most advanced and appropriate subjects, and**
b. **the impact on school teaching practices and student tertiary outcomes of universities having dropped prerequisites for courses or specialisations that require a strong foundation in mathematics.**

Teacher professional learning

To meet industry demand for a highly capable pipeline of graduates with STEM skills, the teaching of STEM disciplines needs to be engaging and reflect the latest developments in rapidly changing fields with extra support for those teachers who face particularly challenging circumstances. While all jurisdictions require professional learning to align to the Australian Professional Standards for Teachers, there is no national requirement for teachers of STEM subjects to undertake specified hours of professional learning in discipline specific content and pedagogy delivered by an accredited provider such as a university, TAFE or other registered training providers.

Recommendation 3

Education Council should develop minimum national requirements for teacher professional learning, a proportion of which should include relevant, discipline specific professional learning from an accredited provider, that must be satisfied in order to retain ongoing registration as a primary or secondary teacher.

Recommendation 4

Education authorities should support principals and lead teachers to engage with industry and other partners to develop and implement high quality, contemporary professional learning materials and teaching practices in mathematics, science and technology. These should include particular support for:

a. principals and other school leaders,

b. teachers working outside their main discipline, and

c. teachers in rural and remote communities with limited travel and broadband access.

VET in schools

Vocational Education and Training is increasingly important in the development of a qualified workforce for industries that rely on STEM skills. VET qualifications are responsive to current industry practice and provide flexibility through micro-credentialing. However, it is challenging for secondary school teachers to gain and maintain the required credentials to deliver VET in secondary schools.

Recommendation 5

To support the delivery of VET qualifications in STEM fields in secondary schools, education authorities should collaborate with industry to help secondary school teachers acquire and maintain industry currency requirements in line with national standards, including providing industry placements and other professional learning opportunities.

Solving real world problems

Engaging students in STEM means discussing with them the real world problems they want to solve rather than focusing on careers in STEM. These efforts should acknowledge the important role of parents, teachers and career advisors in influencing student decision-making.

Recommendation 6

Governments and industry should work together to focus the narrative for primary and secondary students on how STEM skills and knowledge can solve real world problems. Having been motivated by real world problems, students should be introduced to the applicable subjects, skills and jobs that will afford them career flexibility as they contribute to meeting the needs of our future society. There should be particular effort to engage student cohorts underrepresented in STEM fields.

Best practice approaches

A range of industry-school partnership models exist nationally and within states and territories. While some are in early stages, there are common elements to the successful models that states and territories should encourage in future initiatives.

Recommendation 7

Education Council should consider and promote models of best practice to bring together schools and industry at scale and illustrate the potential benefits of adopting approaches across jurisdictions. Key elements of successful approaches include:

a. scalability,

b. a single point of contact for industry to work with a large number of schools,

c. integrated teacher professional learning,

d. real world context, and

e. alignment with the Australian Curriculum.

A national STEM toolkit

A common theme throughout the Forum's consultations was that there are major challenges in establishing industry-school partnerships. Given their different backgrounds, industry is not always sure how to deal with schools, nor schools with industry, and neither are sure where to go for guidance on how to establish a partnership.

Recommendation 8

Education Council should establish a national online resource and provide a toolkit that brings together material to support schools and industry in designing, implementing and evaluating partnerships. The toolkit should:

a. consolidate and provide easy access to resources and guidance on industry-school partnerships,

b. showcase existing high quality, scalable partnerships in which industry can invest,

c. include intermediaries such as universities and TAFEs that can help schools and industry set up new partnerships and navigate regulatory frameworks,

d. assist in defining outcomes and evaluating and measuring the impact of partnerships,

e. provide guidance on curriculum alignment,

f. provide guidance on ways to engage underrepresented groups, and

g. leverage existing platforms wherever possible.

Unique student identifier

While numerous data sets on STEM education exist, they are disconnected. The lack of a lifelong Unique Student Identifier is the biggest barrier to developing national STEM education data sets and a comprehensive understanding of the impact of policy and partnership efforts. Establishment of a national lifelong Unique Student Identifier would assist students in the presentation of their achievements as they move through the school system and assist researchers and policy makers. This could be achieved by building on existing arrangements, such as the system used in the VET sector.

Recommendation 9

Education Council should prioritise and accelerate the introduction by 2020 of a national lifelong Unique Student Identifier to enable a more sophisticated analysis and understanding of student pathways and progress in Australia. Students will benefit from being able to share their educational records as they move between schools. The Unique Student Identifier would:

a. **be developed with strict privacy controls to govern access to individual records and the ethical use of data for research purposes, in compliance with the Commonwealth Privacy Act 1988,**
b. **allow students to determine what information is shared,**
c. **apply across all states and territories, all school levels, all school sectors (government, Catholic and independent) and all tertiary sectors.**

STEM education dashboard

Given their investment in school partnerships, industry seeks to understand the national-level long term impact. Building on existing work underway through the OECD in evaluating enterprise skills Education Council should prioritise work to better present student achievement by creating a national STEM 'dashboard' that brings together a range of existing data and evidence to provide a rich overview of Australia's educational performance across STEM disciplines.

Recommendation 10

Education Council should accelerate efforts on the collaborative action under the National School STEM Education Strategy, to build "national reports to chart national change in a range of STEM data indicators." A suitable one page dashboard would contain up to 10 indicators such as STEM participation and attainment (including for underrepresented cohorts), VET and higher education enrolments, and graduate and employment outcomes.

Snapshot of Recommendations

PRIMARY SCHOOL | SECONDARY SCHOOL | HIGHER EDUCATION AND VOCATIONAL EDUCATION AND TRAINING | WORK

1 Collaborate with industry to develop a more detailed understanding of future workforce needs**

2 Review senior secondary system and university prerequisites **

Teacher professional learning

3 Develop minimum national requirements for discipline specific professional learning to maintain ongoing teacher registration ***

4 Engage with industry and others to develop and implement high-quality professional learning materials in STEM **

5 Collaborate with industry to help teachers deliver VET in secondary schools ***

Solving real-world problems

6 Create a narrative for students and parents on how STEM skills and knowledge can solve real world problems *

School-industry partnerships

7 Consider models of best practice to bring together schools and industry at scale *

8 Establish a national online resource and toolkit to support schools and industry in designing, implementing and evaluating partnerships *

Outcomes and impact

9 Introduce a national lifelong Unique Student Identifier by 2020 ***

10 Create a national STEM education dashboard covering participation, attainment, tertiary enrolments, and graduation and employment outcomes **

Legend

Led by Education Council

Partnership with industry

* Short Term (0-6 months) ** Medium Term (6-18 months) *** Long Term (18 months-3 years)

Definitions and how we use them in this report

There are a range of different approaches to describing STEM and the sorts of skills and knowledge students need for the future. The Forum has used the following definitions in the report.

What do we teach?

STEM disciplines

Used when referring to all the STEM disciplines: Science (physics, chemistry, biology, earth and environmental science), Technology, Engineering and Mathematics.

STEM education

Refers to the teaching of the STEM disciplines, as well as an integrated approach that increases interest and knowledge in STEM disciplines and improves students' problem solving and critical analysis skills.

What do students learn?

STEM skills

Skills and capabilities developed directly through the study of the disciplines of science, technology, engineering and mathematics. They include skills such as applying the scientific method, specific discipline knowledge, theoretical understanding, and data analysis utilising formulas and models. These are the types of skills that STEM professionals such as software engineers or molecular biologists apply in their work in areas such as biotechnology, statistics and artificial intelligence.

Digital proficiency

Digital Proficiency differs from Digital Technology or Technology as outlined in the STEM disciplines above. The term is used to describe the functional skills needed for navigating the technological world. Digital proficiency is the ability to use a range of digital platforms and programs to communicate, market, transact, find information, solve problems or complete tasks. These are the skills that most people need to live and work. Also known as Information and Communication Technology (ICT) capability in the Australian Curriculum and as digital literacy.

Enterprise skills

A term to encompass the universal personal attributes and workplace skills that are required for success in further education and work in a rapidly changing world. These include communication, creativity, critical thinking, personal and social capability, resilience, ethical understanding, collaboration and team work. Other similar terms include 21st Century skills, general capabilities, transdisciplinary skills, soft skills and employability skills.

Introduction

Seemingly every week we are greeted with a new piece of research about the importance of building STEM skills in the workforce to secure economic growth in the face of increasing globalisation and automation. However, despite fears about job loss due to automation, Innovation and Science Australia estimates that due to Australia's ageing population, there will actually be a 6% shortfall in the number of workers needed to maintain Australia's current GDP growth in 2030.

The concern of employers that school leavers are not ready for the workplace is reflected in mathematics and science fields, with stagnating or declining performance in national and international assessments. Participation in challenging STEM subjects in Australian schools has also declined by up to 10 percentage points in some subjects over the past two decades.

We have fewer high achievers than in comparable advanced countries. There is a large achievement gap between both Aboriginal and Torres Strait Islander students and students in regional and remote areas compared to their non-Aboriginal and Torres Strait Islander and metropolitan counterparts.

Girls, Aboriginal and Torres Strait Islander students, students from low socio-economic backgrounds and students from regional and remote areas are underrepresented in the STEM workforce, are more likely to have negative perceptions of STEM disciplines, and are less likely to aspire to STEM careers.

Given Australia is one of the world's greatest economic success stories with nearly three decades of continuous economic growth, we can and must do better.

There is a lot already happening. There are hundreds of programs in schools and extra-curricular activities that seek to improve STEM engagement and performance. Some states and territories have implemented specialist science and technology facilities that exist as a shared resource for schools, and some companies are working with universities to provide professional learning resources.

Teachers are central. They can inspire students and nurture their spark. Ensuring teachers have the support they need to be confident in their disciplines and teaching practices is essential to engaging students and helping them understand how STEM education can help them solve real world problems and lead to fulfilling careers.

Industry is willing and able to help. Industry is not just an employer, but can play a role in connecting the concepts taught in our classrooms to their real world applications.

There are extensive examples of industry contributing to STEM education including through the provision of resources, work experience opportunities and programs supporting schools, teachers and students. However, the proliferation and varying quality of these activities can create confusion for both schools and industry.

To meet the challenges of the future, as noted in the ISA 2030 Plan, governments, educators and industry must work more closely together to maximise and amplify the impact of industry investment and ensure students and teachers keep up with the rapid pace of change in STEM disciplines.[3]

3 Innovation and Science Australia 2017, *Australia 2030: prosperity through innovation*, Australian Government, Canberra, p. 33

The STEM Partnerships Forum has identified three major areas where industry-school partnerships should focus in order to have the greatest impact on the engagement and aspirations of young people in STEM areas – 1) teacher professional learning, 2) awareness of the opportunities for real world problems to be solved through STEM careers and 3) improving our understanding of the outcomes and impact of STEM partnerships.

To support the work of the Forum, a series of consultations was undertaken across state and territory capital cities with experts from education and industry invited to respond to observations, provisional recommendations and questions. A total of 152 people attended 18 meetings over seven weeks. In addition to this, 53 written submissions were provided in response to the Forum's Issues Paper.

The following chapters further explore the national and international trends in STEM education, describe how targeted action by industry, government and other stakeholders in these areas will lead to improved STEM outcomes for students, and provide practical advice on how to optimise existing and new industry-school partnerships.

1. NATIONAL AND INTERNATIONAL TRENDS

Chapter Overview

While government and industry are sending strong messages about the importance of STEM education, student engagement and performance in these areas has been stagnating or declining over a long period of time.

This is particularly the case for groups that have historically been under represented in STEM industries such as girls, students from low socio-economic status (SES) backgrounds, Aboriginal and Torres Strait Islander students and students from rural, regional and remote areas.

Other countries are adopting innovative approaches to improve STEM outcomes and while these may not be directly transferable to Australia's context, there are valuable lessons to be learnt.

National Trends

While industry is regularly calling out for more graduates with STEM skills,[4] official labour market data presents a more nuanced picture.

It is predicted that over the five years to 2022, the largest jobs growth will be in health care followed by professional, scientific and technical services, construction, and education and training. Employment is expected to grow strongly in the computer system design sector by 25%, but this is not replicated across a broader range of traditional STEM careers.[5]

Research conducted by the National Centre for Vocational Education Research (NCVER) acknowledges that additional STEM skills and knowledge are required to support national productivity and prosperity but noted that there seems to be an oversupply rather than a shortage of people looking for work in STEM disciplines.

Over the five years to 2022, the second largest jobs growth will be in professional, scientific and technical services, with only 10% of job vacancies currently reported in this area. [6] The considerable jobs growth in this industry, together with the current job vacancies, would suggest there is, and will continue to be, a need for graduates from both the higher education and VET sectors with STEM skills.

The 2017 Graduate Outcomes Survey shows that STEM graduates have slightly higher than average employment rates, with approximately 75% of undergraduate degree STEM graduates in full time employment four months after graduation compared to 72% for all graduates. This increases to 90% of STEM graduates in full time employment three years after graduation compared to 89% of all graduates.[7]

Given the disconnect between official data and messages coming from employers, there is a need for the Australian Government to work with industry to improve our collective understanding of labour market demand in relation to STEM skills, with clarity around the types of skills in demand and the scope of that demand.

In relation to the capacity of Australian school students to meet this demand, the following data shows this is particularly an issue for students who have typically been underrepresented in STEM fields such as girls, students from low SES backgrounds, students in rural and regional areas and Aboriginal and Torres Strait Islander students.

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4 National Centre for Vocational Education Research (NCVER) 2014, *Readiness to meet demand for skills: a study of five growth industries*, NCVER, Adelaide. p.3.

5 Department of Jobs and Small Business, 2017, *Industry Employment Projections, 2017 Report*, August 2017. p.2.

6 Australian Bureau of Statistics, *6354.0 – Job Vacancies, Australia, Nov 2017*

7 Quality Indicators of Learning and Teaching, 2017, *2017 Graduate Outcomes Survey longitudinal (GOS-L), medium term graduate outcomes, October 2017 National Report.* p.6.

Student performance in national assessments

Over the past decade, between 91% and 96% of Year 3, 5, 7 and 9 students have met the national minimum standard for numeracy in the National Assessment Program – Literacy and Numeracy (NAPLAN).[8]

While this indicates that Australia's education system is working at some level, it is important to note that the minimum standards are not aspirational. The Forum welcomes the Australian Curriculum Assessment and Reporting Authority's (ACARA) work to develop NAPLAN proficiency standards that will provide a more meaningful understanding of literacy and numeracy achievement.

In 2017, while around 96% of non-Indigenous students met the national minimum standard in numeracy across year levels, this ranged from between 80% to 84% across year levels for Aboriginal and Torres Strait Islander students. By the time Aboriginal and Torres Strait Islander students reach Year 9, they are close to three years behind non-Aboriginal and Torres Strait Islander students in numeracy.[9]

Student engagement and interest in STEM

There are a number of factors that drive students to aspire to a career in a STEM field, including gender, cultural capital, age, whether their parents are in a STEM occupation, and prior achievement in reading and numeracy.

Research demonstrates that fostering engagement in STEM education in primary school positively influences later participation in STEM disciplines, particularly in the senior secondary years.[10]

While there does not appear to be an achievement gap between girls and boys in STEM subjects, there is an issue around career aspiration: girls, including top performers, are less likely than boys to expect to work in a science related occupation, with girls more likely to envisage themselves as health professionals.[11] Even when girls do study STEM subjects, the Australian Council for Educational Research has noted a decline in the number of women with STEM qualifications who decide to follow through on their education to enter STEM professions.[12]

A key proxy for understanding interest in STEM and the likelihood of a student being interested in a STEM career, is to look at subject selections in senior secondary school.

As expected, data shows 5% more males undertaking mathematics than females in senior years, however up to 5% more girls are participating in the science learning area than boys.[13]

There has been a long term decline in Year 12 enrolment rates in science and challenging mathematics subjects over the past decades (Table 1).[14]

While overall enrolments in mathematics are steady at around 72%, it is a concern that this increasingly seems to be because students are choosing to enrol in lower level courses. **Intermediate and Advanced Mathematics participation** declined from 54% to 36% from 1992 to 2012.[15]

8 ACARA, 2017, NAPLAN National Report, 2017 published online at www.nap.edu.au.

9 Goss, P., 2018, *Grattan Institute submission to the Refresh initiative for Closing the Gap*, Grattan Institute, p. 5

10 Rosicka, C 2016, *From concept to classroom: Translating STEM education research into practice*, ACER, Victoria. p.9

11 OECD. 2016. *PISA 2015 Results (Volume I): Excellence and equity in education.* PISA, OECD Publishing, Paris, p.116

12 Thomson, S, De Bortoli, L & Underwood C 2017. *PISA 2015: Reporting Australia's results*. ACER, Victoria p.224

13 National Report on Schooling. Data sourced from 2010, 2011, 2012 and 2013 reports. [Online] Accessed at https://www.acara.edu.au/reporting/national-report-on-schooling-in-australia-2013. [Accessed: September 2017]

14 Kennedy, J, Lyons, T & Quinn, F 2014, 'The continuing decline of science and mathematics enrolments in Australian high schools', *Teaching Science*, vol. 60, no. 2, June 2014. p.34

15 Some students are enrolled in more than one mathematics subjects. Wienk, M, 2017, *Discipline Profile of the Mathematical Sciences* 2017, AMSI (University of Melbourne), Melbourne, p.23

Table 1: Participation rate - Year 12 students - Mathematics 1992 to 2012[16]

Subject	1992	2012
Advanced	16%	9%
Intermediate	38%	27%
Elementary (estimated)	38%	49%

Science participation (in one or more science subjects) has declined from 55% in 2002 to 51% in 2013.[17]

While there has been a slight decline in the number of Year 12 students studying STEM subjects over the years, the more concerning trend is what appears to be a reduction in the level of difficulty of the subjects chosen by students.

Are students adequately prepared for post-school pathways?

The declining number of students choosing to take on the most challenging mathematics subjects in Year 12 was raised as a concern by industry and education representatives throughout the Forum's consultations and submissions.

The decline in students studying challenging mathematics courses has a flow on impact for their post-secondary studies.

> ***"Students with adequate and appropriate preparation for STEM related university degrees are likely to perform better and complete their degrees." [Australian Academy of Science]***

Research by the University of Sydney has found that higher levels of mathematics taken in senior secondary school are strong predictors of success in the first year of science and mathematics at university. Failure to study an appropriate level of mathematics in the senior years of secondary school may have serious consequences for a student's success in STEM degrees or indeed completion at university.[18]

16 Wienk, M., Discipline Profile of the Mathematical Sciences, 2017, Australian Mathematical Sciences Institute. p.22.

17 Data from National Reports on Schooling. [Online] Accessed at http://www.acara.edu.au/reporting (Accessed: September 2017)

18 Nicholas, J., Poladian, L., Mack, J., Wilson, R., *Mathematics preparation for university: entry, pathways and impact on performance in first year science and mathematics subjects*, International Journal of Innovation in Science and Mathematics Education. p.39.

While 75% of the intermediate mathematics students who enrolled in a pre-university mathematics bridging course were able to pass their first semester university based calculus course, they did not achieve at the level of their well prepared peers who studied advanced mathematics in secondary school.[19]

Optimising the Australian Tertiary Admissions Rank (ATAR)

A consistent message throughout the consultations was that one of the reasons students are not selecting challenging mathematics and science subjects in Year 12 is because of the perceived impact of particular subjects on their university entrance ranking.

The ATAR is a percentile ranking awarded to students who complete their senior secondary certificate (in all states except Queensland) with a median value of approximately 70. It is used to determine university entry and students are often more concerned about getting into the university of their choice than being adequately prepared for the degree.[20] Universities are autonomous and determine the ATAR score required for each one of their courses and any subject prerequisites.

In 2016, 73% of school leavers who went to university, did so via an ATAR.[21] The concern expressed through the consultations and submissions relates to the signals sent to schools and students. Research conducted in NSW in 2015 found the most frequent reason for students not doing advanced mathematics was the students' desire to optimise their ATAR by aiming for a higher score in a less demanding subject. This was compounded by the time demands of studying intermediate and advanced mathematics.[22] If students do not see the value in the knowledge and skills they will gain through these challenging subjects, or see a benefit or need in relation to their post-school plans, there is little incentive for students to engage with them.

Rising tension between the subjects students need in Years 11 and 12 for a solid foundation for further study in the field, and the need to maximise their ATAR to gain university entry, has led to challenges in schools providing subject selection advice. Only five of 37 Australian universities require intermediate or advanced mathematics for entry into a Bachelor of Science and only four of 31 universities for entry into a Bachelor of Commerce. Thirty-four Australian universities offer engineering degrees. Currently, only one requires advanced mathematics, and at least two do not require any mathematics at all.[23] As a consequence, many schools, careers advisors and parents do not see the need for students to study more advanced subjects that are known to be appropriate for some of the undergraduate courses or specialisations into which the students may want to enrol.

Through national consultations, education and industry stakeholders were unanimous in their view that students who are talented and interested in mathematics are being told, wrongly or rightly, not to take advanced subjects because they would be putting their ATAR score at risk. Stakeholders have suggested that universities could reinstate prerequisites or could allocate bonus points in recognition of performance in advanced level Year 12 subjects that are relevant to a course or specialisation. Some universities have already committed to implementing these changes. This view is consistent with the recent

19 Poladian, L., Nicholas, J., (2013). *Mathematics bridging courses and success in first year calculus*, The University of Sydney, p. 9.

20 Nicolas, J, Poladian, L, Mack, J & Wilson, R 2015, 'Mathematics preparation for university: entry, pathways and impact on performance in first year science and mathematics subjects', *International journal of Innovation in Science and mathematics Education*, vol. 23, no. 1, p. 39.

21 Department of Education and Training, Selected Higher Education Student Data, unpublished.

22 Nicholas, J, Poladian, L, Mack, J, Wilson, R, 2015, *Mathematics preparation for university: entry, pathways and impact on performance in first year science and mathematics subjects*, International Journal of Innovation in Science and Mathematics Education, The University of Sydney, p. 39.

23 Wienk, M., 2017, *Discipline Profile of the Mathematics Science*. Sydney: Australian Mathematical Sciences Institute. p.24.

Innovation and Science Australia report, *Australia 2030: Prosperity through innovation*, which recommended that universities reinstate prerequisites into appropriate tertiary courses.[24]

Currently, the use and allocation of bonus points varies across participating universities. In some universities, eligible students can apply for bonus points that are added to their ATAR to give an adjusted score. A number of universities offer bonus points to students who take higher level mathematics subjects.[25]

There is work underway as part of the Australian Government's university reforms to improve the information available to students about university admissions to help them make more informed decisions. In 2017 the Higher Education Standards Panel found that under the demand driven system, admissions requirements are becoming more complex and harder to understand. The challenges include a lack of comparable information on higher education entry requirements, alternative pathways and student cohort information. This makes it difficult for prospective students to make informed decisions. In particular, there is a lack of clarity on the use of the ATAR rankings and the basis on which bonus points are awarded by universities.

The Panel's recommendations focussed on greater transparency and accessibility of information with clearer reporting requirements and the publication of consistent information about actual admissions. These will be implemented for those entering university in 2019.[26]

> ***"...the reintroduction by universities of course-specific prerequisites, including minimum scores where appropriate, has the advantage of not causing further distortion to the ATAR system, and providing a more direct connection between a senior secondary course of study and tertiary study".***
> ***[Australasian Curriculum Assessment and Certification Authorities]***

Building on this work, the Forum believes a broader examination of the senior secondary system and its interaction with university entrance requirements and prerequisites should be undertaken. This would ensure schools and students are receiving the right signals about the importance of taking on advanced and appropriate mathematics and science subjects to keep their post-school education and work options open and to maximise their chances of success in undergraduate courses and specialisations. The reintroduction of prerequisites by universities would need to be phased in over a number of years to ensure students were aware of the new requirements when selecting their subjects in Years 11 and 12.

Vocational Education and Training for secondary students

Student engagement with STEM education can also be measured by looking at the proportion of secondary school students undertaking VET subjects in a STEM related field as part of their school education program.

A strong message received by the Forum is that through its flexible approach and basis in industry partnerships, VET will play an increasingly important role in equipping the Australian workforce for the jobs of the future.

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24 Innovation and Science Australia 2017, *Australia 2030: prosperity through innovation*, Australian Government, Canberra, p. 33

25 http://www.uac.edu.au/atar/bonus-points/subject-bonuses.shtml (Accessed 22 March 2018)

26 Australian Government, 2017, *Improving the transparency of higher education admissions: Joint higher education sector and Australian Government implementation plan, June 2017*, Department of Education and Training,https://docs.education.gov.au/system/files/doc/other/admissions_tranpsarency_implementation_plan_june_2017.pdf (Accessed 9 February 2018)

The hands on, skills based training provided by VET can play a major role in delivering the qualified workforce that industry is demanding in a rapidly changing environment. Despite this, students are often guided away from considering a VET pathway in secondary school by parents and career advisers who perceive it as less valuable than a university degree.

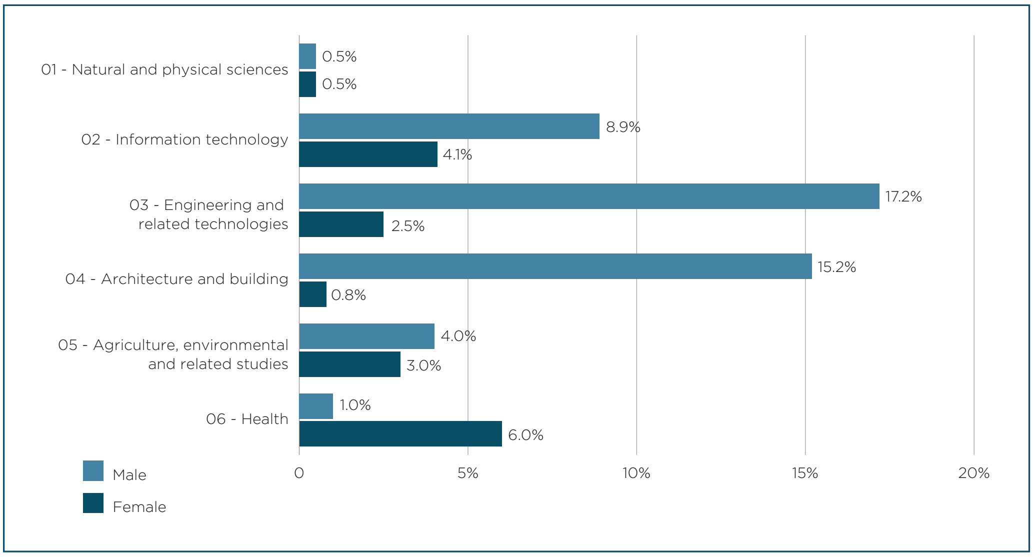
Undertaking VET subjects in secondary schools enable students to gain credit towards their Year 12 certificate, while at the same time gaining or working towards a nationally recognised qualification. Some states and territories also allow credit from VET subjects to count towards a student's ATAR.

In 2016 there were 77,153 secondary school students undertaking some form of STEM related VET subject.[27] This represents 9% of all 15 to 19 year old secondary students and is up by 15,707 from 2011, showing a major increase in student interest.[28]

Encouragingly, there are higher proportions of remote secondary students undertaking one or more VET subjects in STEM related fields of education at 46% compared to 29% in major cities.[29]

The research also indicates a higher proportion of males than females take VET subjects in secondary school. They do so in all STEM related fields, with the exception of health. The gaps are particularly obvious in engineering and related technologies, and in architecture and building, as shown in the graph below.[30]

Figure 1: Proportion of 15 to 19 year old secondary student enrolments in VET subjects by STEM related field of education by gender in 2016[31]



27 NCVER, *National VET in Schools Collection 2016 VOCSTATS* [Online] Available at: http://www.ncver.edu.au/resources/vocstats.html. (Accessed 13 October 2017). National VET education statistics based in the engineering, technology and science sector can be sourced via six field of education: engineering and related technologies; architecture and building; information technology; natural and physical sciences; agriculture, environmental and related studies; and health, see: Siekmann, G., Korbel, P., 2016, *Defining 'STEM' skills: review and synthesis of the* literature, National Centre for Vocational Education Research, p. 44

28 Australian Bureau of Statistics, 4221.0 Schools, Australia, 2016, Table 42b.

29 NCVER, *National VET in Schools Collection 2016 VOCSTATS* [Online] Available at: http://www.ncver.edu.au/resources/vocstats.html (Accessed 13 October 2017)

30 NCVER, *National VET in Schools Collection 2016 VOCSTATS* [Online] Available at: http://www.ncver.edu.au/resources/vocstats.html (Accessed 13 October 2017)

31 NCVER, *National VET in Schools Collection 2016 VOCSTATS* [Online]: http://www.ncver.edu.au/resources/vocstats.html (Accessed 13 October 2017)

Despite increased activity, there are a number of challenges faced by secondary school teachers delivering VET subjects. VET trainers need a Certificate IV in Training and Assessment even if they are a qualified teacher, and are required to maintain industry and vocational currency. School systems must manage the costs and work schedules associated with ongoing teacher professional development to gain and maintain these qualifications. Teachers employed by schools to deliver VET are likely to have strong 'pedagogical practice' capacities, but may have limited industry experience. Confusion regarding the requirements for delivering VET, or a school culture that does not value VET pathways, can also lead to negative perceptions of what VET can offer.[32] Resolving these challenges has the potential to further increase the number of secondary students undertaking STEM related VET and is discussed further in Chapter 2.

Post-school STEM education and outcomes

Beyond VET subjects delivered in secondary schools, there are significant variations in enrolments in STEM related fields of education in the VET and university sectors, with some experiencing stronger enrolment growth and others in decline.

In 2016, there were 3.6 million student enrolments in a VET program of some kind, ranging from short courses of a few weeks to multi year diploma and degree courses. Of those, around 33% were enrolled in a STEM related field, a decrease of 2 percentage points from 2014.[33]

In 2016, there were approximately 860,000 student enrolments in higher education. Of those, around 41% were enrolled in a STEM related field of education, an increase of 2 percentage points from 2011.[34]

Between 2011 and 2016, the proportion of university enrolments in STEM related fields increased in natural and physical sciences, ICT and health, but decreased in architecture and building, engineering and agriculture.[35]

As noted earlier, employment rates for STEM graduates are slightly higher than graduates more broadly. Approximately 90% of higher education undergraduates from a STEM related field were employed after graduation, compared to 89% of all graduates. The value add of studying in a STEM field for VET graduates is greater, with 77% of VET graduates in STEM fields employed compared to 73% of all VET graduates.[36]

International Trends

It is well documented that Australia's performance in international assessments such as the OECD PISA and the International Association for the Evaluation of Educational Achievement's Trends in Mathematics and Science Survey (TIMSS) has declined in both actual and relative terms over a number of years across most domains.

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32 Clarke, K., Volkoff, V., 2012, Education Policy and Leadership, University of Melbourne, *Entry to vocations: current policy trends, barriers and facilitators of quality in VET in Schools*, National Centre for Vocational Education and Research, p. 26

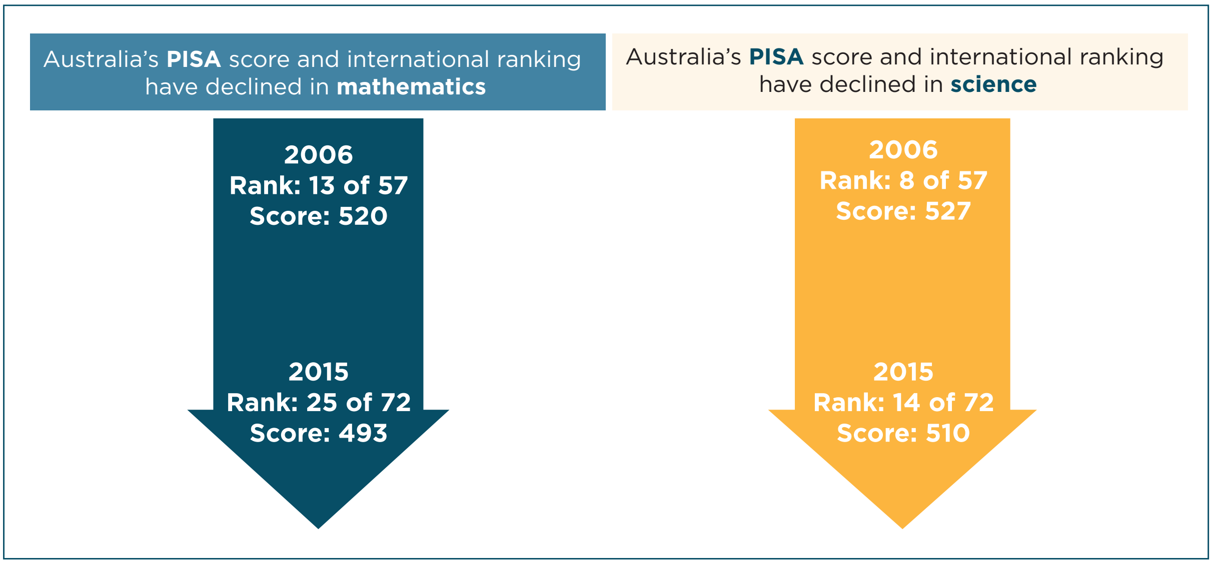
33 NCVER, *National VET in Schools Collection 2016 VOCSTATS* [Online] http://www.ncver.edu.au/resources/vocstats.html (Accessed 7 March 2018)

34 Higher Education Data Cube (uCube) [Online] – 2016 Student enrolment data, Department of Education and Training http://highereducationstatistics.education.gov.au/ (Accessed 14 March 2018)

35 Higher Education Data Cube (uCube) [Online] – 2016 Student enrolment data, Department of Education and Training http://highereducationstatistics.education.gov.au/ (Accessed 14 March 2018)

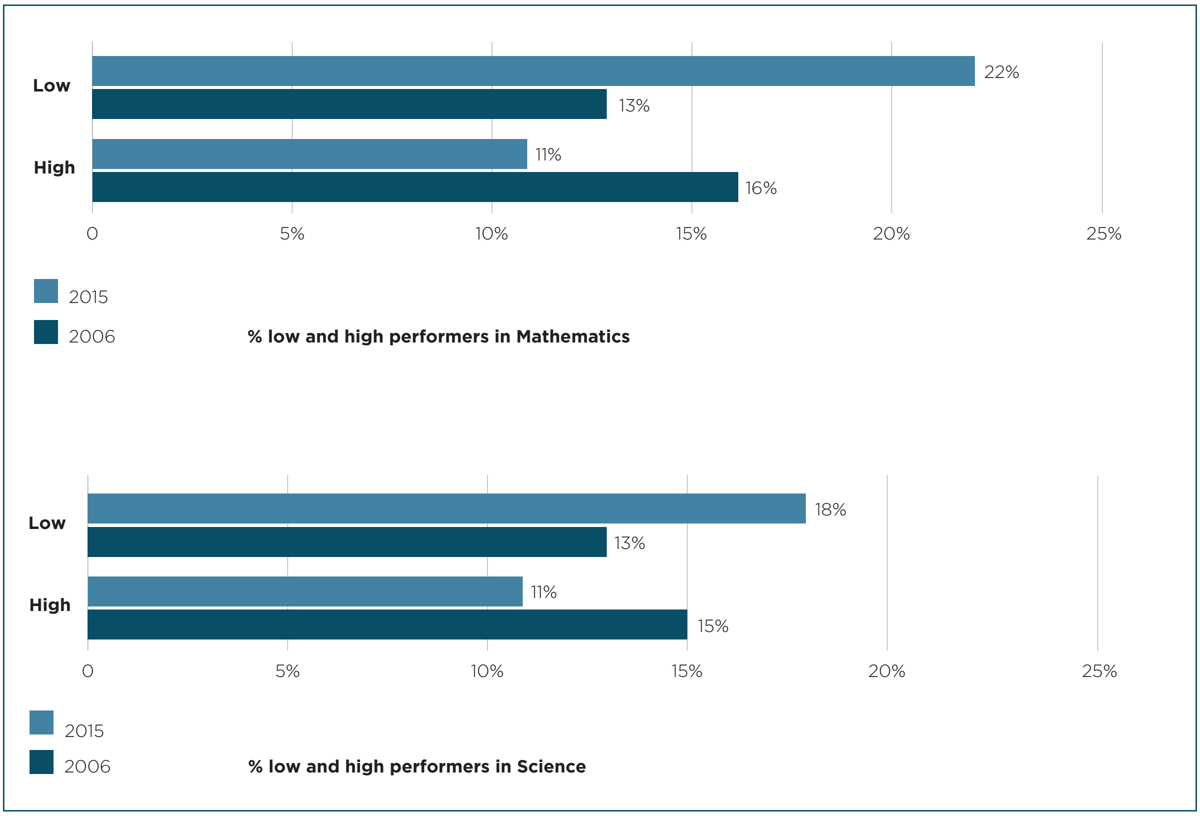
36 Quality Indicators for Learning and Teaching, *2017 Graduate Outcomes Survey, National Report, January 2018*, Graduate Outcomes Survey; NCVER, *Australian vocational education and training statistics, VET student outcomes, 2017*, National Centre for Vocational Education Research, p. 26

Figure 2: Australian student performance in PISA in mathematics and science (2006 and 2015)



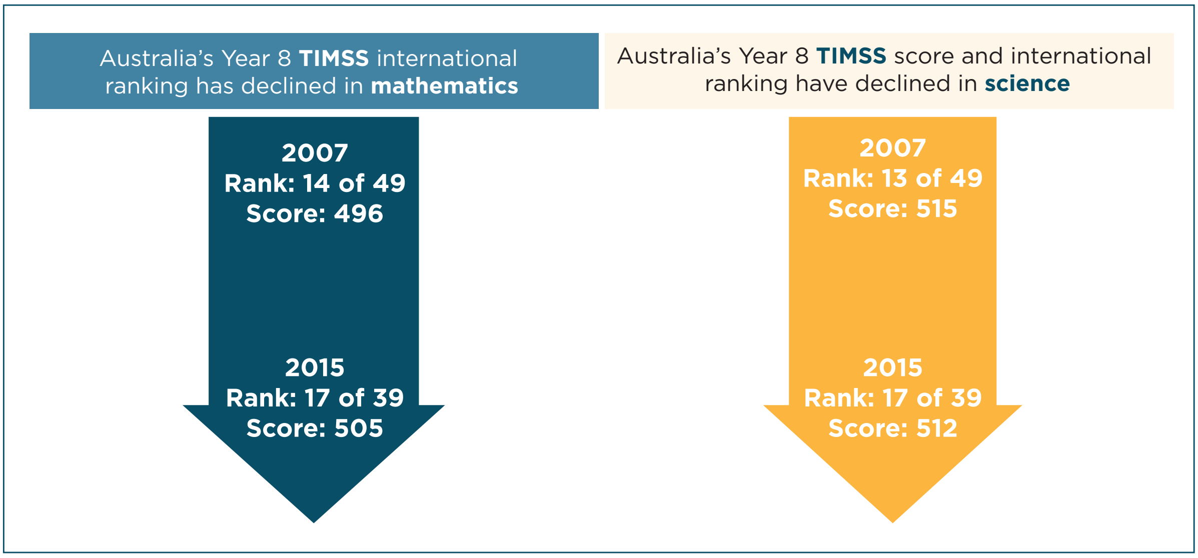
As well as an overall decline, the proportion of low performers in PISA has grown over this time period in mathematics and science, and the proportion of high performers has fallen (see Figure 3).[37]

Figure 3: Percentage of low and high performing Australian students in PISA in mathematics and science (2006 and 2015)



37 Thomson, S, De Bortoli, L & Underwood, C 2016, *PISA 2015: A first look at Australia's results*, ACER, Victoria. p.12.

Figure 4: Australian student performance in TIMSSin mathematics and science (2007 and 2015)



A closer look at Australia's results in international testing also highlights some particular trouble spots. While Australia is performing slightly better than the OECD average in terms of equity, with only 12% of variation in science performance explained by students' SES compared to the OECD average of 12.9%,[38] Australia's rate of improvement in relation to equity is well below the OECD average.[39]

Disadvantaged students

A disadvantaged student is nearly three times more likely to be a low performer in PISA's science test than an advantaged student, a result that is slightly worse than the OECD average. Of more concern, however, is that fewer disadvantaged Australian students are high performers than a decade ago.[40]

STEM outcomes for Australian students in national and international assessments have stagnated or declined in recent years and the number of high achieving students has declined. Even more concerning are the results for Aboriginal and Torres Strait Islander students and students in regional, rural and remote areas.

The latest TIMSS results in Table 2 show the achievement of Indigenous Australian students lags significantly behind that of non-Indigenous Australian students. This gap has changed little over 20 years.

38 Organisation for Economic Cooperation and Development (OECD) 2016. *PISA 2015 Results (Volume I): Excellence and equity in education*. OECD Publishing, Paris, p.46

39 OECD 2017, 'Where did equity in education improve over the past decade?', *PISA in Focus, no. 68*, OECD Publishing, Paris. p.4

40 Organisation for Economic Cooperation and Development (OECD) 2016. *PISA 2015 Results (Volume I): Excellence and equity in education*. OECD Publishing, Paris, p.222

Table 2: Percentage of Indigenous and non-Indigenous students who achieved the intermediate international benchmark in TIMSS in 2015 [41]

	Indigenous Students	Non-Indigenous Students
Year 4 Mathematics	39%	71%
Year 4 Science	47%	76%
Year 8 Mathematics	38%	66%
Year 8 Science	42%	70%

Achievement outcomes for students also vary depending on the geographic location of the school. PISA 2015 showed that the average performance of students in mathematical literacy in metropolitan schools was significantly higher than the OECD average, but significantly lower for students in remote schools.[42] For scientific literacy, the difference between results from students in remote schools compared to metropolitan schools is equal to around one and a half years of schooling.[43]

> ***"Time series analysis of Australia's PISA data across all three testing domains and by year cohort, school sector and student background has so far revealed no clear or consistent pattern in Australia's declining results". [Association of Heads of Independent Schools of Australia]***

Throughout the Forum's consultations, education and industry stakeholders were unanimous that PISA and TIMSS science and mathematics metrics tell us important things about where Australia stands internationally. However, the expansion of subject choices for students into areas that are regarded to be relevant for future studies and work, such as Design and Technologies, Digital Technologies and Work Studies, means that a richer picture to determine whether students have the enterprise skills that employers want is needed. The OECD Future of Education and Skills 2030 project seeks to build a common understanding of the knowledge, skills and attitudes necessary to shape and thrive in the future as we move towards 2030.[44] In the collaborative problem solving element of PISA 2015, Australian students performed significantly above the OECD average and had nearly twice as many high performing students.[45]

The data Dashboard discussed in later sections will provide a richer picture of student performance and contribute to a better understanding of skills requirements.

41 Thomson, S, Wernert, N, O'Grady, E & Rodrigues, S 2016, *TIMSS 2015: A first look at Australia's results*, ACER, Victoria. p. 24, 43, 61, 80

42 Thomson, S, De Bortoli, L & Underwood C 2017. *PISA 2015: Reporting Australia's results*. ACER, Victoria. p.183

43 Thomson, S, De Bortoli, L & Underwood C 2017. *PISA 2015: Reporting Australia's results.* ACER, Victoria, p.51

44 OECD, 2018, *The Future of Education and Skills Education 2030, The Future We Want*, http://www.oecd.org/education/2030/oecd-education-2030-position-paper.pdf

45 OECD 2017, 'Collaborative Problem Solving', *PISA in Focus, no. 78*, OECD Publishing, Paris. p.3

What is happening in other OECD countries?

With Australia being outperformed by 19 countries in mathematics in PISA 2015, it is useful to examine the policies and initiatives being implemented in these countries around STEM education.

The Australian Council of Learned Academies undertook a major research project on STEM practices in a range of countries in 2013. The findings showed recurring features in countries with strong STEM outcomes:

- school teachers enjoy high esteem, are better paid and undertake discipline specific professional learning,
- secondary school STEM teachers are expected to be fully qualified in their disciplines,
- science and mathematics pedagogy is focussed on problem based and inquiry based learning, with an emphasis on creativity and critical thinking,
- longer school hours and more hours in science and mathematics,
- innovative STEM policies exist for formerly excluded groups, and
- national STEM policy frameworks that provide favourable conditions for a range of activities (such as centrally driven and funded programs, curriculum reform, partnerships and engagements that link STEM activities in schools, vocational and higher education with industry, business and the professions).[46]

Singapore

Singapore has gone from being a poor mathematics performer in 1985, to a great performer in 2010, and an excellent performer in 2015. Singapore places a high value on education as the key to economic development in a country with no natural resources.[47]

Case Study: Singapore

At the primary and secondary level, mathematics and science are core subjects that every student must take. Students have specialist teachers in mathematics and science from upper primary onwards. There are a range of specialised mathematics courses at higher levels for those students who are interested.

Mathematics and science teachers are selected from the top third of their cohort, receive initial training on the national math and science curricula during their pre service training, and are entitled to 100 hours of professional learning each year.

Mathematics focusses on helping students understand how to solve problems and master mathematical concepts to solve problems, rather than rote production of correct answers.

The science curriculum focusses on developing the idea of science as a process of inquiry with projects based on the role played by science in daily lives, society and the environment.

Singapore has developed a comprehensive system of selecting, training, compensating and developing teachers and principals. Singapore also has various STEM related programs to create and promote students' STEM awareness.

46 Australian Council of Learned Academies, 2013, STEM: *Country Comparisons, International comparison of science, technology, engineering and mathematics (STEM) Education*, page 15
47 Australian Council of Learned Academies, 2013, *STEM: Country Comparisons, Country Report Singapore*

Japan

Although students in Japan have low levels of motivation and enjoyment in mathematics and science, Japan is one of the highest performing countries in PISA testing.[48] Japan's education system rests on a deep commitment to children, a first-rate teaching force, family support for Japanese students, and the belief that effort, not innate ability, leads to success.[49]

Case Study: Japan

In Japan, from the late 1980s, mandatory hours and standards in STEM teaching were successively lowered for two decades and PISA performance declined. To reverse that decline, since 2008 there has been a return to stronger content requirements, fewer choices and more mandatory hours for science and mathematics teaching.

Teachers are respected, and STEM classes are taught by discipline qualified teachers teaching in the fields in which they were trained.

There is national consensus that the competitiveness of the economy depends on the strength and capacity of research and development, and subsequently on human capital development.

48 Thomson, S, De Bortoli, L, Underwood, C, 2017, *PISA 2015: Reporting Australia's Result*, pages 230 and 237

49 Organisation for Economic Co-operation and Development, 2012, *Strong Performers and Successful Reformers in Education: Lessons from PISA for Japan*, OECD, page 35

Germany

As an advanced manufacturing nation, with a large engineering presence, STEM education in Germany is significant and successful.[50] Germany has a well developed dual system, offering secondary school students both vocational and academic pathways, easing the integration into employment.[51]

Case Study: Germany

Germany has a decentralised education system, with responsibilities shared between the Federation, the Lander (states) and local authorities. Schooling decisions are made by the Lander, while VET is a joint responsibility of the Federation and the Lander, with strong engagement of social partners who work together to adjust curricula. The private sector makes large contributions to vocational secondary programs. Germany's dual vocational system contributes to above average attainment rates in upper secondary education as well as high skills proficiency levels, and lower unemployment rates. Education is compulsory from ages six to 18.

Germany has a high proportion of children enrolled in early childhood education which is believed to contribute favourably towards equity. Germany is one of the more successful countries in attracting women to STEM.

Germany's teachers have the longest pre-service teacher training among all PISA countries, with teacher salaries among the highest across OECD countries.

Germany has a highly structured legal framework for external school evaluation. Regular assessment of student achievement is a key element of the comprehensive strategy for educational monitoring. Overall education standards are set in primary and secondary education, mainly in mathematics, German, English and French.

Effort is being made in Germany to improve equity and boost participation for disadvantaged students, improve teacher training, and adopt a comprehensive strategy for educational monitoring.

Australia has the potential to learn from these countries, with a strong focus on compulsory studies in mathematics and science and quality teaching central to their success in delivering high quality STEM education.

50 Robson, I.R., 2013 *Consultant Report Securing Australia's Future STEM: Country Comparisons – Europe*, Australian Council of Learned Academies; OECD Country Note, 2015, *Programme for International Student Assessment (OPISA) Results from PISA 2015 - Germany*

51 OECD, 2014, *Education Policy Outlook, Germany*, April 2014. p.4.

2. TEACHER PROFESSIONAL LEARNING

Chapter Overview

Teachers must be at the centre of any effort to improve STEM engagement and outcomes for our students. Ensuring teachers have the support they need and access to high quality professional learning is essential.

Most states and territories require teachers to undertake a mandatory number of professional learning hours to maintain teacher registration. However, there is no national requirement for teachers of particular subjects, such as mathematics or science, to undertake specified hours of professional learning in discipline specific content and pedagogy delivered by an accredited provider such as a university or TAFE. This can make it difficult for teachers to keep up with rapid change within STEM disciplines.

Industry-school partnerships with a focus on teacher professional learning are most effective when led by educators, and supported by industry.

Intermediaries such as teacher professional associations and universities can work alongside industry to design and deliver discipline specific professional learning to support teachers.

Industry can provide resources to help teachers link real world practice to curriculum content, and provide experiences (such as industry placements for teachers) to reflect emerging developments and demonstrate the real ways in which STEM skills are used in the workforce. Industry should focus on supporting existing, effective partnership models with scale and impact.

Teachers have the greatest in-school influence on student achievement. High quality professional learning and support for teachers are key avenues where industry can contribute to the quality of STEM education.

Teacher professional learning is varied. It can include:

- working with an experienced mentor,
- participating in classroom observations,
- implementing whole of school activities,
- working with discipline experts and professionals,
- attending conferences,
- building professional learning communities,
- participating in sessions run by museums and science centres,
- undertaking formal programs leading to a certified qualification,
- progressing through structured material online, such as a Massive Online Open Couse (MOOC), and
- other professional learning agreed between the school principal and the teacher as part of their professional development plan, that aligns to the *Australian Professional Standards for Teachers* (Teacher Standards).

Despite the importance of quality teaching and the difficulties with staying up to date with content in STEM disciplines, there are no nationally agreed standards focussed on professional learning that teachers are obliged to complete to maintain their registration. There are, however, requirements in each state and territory for the renewal of teacher registration, with teachers in most jurisdictions required to complete a mandatory number of professional learning hours to maintain registration.

Strengthening the pipeline: initial teacher education reforms

Following a review of initial teacher education in 2014, the report, *Action Now: Classroom Ready Teachers*, formed the basis of reform efforts across Australia to improve the quality of teacher training. In 2015, the revised *Accreditation of initial teacher education programs in Australia: Standards and Procedures* were endorsed by education ministers. These standards include mandatory content requirements for secondary school teachers, including discipline specific and pedagogical requirements.

Education ministers have also agreed to phase in a requirement for all primary school teaching graduates to have a specialisation by 2019, with a focus on subjects and curriculum areas that are in demand, such as the STEM disciplines. New primary school teachers will have expert content and pedagogical knowledge in their area of specialisation.[52]

Professional learning requirements to maintain registration

Maintaining and renewing registration, including the time period for renewal and the number of hours of professional learning required, differs between states and territories. State and territory regulators are responsible for teacher registration and all jurisdictions (except Tasmania) mandate that teachers undertake a certain number of professional learning hours to renew their registration. The number of hours, and the time period this occurs in varies. For example, Tasmania has no minimum hourly requirement, the ACT requires 20 hours per year, Victoria requires 60 hours over three years, and NSW requires 100 hours over five years.

All states and territories require teacher professional learning to align to the Teacher Standards. In NSW and the ACT, a proportion of the professional learning hours undertaken by teachers must be accredited or through an approved provider. No state or territory requires teachers of particular subjects, such as mathematics or science, to undertake a specified number of hours of professional learning in their discipline area.

Strategic directions for teacher professional learning are generally set by the employer, which may be the individual school depending on the sector or the level of school autonomy. Priorities will also be identified through the teacher's annual performance and development review process. Generally, it is up to the teacher, in the context of the school plan and priorities, to identify what professional learning they will undertake. Additionally, state and territory education authorities may invest in large scale programs to meet specific needs, for example, to support the roll out of a curriculum area or ICT training.

52 Innovation and Science Australia also included a number of recommendations in its' recent report seeking to strengthen the quality of initial teacher education (see: Innovation and Science Australia 2017, *Australia 2030: prosperity through innovation*, Australian Government, Canberra, p. 33)

A National Review of Teacher Registration, chaired by Mr Chris Wardlaw PSM, is currently underway, with a final report due in September 2018. The review seeks to examine:

- how the current registration framework is operating,
- the extent to which the Teacher Standards are used to drive teacher quality and how these could be further strengthened, and
- options for the implementation of any improvements to the current teacher registration arrangements.

The review will also examine the registration of teachers in schools, including vocational education and training teachers, and early childhood teachers.

All Australian governments acknowledged the importance of high quality professional learning in improving the knowledge and practice of teachers through the *Australian Charter for the Professional Learning of Teachers and School Leaders*.[53] The Charter, endorsed in 2012, aimed to change professional practice in ways that improve the learning, engagement and wellbeing of every Australian student.

Staying up to date in the classroom: the need for discipline specific professional learning

It is important for teachers to undertake professional learning that supports their needs in the context of school priorities and the needs of their students, however, STEM disciplines are rapidly changing. This makes it difficult for teachers to stay informed of the latest research, developments or workplace opportunities.

To be able to provide students with contemporary contexts for learning, and to be able to link curriculum content to problems being addressed in STEM occupations and industries, teachers need access to current practices, skills and knowledge, particularly relating to their teaching area. A set amount of time spent on relevant, discipline specific (science, technology, mathematics) professional learning and practices will equip teachers with the content to provide engaging lessons reflecting the latest developments. Quality discipline specific professional learning, which includes a blend of content and pedagogical practice, may also reignite the passion of teachers and provide them with a repertoire of teaching methods and strategies with which to engage students. This requirement for discipline specific professional learning is consistent with the view of Innovation and Science Australia that governments should work towards a nationally agreed number of annual hours in discipline specific training.[54] Importantly, this discipline specific training should not replace other types of professional learning and should only be one component of a balanced approach.

The importance of discipline specific professional learning is reinforced by international experience, with the STEM report by the Australian Council of Learned Academies emphasising the importance other countries place on discipline specific development:

> ***"In China, STEM teachers receive salary increases not on the basis of seniority but via continuing professional development programs, specific to the discipline…They do not equate teaching with class management and credentialing alone. They focus on knowledge. STEM teachers are expected to be fully qualified in their discipline and to teach in that field and not others. This contrasts sharply with Australia."*** [55]

53 Australian Institute for Teaching and School Leadership 2012, *Australian Charter for the Professional Learning of Teachers and School Leaders.* p.1.

54 Innovation and Science Australia, Australia 2030: Prosperity through Innovation, Australia Government, Canberra, p. 32

55 Marginson, S, Tytler, R, Freeman, B & Roberts, K, 2013, STEM: *country comparisons: international comparisons of science, technology, engineering and mathematics (STEM) education. Final report*, Australian Council of Learned Academies, Melbourne, Victoria. p.15

Additionally, a recent review conducted in the United Kingdom found evidence to suggest that quality subject specific teacher professional learning is more beneficial to teaching then generic professional learning.[56]

Principals and school leaders

Principals are responsible for setting a school's culture and priorities. Ensuring school principals and other leaders such as head teachers or subject coordinators have access to high quality professional learning in STEM disciplines is important in ensuring a whole school approach is taken to delivering STEM education. It is important to develop and effectively resource school leaders to enable them to act as mentors and instructional leaders in their school and region.[57]

Case Study: Evatt Primary School

At Evatt Primary School in the ACT, the principal and leadership team had a vision to embed an inquiry based learning approach across the school that engages students.

The school tapped into local resources and collaborated with the University of Canberra, CSIRO, and Questacon and implemented the Primary Connections program across the school.

A STEM Team was formed across the school that included parent representatives, engaging the broader community in the school's priority.

Regular professional learning focussed on teaching collaboration, critical thinking and general capabilities. The partnership elements ensured the learning was authentic and relevant.

A staff questionnaire at the end of 2017 showed the leadership team's commitment to a whole school approach to STEM education led to increased recognition of staff expertise.

Ensuring professional learning is high quality

High quality professional learning in STEM disciplines is required across primary and secondary schools to support teachers to engage and meet the needs and aspirations of all students. High quality professional learning is relevant, builds on pedagogical content knowledge and aligns to the Teacher Standards.

Not all professional learning opportunities are equal. Teachers and schools are busy and direction or guidance to help inform decisions around accessing appropriate and relevant professional learning is essential. It makes sense that a mechanism should exist that provides principals, school leaders and teachers with guidance so they can make informed decisions around the right professional learning for them, or their school.

As it stands much of the professional learning provided across Australia is not accredited, nor is it provided by accredited providers such as universities, TAFEs or other registered training providers. There is therefore no method of ensuring the quality of professional learning delivered.

56 Bradbury, B, Cordingley, P, Crisp, B, Greany, T, Perry, T. Seleznyov, S. Developing Great Subject Teaching. Rapid Evidence Review of Subject-Specific Continuing Professional Development in the UK. Wellcome Trust, February 2018. p.2.

57 Innovation and Science Australia 2017, *Australia 2030: prosperity through innovation*, Australian Government, Canberra, p. 32

While NSW and the ACT have a formal process for approving professional learning, the Forum recognises that it would be challenging to require all professional learning to be nationally accredited. The Forum has therefore recommended that discipline specific professional learning should be delivered by a provider such as a university, TAFE or other provider that has been through a formal quality assurance process to provide a level of rigour around the quality of their offerings. For example, universities and TAFEs are accredited by the Tertiary Education Quality and Standards Agency (TESQA) or the Australian Skills Quality Authority (ASQA). These providers can act as intermediaries to support programs delivered by teacher professional associations such as the STEM X program or the STELR program provided by the Australian Academy of Technology and Engineering.

Where can industry further support teacher professional learning?

Industry can provide a means for teachers and students to understand the latest developments in STEM careers, and experience the kinds of problems professionals are working on. This enables students and teachers to link real world practice to lesson content.

> ***"Rather than focus upon getting industry directly into classrooms, the primary role of industry should be to contextualise STEM for teachers and build their capacity to teach 21st Century skills effectively."***
> ***[Australian Primary Principals Association]***

Industry can do this through the provision of appropriate and relevant resources that reflect the latest developments, by arranging for teachers and students to access contemporary workplaces and practices, or by encouraging and supporting their expert employees to share their knowledge in schools. Industry can also provide time and funds for professional learning, teacher release, or funding for teaching fellowships or association memberships.

There are many existing models of effective industry supported professional learning in STEM disciplines. High quality professional learning with opportunities for ongoing support, collaboration, interaction, connections and communities of practice provide the most successful industry partnerships. It is important to build on existing professional learning programs that have already demonstrated a positive impact or elements of success.

Through the consultations, industry stakeholders indicated industry-school partnerships work best when teachers engage with industry and take an interest in what the students are learning through these partnerships. Students also benefit from seeing their teachers participate in the learning. The Forum is aware of a number of excellent programs to promote STEM education in schools, such as 'Dimensions' offered by the Australian Association of Mathematics Teachers, STELR developed by the Australian Academy of Technology and Engineering (ATSE) and 'Primary Connections' developed by the Australian Academy of Science.[58] While these examples are not industry partnerships per se, the Forum acknowledges that teacher professional associations and universities play a key role in discipline specific professional learning and can work with industry to support teachers.

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58 Refer: http://dimensions.aamt.edu.au/; https://primaryconnections.org.au/about

A framework for successful partnerships

Identifying a framework within which schools and industry can operate is important. There is a need to clearly identify the role of industry and provide resources to support industry and schools to engage with each other, noting that high quality professional learning should be led by educators and supported by industry.

Key elements of successful industry-school partnerships focusing on teacher professional learning

- Strong commitment and support from the school principal and leaders in maintaining a collaborative professional learning culture.
- STEM content is up to date, relevant and linked to the Australian Curriculum.
- Teachers are clear that what they are learning is relevant to the classes they teach and focuses on improving the learning experiences and educational outcomes of their students.
- Professional learning is aligned with the Australian Professional Standards for Teachers.
- Provides ongoing support and opportunities for collective learning, reflection and interaction with colleagues such as communities of practice.
- Provides a balance between content, skill development and practice knowledge (pedagogy) including practical strategies on how to organise and deliver discipline specific content to students.
- Includes a clearly defined role for industry and a clear process for engaging industry partners.
- Recognises and promotes the value of educators and their knowledge of curriculum and demands of teaching in the classroom.
- Incorporates the needs of underrepresented groups.
- Is scalable or builds on existing, effective partnership models with scale and impact.
- Is suitable for delivery to teachers in regional and remote communities.

What role can industry play?

- Support staff with expertise to engage with schools.
- Provide context and content.
- Provide facilities or technical capabilities.
- Provide real examples of how curriculum knowledge is useful in the workplace.
- Provide financial support, for example seed funding, or teacher replacement.
- Provide opportunities for work placements or pathways to work in conjunctions with schools and VET where appropriate.
- Provide concrete links between STEM skills in school and pathways to employment opportunities through careers information.

Industry needs guidance on how it can connect with schools, support teachers and identify emerging areas where it can support the take up of new large scale developments, such as the rollout of the new Digital Technologies learning area within the Australian Curriculum.

The University of Adelaide's Digital Technologies MOOCs are a successful example of effective industry supported professional learning.

Case Study: University of Adelaide's Digital Technologies MOOCs

Initiated by seed funding and technical content from Google Australia, the University of Adelaide's Digital Technologies Massive Open Online Courses (MOOCs) offer free online professional learning in Digital Technologies for Australian teachers.

Teachers across different year levels and with different levels of prior knowledge are supported to implement the Digital Technologies learning area in the Australian Curriculum. Through the MOOCs, teachers learn content and are provided with practical examples to use in the classroom.

A learning community provides a vehicle for teachers to share the tasks they complete within each unit, building a repository of resources and a supportive community of practice. The learning community plays a strong part in ensuring completion of the MOOC, as well as the provision of face to face professional learning.

A recent survey of participants revealed that 91.8% of participants feel confident to move on with their professional learning and 93.9% now know where to access further support.

As of December 2017, 16,521 teachers were enrolled in a MOOC with 77.8% of participants completing one or more activities within the course. 24.5% of participants are from low SES schools, remote schools or schools with high enrolment from Indigenous Australians. Based on the success and observable impact, Google and the University of Adelaide have collaborated further to build Professional Learning in a Box, an open source workshop based program for school leaders to implement Digital Technologies professional learning in schools face to face. The Australian Government has also funded expansion of the program in every state and territory and a National Lending Library that gives schools access to equipment for use in the classroom.

Building on this, industry could provide seed funding and technical capabilities to develop similar programs for other STEM discipline areas in partnership with universities or other organisations, as well as providing real life examples of how curriculum knowledge is useful in the workplace.

An example of a partnership that emphasises real world applications of STEM skills through contribution of practising STEM discipline organisations, as well as financial support, is the STEM X Academy.

Case Study: STEM X Academy

The Australian Science Teachers Association, Questacon and CSIRO work together to deliver STEM X Academy, a five day residential teacher professional learning program. Over five days, teachers experience a diverse range of presentations by scientists and researchers and explore current research in collaboration with STEM Professionals – including undertaking their own open inquiry project. Since its debut in January 2016, 186 teachers have participated in the program.

Following the completion of the program teachers become members of an alumni led STEM X network. Here they can create a network and use their training to continue sharing inquiry based classroom resources, ideas and inspiration.

A regional model of the program has also been trialled to allow regionally based research organisations to provide teachers with access to genuine STEM driven research activities.

The STEM X Academy is partnered with many STEM industry organisations. The value of the industry partners is much more than financial leverage. The partners offer the potential to unlock critical content and context and provide teachers with a significant stimulus and learning experience.

Targeted support for teachers facing challenging circumstances

While all teachers would benefit from high quality, discipline specific professional learning, there are some teachers who face more challenging circumstances where additional support from industry would be particularly welcome.

Teachers teaching outside their main discipline

Our current understanding of the teacher workforce is limited by a lack of robust national data about the qualifications and specialisations of teachers who are teaching STEM disciplines in our schools. This issue was recognised by Innovation and Science Australia's recent report, with a recommendation to improve measurement of the scope of out of field teaching in STEM disciplines.[59]

Work has commenced in this area, with Education Council asking the Australian Institute for Teaching and School Leadership to implement an Australian Teacher Workforce Data Strategy (ATWDS). This strategy will provide a comprehensive national dataset to assist with teacher workforce planning, bringing together data on initial teacher education as well as the existing teacher workforce. The initial data collection is expected to be available in 2018 and then updated annually.

While there is no nationally agreed definition or data around teachers who are required to teach outside of their main discipline, a number of studies have attempted to quantify the issue.

Based on the Staff in Australian Schools agreed definition, the Australian Council for Educational Research estimates that around 21% of teachers of mathematics are trained in a different field of teaching.[60] Evidence suggests this is more common in remote schools, schools in low SES areas and among early career teachers. It is also reported to be more

59 Innovation and Science Australia 2017, *Australia 2030: prosperity through innovation*, Australian Government, Canberra, p. 101

60 Weldon, P 2016, *Out-of-field teaching in Australian secondary schools*, Policy Insights, Australian Council for Educational Research, Melbourne. p.3

common in Years 7-10 than Years 11-12.[61] This level of out of field teaching cannot be wholly replaced in the short or medium term by the existing pool of discipline specific STEM teachers, which means support for out of field teachers is critical to lifting student outcomes, particularly for groups already underrepresented in STEM careers.

Analysis by state and territory teacher employers also indicates that a significant proportion of mathematics and science teachers are many years past their initial teacher education. Without continued discipline specific professional learning, these teachers may not have up to date knowledge about the rapidly advancing applications of these disciplines in areas such as biotechnology, laser technology, nanotechnology or synchrotron science.[62]

To keep up with technological changes, there should be a greater emphasis on high quality, discipline specific professional learning for teachers of STEM disciplines.

Teachers in regional and remote areas

Providing high quality resources and exposure to current industry practice is especially important for teachers who do not have easy access to a range of businesses. These teachers face particular challenges in accessing quality professional learning due to distance or other circumstances, so delivery needs to be flexible. The style and content of professional learning and support may also need to be targeted differently depending on the teacher's prior experience, level of knowledge, and training in the discipline. There is an opportunity to explore existing delivery mechanisms, such as Skype, video conferencing and online platforms to reach teachers in these locations. Both the Royal Institution of Australia and ABC Splash TV have a broad reach to rural and remote areas, and a range of classroom resources that could also support teacher professional learning opportunities.

Teachers delivering VET to secondary students

With VET qualifications becoming more important in developing the pipeline of workers with STEM skills, encouraging growth in the number of secondary students who can commence a VET qualification in a STEM field while they are at school will give young people a head start and help meet industry demand.

As noted earlier, secondary school teachers who deliver VET courses in school settings are required to hold an additional qualification in training and assessment with requirements for maintaining these skills through professional development. They must also have current industry skills and knowledge and vocational competency.[63]

The biggest barrier to more students undertaking VET courses in STEM fields is the availability of qualified teachers. This is due in some part to the challenge for school teachers in maintaining industry currency and complying with professional learning requirements as part of the school system. While the registration requirements for VET teachers may be considered by the National Review of Teacher Registration, in the interim, this is an area the Forum has identified where industry can make a particularly valuable contribution, through the provision of industry placements and other professional learning opportunities. Education Queensland has a teacher placement in industry scheme to support teachers to maintain currency to teach VET courses that is an example of how this can work on a large scale.

61 Weldon, P 2016, *Out-of-field teaching in Australian secondary schools*, Policy Insights, Australian Council for Educational Research, Melbourne. p.9-10

62 Education and Training Committee, Parliament of Victoria 2006, *Inquiry into the promotion of mathematics and science education Final Report*, Parliament House, East Melbourne. p 203

63 Australian Skills Quality Authority, 2016, *Fact Sheet – Meeting trainer and assessor requirements.* p.1.

3. SOLVING REAL WORLD PROBLEMS

Chapter Overview

Students often do not aspire towards a STEM career because they struggle to see the relationship between STEM disciplines and the careers they want. Industry can play a vital role in supplying examples of real world problems and providing work experience in STEM related occupations. These activities help students see how STEM careers solve real world problems.

It is important for career education to start at a young age to inspire students to make subject choices that will prepare them for a wide range of career paths.

Engaging parents in career education programs is equally important because they are the major influencers of student subject choice.

Increasing the awareness of opportunities in STEM related careers, as well as the opportunities that can be unlocked in other careers by those with STEM skills and knowledge, will assist in overcoming the negative stereotypes of lab coats and university lecture halls that the term STEM careers evokes.

Rather than focussing students on what careers they want to pursue, a more effective approach is to bring real world content into the classroom so students can see that what they learn at school is relevant to things that they care about.

> ***"STEM brings the opportunity to integrate classroom activity with 'real world' learning."***
> ***[Australian Primary Principals Association]***

Students can then consider what careers would contribute to solving real world problems, and the skills and knowledge they need, so they can make the subject choices that will equip them with the relevant skills for a changing work environment and the uncertain nature of future jobs.

Analysis of the Longitudinal Survey of Australian Children (LSAC) shows that, for a marked proportion of adolescents, there is a mismatch between their expected educational pathway and their career aspirations, and that for most of these students their planned educational pathway is inadequate.[64]

64 Baxter, J 2016, *LSAC Annual Statistical Report 2016: The career aspirations of young adolescent boys and girls*, Australian Institute of Family Studies, Melbourne, p.29

Case Study: Re-Engineering Australia Foundation

Over the past two decades, Re-Engineering Australia's applied learning programs have been linking students and schools, industry (including Autodesk, SAAB and Jetta), TAFEs, universities and parents with the aim of attracting students to take up STEM school subjects and STEM careers.

Their programs include the F1 in Schools STEM Challenge, the 4x4 in Schools Technology Challenge and the Subs in Schools Technology Challenge. A major reason for the success of these programs is the practical and applied learning techniques they employ. Students are presented with exciting challenges, equipped with world class tools and connected to industry mentors.

The Re-Engineering Australia programs deliver curriculum-based learning outcomes from the earliest years of primary education through to senior secondary.

What are the barriers to STEM career aspiration?

Research conducted in 2016 found there is a persistent negative view that STEM disciplines are difficult and complex, requiring a great deal of effort, and that STEM related careers are predominantly male oriented, resulting in an underrepresentation of girls, with boys more likely to aspire to a STEM related career than girls.[65]

The research also found that students with an Aboriginal and Torres Strait Islander background or from a low SES background were significantly less likely to express interest in a STEM discipline related career compared to other students.

This gap is reduced for students who have higher levels of academic achievement. In addition, it was found that Aboriginal and Torres Strait Islander students and low SES students who have relatively high prior achievement in reading and numeracy are just as likely to aspire to a STEM related career compared to other students.[66] For girls, however, a lack of aspiration towards a STEM related career exists even when their achievement levels are comparable to boys.

A 2012 South Australian study of girls participating in STEM education found girls were more likely to aspire to study STEM subjects in university if they studied at least two or three STEM subjects at school. At university, girls tended to enrol in health related STEM subjects while boys tended to enrol in engineering, ICT and physics subjects, with the flow on impact of girls being underrepresented in these traditional STEM careers.[67] Underrepresentation, an absence of female role models, poor sense of belonging, and poor relative pay create career barriers and decrease incentives for women to continue in these fields.[68]

65 Holmes, K, Gore, J, Smith, M & Lloyd, A, 2017, 'An Integrated Analysis of School Students' Aspirations for STEM Careers: Which student and school factors are most predictive?', *International Journal of Science and Mathematics Education 2017,* p.3

66 Holmes, K, Gore, J, Smith, M & Lloyd, A, 2017, 'An Integrated Analysis of School Students' Aspirations for STEM Careers: Which student and school factors are most predictive?', *International Journal of Science and Mathematics Education* 2017, p.13

67 South Australia, Department of Further Education, Employment, Science and Technology, *Female participation in STEM study and work in South Australia 2012*, pp. 12 - 13

68 Christie, M, O'Neill, M, Rutter, K, Young, G & Medland, A, 2017, 'Understanding why women are under-represented in Science, Technology, Engineering and Mathematics (STEM) within Higher Education: a regional case study', *Production, vol. 27 (spe)*, p.8

The importance of early engagement

Research has found that as early as Year 4, the vast majority of students expressed interest in real occupations. This demonstrates that career aspirations start early in life. The challenge is achieving and maintaining these early aspirations in STEM careers so they become a reality. Primary school students were significantly less tentative about careers they might pursue than students in secondary school.[69] This would suggest career education should commence in primary school before students are required to choose elective subjects that may propel them on a certain career path.[70]

This is particularly important for girls who aspire to STEM careers in engineering or physics as they are less likely to participate in STEM education in advanced mathematics and physics than boys.[71] In addition, embedding experiences of the real world in learning and the school curriculum can lead to increased motivation resulting in increased educational attainment.[72]

Through the national consultations, education and industry stakeholders agreed targeting high school students with STEM programs is too late. Student attitudes to STEM are established in primary school and this is when the work on engagement and excitement needs to begin.

It was also found that interest in STEM disciplines in early secondary school is a key predictor of interest in later years at school, reinforcing the importance for teachers to maintain student interest and achievement levels in STEM skills from an early age, particularly for girls.[73] Further research supported the notion of early engagement to enable students to make informed choices about STEM disciplines. Several studies point to the lack of female role models in STEM discipline related occupations as a reason for the persistent lack of female interest in STEM disciplines.[74] There is a similar theme across other underrepresented groups which include Aboriginal and Torres Strait Islanders, low SES and students in regional and remote areas.[75]

Research conducted in 2017 suggests participation by girls in STEM disciplines could be improved through a focus on early years and primary education to address unconscious gender biases. Working with teachers and schools to encourage girls to engage in STEM subjects, building partnerships between industry, schools and community to provide girls with authentic STEM education opportunities, and quality career advice highlighting the diversity of STEM based career possibilities.[76]

69 Gore, G, Holmes, K, Smith, M, Southgate, E, Albright, J, 2015, *Socioeconomic status and the career aspirations of Australian school students: Testing enduring assumptions*, School of Education, University of Newcastle, pp. 171-172

70 Galliott, N, Graham, L, J, 2015, *School based experiences as contributors to career decision-making: findings from a cross-sectional survey of high-school students*, The Australian Association for Research in Education. pp. 183; 194

71 Hobbs, L, Jakab, C, Millar, V, Prain, V, Redman, C, Speldewinde, C, Tytler, R, van Driel, J, 2017, *Girls' Future – Our Future, The Invergowrie Foundation STEM Report*, Deakin University, The Invergowrie Foundation, The University of Melbourne, p. 7

72 Chambers, N., Kashefpakdel, E. T., Rehill, J., Percy, C., 2018, *Drawing the Future, Exploring the career aspirations of primary school children from around the world*, Education and Employers, UK, p.vi

73 Holmes, K, Gore, J, Smith, M & Lloyd, A 2017, 'An Integrated Analysis of School Students' Aspirations for STEM Careers: Which student and school factors are most predictive?', *International Journal of Science and Mathematics Education 2017*, p. 17-18

74 Christie, M, O'Neill, M, Rutter, K, Young, G & Medland, A, 2017, 'Understanding why women are under-represented in Science, Technology, Engineering and Mathematics (STEM) within Higher Education: a regional case study', *Production, vol. 27 no. sp*

75 Holmes, K, Gore, J, Smith, M & Lloyd, A, 2017, 'An Integrated Analysis of School Students' Aspirations for STEM Careers: Which student and school factors are most predictive?', *International Journal of Science and Mathematics Education 2017*, p. 13

76 Hobbs, L, Jakab, C, Millar, V, Prain, V, Redman, C, Speldewinde, C, Tytler, R, van Driel, J, 2017, *Girls' Future – Our Future, The Invergowrie Foundation STEM Report*, Deakin University, The Invergowrie Foundation, The University of Melbourne, p. 5

How do young people make career decisions?

Research shows that when students are making career choices, they are influenced by the information and attitudes from three main groups of adults in their school lives – parents, teachers and careers advisers.

Analysis of the Longitudinal Survey of Australian Children (LSAC) published in 2016 noted that at 14 to 15 years old:

- 88% of boys and 86% of girls talk to their parents about their future plans,
- 29% of boys and 32% of girls talk to teachers, and
- approximately 12% of boys and girls talk to career counsellors.[77]

These findings are consistent with other surveys such as the *Mission Australia's Youth Survey Report*, which also noted the internet as an influencer for youth.[78]

Parents

Research conducted for the Career Industry Council of Australia in 2012 found that different types of parental engagement can determine whether the outcome is positive. The main factor seen as having a positive impact on student learning and achievement, is the parents' level of educational aspiration for their children. It is therefore important to raise the career awareness of parents and ensure they are equipped with the right information about STEM related careers.[79] Parents need to know how to help their children understand what STEM education includes, how to decide which subjects will be helpful and how to help their children find out about the different pathways through both VET and universities.

Targeting families in disadvantaged cohorts is especially important to overcoming a lack of access to career advice. Only 68% of children aged five to 14 in Australia's most disadvantaged communities access the internet at home, compared with 91% of students from the most advantaged communities. Without the internet, students are disadvantaged as they are unable to reach online resources like Job Outlook that allows students to complete a quiz on their work style, and get tailored information about the tasks, pay, skills and knowledge required for different jobs as well as job prospects.[80]

While governments often struggle to reach or influence parents through their existing policy levers, industry can help inform parents through advertising and promoting the different ways STEM skills are used in their businesses. Industry and government can work together to change the negative connotations around STEM related careers and counter the fear being generated in media about future jobs.

> ***"The industry and government narrative to highlight the use of 'implied' STEM in current jobs will facilitate parent engagement through the family unit." [Catholic School Parents Australia]***

One way to engage parents is through the STARportal, a website developed by a consortium of businesses (CBA, BHP Billiton Foundation and Telstra), associations (Engineers Australia and AMSI), government and the Office of the Chief Scientist. It is designed equally for parents, students and teachers, helping them to find extracurricular STEM activities, most of which are based on real world contexts and challenges.

77 Baxter, J 2016, *LSAC Annual Statistical Report 2016: The career aspirations of young adolescent boys and girls*, Australian Institute of Family Studies, Melbourne, pp. 25-26

78 Bailey, V., Baker, A-M., Cave, L., Fildes, J., Perrens, B., Plummer, J. and Wearring, A. 2016, *Mission Australia's 2016 Youth Survey Report*, Mission Australia, Sydney, p. 16

79 Morgan, M, 2012, *Engaging Parents in the Career Development of Young People*, Career Industry Council of Australia, p. 42

80 The Smith Family, 2017, *Without Access to Computers and the Internet, Disadvantaged Students are Getting Left Behind* [Online] Available at: *www.thesmithfamily.com.au/stories/family-news/digital-divide* (Accessed 3 November 2017).

Teachers

Classroom teachers are in a unique position to communicate career information as they teach, identifying skills and knowledge that may be relevant to particular careers. They need access to correct and up to date career information and how it connects to what they are teaching. They have the potential to enthuse student learning by making linkages to potential careers or identifying particular skills that a student has that may be relevant to a particular career.

While companies often offer opportunities for students to visit their workplaces, opening this to teachers has the potential to multiply the effect, particularly if it is linked to what they are teaching.

Industry can also work collaboratively with teachers and participate in STEM related education. A successful example of how this can work is the Regional Development Australia (RDA) Hunter's ME Program.

Case Study: RDA Hunter's ME program

RDA Hunter's ME Program links schools and industry to build student interest and experience in STEM related studies and careers in the region.

The ME Program includes a variety of initiatives, including STEM Ex (work experience), the Defence STEM Scholarship and Mentoring Program, a 'Living Toolbox' (classroom resources) and iSTEM.

iSTEM was created in 2013, through a collaboration between the RDA Hunter ME Program, industry and local STEM teachers. The iSTEM curriculum for students in Years 9 and 10 supports the delivery of STEM subjects in an integrated way, incorporating mechatronics, aerodynamics, engineering, 3D CAD/CAM, aerospace and motion modules. It engages students in problem based learning and involves them in real on the job situations.

The course seeks to present mathematics and sciences to students in ways that challenge not only their understanding of these key subjects, but also their ability to manage projects and work in teams. As an endorsed course, iSTEM forms part of a student's academic record.

iSTEM was created in the Hunter region in direct response to industry's need for young people qualified in science, technology, engineering and mathematics. BAE Systems, Ampcontrol and Varley Group were among 50 ME Program industry partners who were integral to the formation and implementation of the iSTEM syllabus. The elective subject provides students with curriculum to support the most up to date technologies including 3D printers, virtual reality, drones, robotics and a range of intelligent systems.

Developed in a Hunter Valley school with the assistance of industry, the ME Program's iSTEM course has now been rolled out to over 235 schools across NSW. Schools with long term involvement in RDA Hunter's ME Program have shown a 19% higher engagement in STEM subjects from 2010 to 2017, compared to a 0.5% decrease for all NSW schools. Female students at these schools are 370% more likely to study engineering in Year 11 than the state average. Performance in chemistry, physics and mathematics has also gone from below to above the state average.

Career advisers

Career advisers in schools operate under national professional standards, however, they have a varying presence and different levels of support across states and territories.

Career advisers can give students advice about pathways of study for certain careers, or advise on career options that use a particular skill set. They may also provide support to classroom teachers to include career education in their classroom practice.

A study by the University College London Institute of Education concluded that there are good grounds to believe that embedding careers awareness in STEM education should increase the uptake of STEM disciplines in the senior high school years.[81]

Internet

We know parents are the primary influence on young people, however research also indicates nearly 70% of young people are influenced by the internet and social media when making post-school plans.[82] This is supported by the experience of the Australian Defence Force's defence careers campaign. It shifted from traditional marketing to focus on inspiration and opening social media channels after noting that individuals who made a connection through social media took less time to move from considering to actually joining the Australian Defence Force.

What is already happening?

There are a broad range of programs and initiatives in place to improve career advice and career education across Australia – both government and industry led.

National Career Education Strategy

The Australian Government is leading the development of a National Career Education Strategy (NCES). The NCES aims to improve career education for students to help them make a successful transition from school to further education, training or work. The NCES Working Group, made up of representatives from education, industry, career advisers and parent stakeholders has identified three areas where national consistency and leadership can support students in making informed choices through:

- building students' skills and capabilities for the future through a planned program of learning,
- strengthening school and employer collaboration, and
- career management and navigation.

The NCES Working Group has provided advice and recommendations to the Australian Government for consideration. The working group highlighted actions and initiatives to support schools to deliver high quality career education to Australian students. The Australian Government will consider the recommendations and develop steps to be undertaken from now through to 2020.

Students, teachers and parents can also access information about careers and career pathways through the Australian Government funded websites *MySkills, Job Outlook* and *Quality Indicators for Learning and Teaching*, and the state and territory funded *MyFuture* website. The Australian Government's *Learning Potential* app, website and newsletter are designed specifically to give parents information about their child's learning and development from the early years to the end of high school, and includes articles about and links to careers information.

81 Reiss, MJ & Mujtaba, T 2017 *Should we embed careers education in STEM lessons?* The Curriculum Journal, vol. 28 no.1, pp 137-150, p. 147

82 Bailey, V., Baker, A-M., Cave, L., Fildes, J., Perrens, B., Plummer, J. and Wearring, A. 2016, Mission Australia's 2016 Youth Survey Report, Mission Australia. p.3.

Non-government career guides

There are also numerous careers resources developed by industry or other organisations. These include STEM discipline specific awareness resources that have a focus on the types of careers that are available and emerging in STEM discipline related occupations. Two such publications, both online and hardcopy magazines with supporting teacher and student resources, are the Careers with STEM magazines developed by Refraction Media and the Ultimate Careers magazine developed by the Royal Institution of Australia. Both providers report that the hardcopy versions are more valued by students and parents than the online versions.

The Australian Curriculum

All states and territories have endorsed an Australian Curriculum Work Studies unit for Years 9-10 to focus on strengthening the general capabilities of the Australian Curriculum. The Work Studies unit is a school-based subject that provides opportunities for students to undertake vocational learning and develop work readiness skills. The subject features applied learning and work exposure. Students explore their preferences as learners and engage in a range of activities to develop an understanding of work, careers and post-school destinations.

Case Study: Victorian Space Science Education Centre

The Victorian Space Science Education Centre (VSSEC) uses space as a tool to engage teachers and students in wide ranging topics across all the sciences and all year levels. Offering onsite, online and outreach programs, the VSSEC supports student and teacher learning in subject and cross-curricula domains. The VSSEC acknowledges that partnerships with key stakeholders are important in building knowledge and engagement in STEM, providing access to high quality facilities, leading researchers and employers and real world contexts.

Another example of how STEM can be integrated into the Australian Curriculum is the STELR initiative. STELR is a hands on, inquiry based science teaching program for primary (Year 6) and secondary students (Years 7 to 10) that shows students how science and mathematics is relevant to their lives. STELR also provides career profiles that highlight the study paths necessary for jobs in STEM related industries.[83]

What is the role of industry?

The challenge for increasing participation in STEM disciplines is building aspiration. Industry has a role to play in building awareness of the role STEM skills play in solving real world problems and highlighting the breadth of STEM related careers.

> ***"The importance of real world learning [is] not only a career awareness exercise, but a mechanism to engage and teach general capabilities and STEM skills."***
> ***[Social Ventures Australia]***

They can do this by increasing the flow of reliable information about careers and communicating about the changing labour market, focusing on opportunities rather than job losses through automation. As well as exposure to reliable career information, building positive perceptions around STEM related skills and occupations in schools and as a study choice is vital.

83 Office of the Chief Scientist, 2016, *SPI 2016, STEM Programme Index 2016*, AiGroup, p. 103

Contributions from industry should build on success, and contribute to and amplify existing, proven initiatives rather than increasing the number of small initiatives.

Partnerships between schools and industry can provide opportunities for students to engage with the world of work to better understand the relevance of their learning to jobs and post-school pathways. This is particularly important for disadvantaged students.

Case Study: Beacon Foundation

Beacon Foundation's mission is to reach, inspire and connect Australia's future workforce. Beacon focuses on disadvantaged communities and areas of high youth disengagement and unemployment, where the risk and the need are greatest. It brings together schools, businesses and communities to help bring context to the curriculum, inspire young people to think about careers and experience the workplace before they leave school.

Alice, a former student from Kings Meadow High said 'When business comes into the school kids relate more to them, they are interested in hearing from someone other than a teacher or a parent. They can really connect with the business owner and ask questions.'

Beacon allows a teacher and an industry representative to work together to co design a lesson plan around how industry uses that particular subject area. Teachers will be able to access relevant businesses that are linked to science. Technology enables business to reach more people, particularly in remote areas.

Beacon assisted over 15,000 young Australians from just over 200 schools and communities around Australia in 2017.

"By drawing the relationship between STEM at school and STEM at work, students are immediately more engaged in STEM subjects."
[Australian Business & Community Network]

It is also extremely beneficial for young people to interact with volunteers from the world of work. It helps to raise aspirations, broaden horizons, show the relevance of what they are studying to later in life, and challenges stereotypes about jobs. It can also stop students ruling out options for themselves at a young age and help with their transition into the labour market.[84]

Case Study: Inspiring the Future – THALES

Inspiring the Future is a program that connects volunteers from employers and working professionals with schools across Australia. Volunteers attend a school for an hour to talk to young people about their job, career and their educational route.

In 2017, 12 students and six teachers from three secondary schools in Sydney visited the Garden Island Naval Base to participate in interactive career conversations with staff from THALES Maritime Ship Repairs division. Students and staff were able to tour the facilities to investigate career opportunities in each of the different work areas. Staff from the Human Resources department were able to provide advice to students on preparing job applications and applying for apprenticeships at THALES, with five students expressing an interest in undertaking work experience at THALES.

84 Chambers, N., Kashefpakdel, E. T., Rehill, J., Percy, C., 2018, *Drawing the Future, Exploring the career aspirations of primary school from around the world*, Education and Employers, UK. p.iii.

The importance of improving perceptions of VET

VET provides an ideal platform for engaging in the world of work, with ABS 2010-11 census data suggesting vocationally trained people comprise over 65% of the STEM workforce.[85]

> ***"VET [should be] a core rather than a tangential consideration of a future school STEM strategy."***
> ***[Australasian Curriculum, Assessment and Certification Authorities]***

A strong feature of VET qualifications, which are built on the foundation of close collaboration with industry and employers, is work based learning. Work based learning employs a learning model suited to teaching skills in real or simulated workplaces.[86] As well as work based learning pathways such as Australian School-Based Apprenticeships and other VET qualifications undertaken by secondary school students, alternative approaches are being piloted across the country to expose students to careers in STEM related occupations and the skills they will need.

VET qualifications enhance employment and career prospects and provide an opportunity to engage with further education and the broader community. For a number of student cohorts including, for example, Aboriginal and Torres Strait Islander people, participation in VET can provide a pathway to employment, a career, reemployment or higher education.[87]

Case Study: St Teresa's College, Abergowrie – Remote Health Education Centre

St Teresa's Abergowrie College is a secondary boys' boarding school located north-west of Ingham, Queensland.

In partnership with Registered Training Organisation Connect 'n' Grow, St Teresa's has initiated the Remote Health Training Model. The program is now a core part of the secondary curriculum and a model that is being replicated by secondary colleges throughout Queensland.

Through the program, Aboriginal and Torres Strait Islander youth from remote and rural communities are given opportunities to become involved in the health industry and pursue a career in health. The program connects with industry, community and higher education stakeholders such as local Aboriginal Medical Services and James Cook University.

In 2013, 19 out of 22 students completed the Certificate II, six students were accepted into TAFE Tropical North Queensland Diploma in Nursing and one student was accepted into Dentistry at James Cook University.

85 Siekmann, G., Korbel, P, 2016, *Defining 'STEM' skills: review and synthesis of the literature*, National Centre for Vocational Education Research. p.9.

86 Siekmann, G & Korbel, P, 2016, *Defining 'STEM'skills: review and synthesis of the literature*- Support Document 1, NCVER, Adelaide, p. 51.

87 Bandias, S., Fuller, D., Larkin, S., *Vocational education, Indigenous students and the choice of pathways*, 2013, National Centre for Vocational Educational Education Research, p. 34

Through the national consultations, it was noted the VET sector is important in delivering STEM qualifications that have industry currency and are more applied. An emphasis on how industry can work with schools to improve perceptions of VET qualifications would be beneficial. In spite of the VET sector's substantial share in the provision of engineering and technology skills, as well as employability skills, the sector's contribution and potential are underreported and underrepresented in current STEM debates. The VET system has a lot to offer in relation to foundational literacy and technical skill development as well as valuable links with industry. It has the ability to respond to skills shortages and skills mismatches through targeted skills training, in a relatively short time.[88]

Unfortunately, public emphasis on university pathways means VET pathways are often not given due consideration by students. In order to build community awareness and ensure young people, parents and teachers are aware of the breadth and depth of career and employment opportunities available through VET programs and pathways, we need to raise the profile of VET.[89]

88 Siekmann, G., Korbel, P, 2016, *Defining 'STEM' skills: review and synthesis of the literature*, National Centre for Vocational Education Research. p.7.

89 McCrindle, Skilling Australian Foundation, 2017, *Perceptions Are Not Reality: myths, realities & the critical role of vocational education & training in Australia, May 2017.* p.2.

4. OPTIMISING INDUSTRY SCHOOL PARTNERSHIPS

Chapter Overview

While schools and industry are keen to form partnerships, each have differing objectives and cultures. This can make it challenging to establish a successful project that works for both partners.

There is a strong interest in practical advice on how to form a partnership and an important role for intermediaries to help overcome these challenges and assist in designing and establishing effective partnerships.

While the Forum has identified a need for a central repository that brings together existing resources, it is clear that different types of partnerships have different objectives and being clear about these is essential in determining the type of partnership that will be most effective.

There are various models of industry-school partnerships currently in use across Australia, from small scale one to one partnerships through to significant arrangements involving multiple industry organisations, education providers and schools. Some are led by governments and others are organic or more locally established.

It is acknowledged that industry has been a strong contributor in our national STEM education landscape for many years, including partnering in a number of notable long term education initiatives such as the Shell Questacon Science Circus (in partnership with Questacon and the ANU), the BHP Billiton Awards (in partnership with CSIRO) and RioTinto's initiatives with SciTech in Western Australia.

> ***"There is no lack of enthusiasm from industry to support school partnerships and programs. The challenge is that there are many different programs at national, state and local levels, which target different aspects of STEM education, at different levels and age groups. Industry is paralysed by choice." [Engineers Australia]***

A strong theme in the consultations was the level of interest from school leaders, teachers and industry in establishing partnerships, but not knowing where to start. Challenges include differences in organisational culture between schools and industry, regulation obligations including occupational health and safety and child protection requirements, as well as uncertainty or a mismatch in partner objectives.

While there are a range of different guides and resources available to support schools and industry in establishing partnerships these tend to focus on small scale partnerships or a particular aspect of partnering. This chapter seeks to build on the substantial work that has been identified through the consultations and submissions to provide clear, practical guidance on establishing partnerships that maximise the potential of all partners.

Large scale partnerships led by government

Governments across Australia have taken very seriously the challenge of ensuring Australian students have access to high quality STEM education, not only with the National STEM School Education Strategy, but with substantial policy interventions.

Nationally, the Australian Government is rolling out the P-TECH program. The P-TECH model was first established in 2011 in the United States by IBM and a consortium of education partners in New York City. In January 2016, Australia's first two P-TECH sites commenced in Geelong and Ballarat, with an additional 14 P-TECH sites being established across Australia.

Under the P-TECH model, schools work with participating industry partners and other education providers (TAFEs, Registered Training Organisations and universities) to deliver elements of the P-TECH learning program, including mentoring, workplace visits, and opportunities for hands on project based learning that draws on real world issues.

Secondary students participating in P-TECH are able to achieve two qualifications, their Senior Secondary Certificate of Education and a STEM related diploma, advanced diploma or associate degree. The key objective of the partnership is to provide a seamless pathway and continuity of support for students as they complete and transition from school to further education and work.

The Australian Government engaged an intermediary organisation (Skilling Australia Foundation) to support the formation of effective and sustainable education and industry partnerships at each P-TECH site. Importantly, a locally based Industry Liaison Officer and Steering Committee works with the partners to design and implement a learning program that meets local community needs.

Case Study: Pathways in Technology (P-TECH) Pilot

The Pathways in Technology (P-TECH) pilot is improving pathways to STEM related tertiary qualifications through long term partnerships between industry, schools and tertiary education providers. A key element of P-TECH is local industry engagement. Secondary students participating at P-TECH sites are being introduced to jobs where STEM skills play a major role now and in the future.

In Port Stephens, Hunter River High School has partnered with Jetstar Airways, Varley Group, BAE Systems and Ampcontrol to introduce an innovative skills based program focussing on aeronautical and related aerospace industries. Year 9 and 10 students attend weekly workshops and undertake a pathway in advanced manufacturing and engineering, starting with a Certificate I in Engineering, Certificate II in Aero Skills or Certificate III in Aviation.

While the P-TECH pilot is only in its early stages, 76 of the 130 students from the two original P-TECH sites selected a STEM related pathway in 2017.

In Victoria, a new approach called Tech Schools is being created across the state. The Tech Schools are delivering programs to students from partner government and non-government secondary schools. Tech Schools are hosted on TAFE or university campuses to introduce students to the future learning and work environments, smoothing or navigating their potential pathways into post secondary education and training. Tech

Schools use leading edge technology, discovery and innovation to prepare students for a changing world, strengthen employability skills and link education to industry.

By exposing high school students to real world applications, they will understand why studying STEM subjects is important and will be motivated to explore further STEM offerings.

Tech school staff are the liaison between numerous local industries and 20 to 30 partner schools. This substantially increases the efficiency for the industry and school partners.

Case Study: Ballarat Tech School

The Ballarat Tech School is engaged with a number of industry partners, including Albins Performance Transmissions, AGF Seeds, Australian Industry Group, Ballarat and Regional Trades and Labour Council, C.E. Bartlett, Dark Shadow Studios, IBM Australia, Lateral Plains Pty Ltd, Museums Victoria, Royal Society of Victoria, Saltbush Kitchen, Southern Farming Systems and Staley Automation.

Recently, the Ballarat Tech School hosted a Girls in STEM event for girls in Years 7-10 from 11 of their partner schools. The event included workshops in robotics, virtual reality, programming, electronics and prosthetics and was designed to encourage the girls to consider a career in STEM. In 2018, the Tech School and Girls in STEM will link with the IBM EXITE Camp. The camp will introduce girls living in the Ballarat area to career opportunities in IT and encourage deeper learning in technology. Girls will also be paired up with volunteer female STEM leaders who will provide academic assistance and career advice during the camp and throughout the remaining school year.

The Tech School has also launched the Ballarat STEM Network with the specific aim of fostering collaboration across education, industry and the community by providing members with access to industry leaders, resources and specialist support to build regional capacity and connect young people to their futures in the Ballarat region.

While these models, and others such as SchoolTech in Queensland are all different, they share a number of common elements that make them successful in delivering large scale, relevant STEM education in partnership with industry. The common elements include:

a. **scalability and sustainability** – ensuring that effective approaches are implemented broadly not only delivers economies of scale, it ensures that high quality programs are accessible to a greater number of students,
b. **intermediaries and agreed points of contact for industry** – to make the partnership easy for industry to engage with and work with a large number of schools or students,
c. **integrated teacher professional learning** – to deliver longer term benefits to the teaching workforce,
d. **real world context** – to connect STEM education to real world experiences and improve student understanding of the different types of pathways they can take towards a STEM career, and
e. **alignment with the Australian Curriculum** – to ensure that schools are not having to crowd out other areas of the curriculum in order to deliver engaging STEM programs in the mathematics, science and digital technologies learning areas.

The Forum has identified these elements as central to effective, large scale partnerships supported by government and recommends Education Council consider these as key elements in future approaches.

Best Practice School Industry Partnerships

A lot of work has been done in this area, and a list of existing guides and resources included at Appendix 2. This list includes the framework developed recently by the Australian Council of Deans of Science and the Australian Council of Engineering Deans in partnership with AiGroup on principles for successful school-STEM partnerships. A review of the literature and submissions to the Forum identifies the following key factors as important in the creation of effective partnerships between schools and industry:

- clear objective and goals,
- well planned,
- sustainable,
- flexible,
- inclusive, with high commitment from participants, and
- includes arrangements for monitoring and evaluation.[90]

The key challenge for both industry and schools is where to start.

Intermediaries

The cultures of schools and industry can be quite different, with partners experiencing a degree of mutual unfamiliarity. Industry-school partnerships that include activities within the school environment require navigation and negotiation of both school and system requirements. Activities involving contact with students also involve administrative issues such as child protection and working with children check requirements.

> ***"There are many barriers for cross industry collaboration but there is willingness."***
> ***[Sue Doherty, Senior Manager, WESTPAC]***

> ***"Schools see value in industry-school partnerships, but often lack the connections, time or experience to create and nurture them."***
> ***[Australian Schools Plus]***

An intermediary organisation can act as a bridge, working with both parties to clarify the objectives of the partnership, design activities for mutual benefit and support implementation.

For this reason, schools and industry can benefit from working with intermediary organisations when seeking to establish a partnership. Intermediary organisations can support participants in working through the key elements of successful industry-school partnership, with varying roles depending on the goals of the partners. Intermediaries can simply act as a broker or match maker or they can become an additional, active partner in the arrangement from design to implementation. Importantly, intermediaries were a feature of every successful partnership looked at by the Forum.

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90 Business-School Connections Roundtable, PhilllipsKPA study of school-business relationships in Australia conducted in 2009/10; The Australian Industry Group (2017), *Strengthening School-Industry STEM Skills Partnerships*. Final Project report; submissions to the STEM Partnerships Forum

There are a range of organisations that can act as an intermediary. These may include:

- education authorities – state education departments or non-government representative bodies,
- charitable foundations and other non-government organisations (*e.g.* Australian Schools Plus, Social Ventures Australia),
- regional or state based brokerage organisations (*e.g.* local governments, Regional Development Authorities),
- teacher professional associations
- science centres and agencies (*e.g.* CSIRO, Questacon),
- TAFEs and other Registered Training Organisations,
- universities, science and education faculties, and
- learned academies (*e.g.* Australian Academy of Technology and Engineering or Australian Academy of Science).

Case Study: Australian Schools Plus with Salesforce

Enterprise software company, Salesforce, currently partners with nine schools across Australia, benefitting approximately 2,500 students and plans to extend its support to a further nine schools this year. Australian Schools Plus connected the company with each of these schools after having ascertained the schools' needs and priorities and Salesforce's objectives.

Salesforce approached Australian Schools Plus in 2015 to match the company with schools wanting to teach students digital skills to equip them for the 21st Century workforce. Australian Schools Plus connected the company with Casula High School and Wyndham Park Primary School, which needed support to introduce coding and robotics. Over two years, Salesforce contributed funding and its staff taught students how to code at regular coding sessions in the Salesforce offices, provided work experience for students interested in IT careers and worked with teachers to expand their skills and network.

The main benefits for schools and industry in working through an intermediary are that the intermediary organisation can:

- be a single point of contact for both schools and industry, identifying partnership opportunities and potential partners from a broad pool,
- assist partners to define and clarify their objectives to ensure expectations can be met and link industry objectives to the curriculum,
- point to an existing initiative or support the design of a new program based on expertise and evaluation of previous initiatives,
- reduce the time and resource burden on partners who are usually engaging in the partnership in addition to their regular roles, by performing administrative activities,
- support the sustainability of partnerships including leveraging economies of scale,
- assist in overcoming location and resource limitations for schools and educators in rural and remote locations and connecting schools to industry partners that may not have an immediate and obvious presence in the area, and
- assist with professional learning activities.

Case Study: CSIRO STEM Professionals in Schools

STEM Professionals in Schools is the largest national skilled volunteering program for STEM professionals and classroom educators. The program is funded by the Australian Government's Department of Education and Training and is managed by CSIRO. Under the program, the CSIRO brokers and supports flexible partnerships between STEM professionals and primary and secondary schools. It involves volunteer science, mathematics, engineering and technology professionals, from areas including industry, government and tertiary institutions, working in partnership with teachers to engage students in quality learning in the STEM disciplines.

Flexible partnerships enable students and teachers in both primary and secondary schools to:

- support delivery of the Australian Curriculum,
- understand how STEM skills and knowledge are applied in the real world,
- introduce them to emerging STEM innovations and potential career paths,
- provide them with student mentoring opportunities, and
- connect with industry to understand workplace expectations and aspirations.

One of the key strengths for the STEM professionals is that CSIRO not only provides support to broker the partnership but helps the STEM professionals navigate the complex process for working in and with schools across Australia.

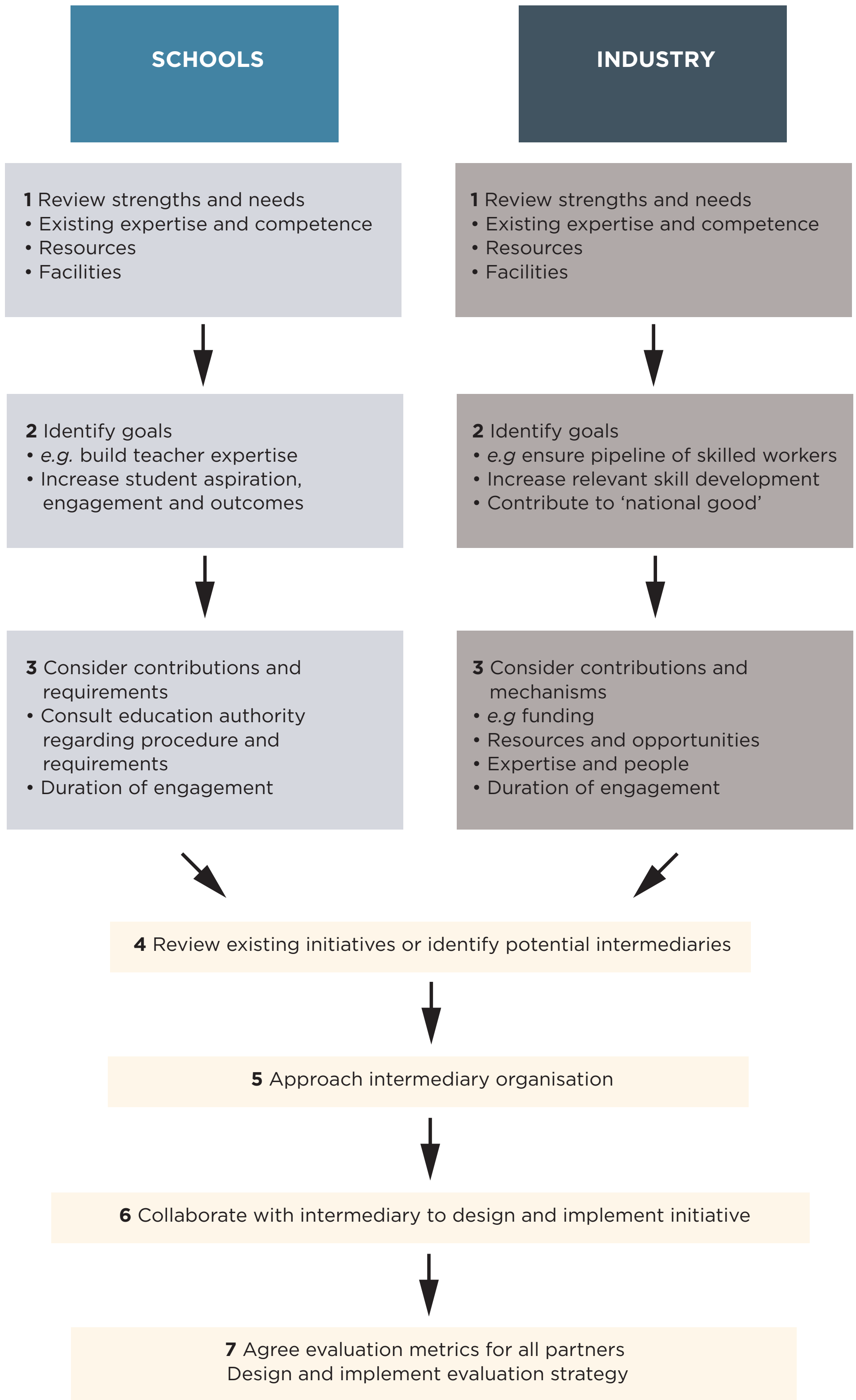
STEM Professionals in Schools now supports almost 2000 partnerships in Australia, involving approximately 300 industry groups and benefitting over 60,000 students per annum. These partnership activities are looking to increase participation of female STEM professionals: engagement with regional and remote schools, and engagement with low SES, high disadvantaged schools.

Industry initiated partnerships

Industry is not monolithic, and neither are their motivations for engaging in partnerships with schools. Throughout discussions and consultations with the Forum, key objectives for industry to engage in partnerships included ensuring a local pipeline of skilled workers, to a broader effort to improve skills in a specific area (such as computer science), to contributing to the national good or giving back to a local community.

Different industry organisations will also be looking for differing levels of involvement in a partnership. This might be providing funding to support a school or project through an organisation such as Australian Schools Plus. It might be releasing their expert employees to engage with schools through a program such as CSIRO's STEM Professionals in Schools. Others might want to be involved in the design and delivery of a specific partnership. The key is a conduit that supports all potential participants to find the intermediary organisation and partners that are right for them. Figure 5 outlines the initial process for establishing a partnership.

Figure 5: Forming an industry-school partnership



School initiated partnerships

Given the potential benefits, schools will often seek out industry partnerships with individual teachers taking the initiative to provide extra opportunities for their students.

> ***"Schools repeatedly tell us that by partnering with skilled subject matter experts, they save on time, training, capital expenditure and timetabling to allow for a high impact on student learning…"***
> ***[Scope IT Education]***

A clear message throughout our consultations was that partnerships are most effective when they have the support of the school principal and align with the broader goals of the school. Ensuring a whole of school approach to partnerships is also an important way of managing the risk of an individual driving the project moving on, thereby making the partnership more sustainable in the long term.

> ***"Principals and teachers know best how to meet the needs of their students and community. One-size-fits-all programs that don't take into account local needs… are not the answer to transforming learning outcomes for students'"***
> ***[Australian Schools Plus]***

Research shows that establishing industry partnerships is easier for some schools due to greater access to STEM resources, including geographic proximity to industry or professional connections within the parent community.[91] For schools that lack these advantages, determining where to start can be challenging.

A national online resource

When industry and government are looking at how to invest and improve the take up of STEM programs in schools, there is no single place to go that brings together research or provides a comprehensive source of guidance as to which programs are most effective, deliver the best outcomes for students or offer the greatest value for money.

Similarly, schools and teachers currently need to navigate a range of information of varying quality to inform decisions on whether to invest their time and energy in a program. The Forum recommends the establishment of a national online resource that connects existing repositories, bringing together best practice material to support all Australian schools and industry in designing, implementing and evaluating partnerships.

91 McInnis, C., Noblett, G., Aziz, Z. A., & Noonan, M. (2010). *Unfolding opportunities: a baseline study of school business relationships in Australia: Final report*. Canberra: Department of Education, Employment and Workplace Relations.

5. OUTCOMES AND IMPACT

Chapter Overview

There are hundreds of STEM initiatives being implemented across schools in Australia but there is no sense of whether these initiatives are achieving good outcomes and whether they should be scaled up.

A connected evidence base is needed to enable better analysis of the STEM student pipeline and assist policy makers to direct resources to the greatest area of need. A national Unique Student Identifier with strong privacy provisions may allow this analysis to be undertaken. It could be built on the unique student identifier already in use in the VET sector.

Industry can play a role through providing workforce data for existing or emerging occupations that will require STEM skills.

A crucial challenge to ensure the strategic investment of time and resources in STEM programs and partnerships are having an impact, both at the partnership level and as part of our collective efforts to improve outcomes in STEM disciplines, lies in our ability to measure the impact and outcomes of these initiatives.

Evaluation of STEM initiatives

> ***"We always had a focus on evidence, we just didn't realise how powerful a tool it was to show the value of what you are doing.***
> ***We have learned how evidence can be used to show impact and how this impact drives philanthropy – that has been a powerful lesson for our school."***
> ***[Jennifer French, Principal, Casula High School]***

A key element of a successful partnership involves all partners having clear goals and objectives, and ensuring these are able to be measured. There are a huge number of STEM initiatives, projects and partnerships targeted to Australian school students, with the STARportal including over 500 initiatives. While many activities and resources include some form of evaluation, there is no nationally consistent framework to determine and compare how successful these initiatives are.

Evaluation of current industry-school partnerships is inconsistent, making decisions about whether to engage in a partnership challenging for schools and industry.

It is important to consider the intended educational outcomes and impacts before designing or funding STEM school education initiatives. While some businesses would be familiar with the idea of establishing a program logic, and articulating intended outcomes and impacts in program planning, practical and accessible guidance on how to establish and evaluate STEM education programs would be welcomed by most schools and businesses seeking to develop a partnership.

In New South Wales, the Centre for Education Statistics and Evaluation provides advice on undertaking evaluations, including of STEM initiatives, using explicit standards and criteria and exploring causality and effect. Another resource is the Australian Teaching and Learning Toolkit, which is a website supported by Social Ventures Australia and the Education Endowment Foundation that provides an easy to navigate snapshot of the cost, average impact and evidence base of 34 different approaches to improving learning outcomes in schools. It aims to provide guidance for principals, teachers and schools on how to use their resources to improve educational outcomes for their students.

The National STEM Education Resources Toolkit

Through the consultations, education and industry stakeholders agreed there are a number of successful STEM initiatives in schools but this information is not shared. It was suggested a central place for sharing this information that is easily accessible would be beneficial.

The Forum has identified the need for a simple toolkit to assist schools and industry to understand best practice in STEM initiatives, evaluate existing and future STEM initiatives, and provide guidance for designing and building industry-school partnerships. The toolkit would be made available on the national online resource outlined in Chapter 4 as part of providing a single point of information on partnerships.

The toolkit should:

a. consolidate and provide easy access to resources and guidance on industry-school partnerships,
b. showcase existing high quality, scalable partnerships with proven impact, in which industry can invest,
c. identify intermediaries that can help schools and industry set up new partnerships,
d. assist in defining outcomes and evaluating and measuring the impact of partnerships,
e. provide guidance on ways to engage underrepresented groups, and
f. leverage existing platforms wherever possible.

The most appropriate location for this toolkit and the exact content should be determined collaboratively between the Australian Government and states and territories to make it a genuinely national resource that draws on the wealth of existing information available. To guide this work, a blueprint for the toolkit is provided at Appendix 3.

Building the evidence base

One of the five areas of action under the National STEM School Education Strategy is focussed on building a strong evidence base. The Strategy notes there are multiple approaches to partnership programs and to the integrated and project based teaching of STEM that aim to improve student aspiration, engagement and performance. Better guidance is needed for schools and teachers to determine which approaches work best for different purposes and student cohorts.

Australia has robust, national data on student enrolments in VET and universities and Year 12 subject enrolment data. The key findings from these are detailed in Chapter 1.

The information missing from current datasets is an understanding of what practices are being used in schools today and data about the labour market and STEM workforce such as the numbers of first time employees in occupations that require STEM knowledge and skills, and whether these employees meet the expectations of industry.

Importantly, as flagged in Chapter 1, industry has a role in filling these gaps by providing data on their workforce to help build an overall picture of STEM participation and the STEM education pipeline. Industry may also be able to assist in identifying new and emerging data sets available from recruitment information or sources such as LinkedIn.

A Unique Student Identifier

There are also a range of additional datasets across the primary and secondary schooling sectors held by state and territory governments and non-government education authorities. Forum members have noted the potential benefits and acknowledged the practical complexities of connecting these datasets.

Knowing which programs have an impact on student outcomes is crucial for targeting investment, resources and interventions for both governments and industry. To do this effectively requires detailed analysis over many years of student progress, learning gaps and the factors that influence education outcomes. Datasets that track individual student progress over time are an invaluable resource for policymakers.[92]

All Australian governments collect large amounts of education data. However, these datasets are disconnected and often inaccessible across school sectors and across state and territory borders. This results in a gap in data at the national level about the pathways, multiple transition points and trajectories of students throughout their schooling.

While numerous data sets on STEM education exist, they are disconnected. The lack of a Unique Student Identifier is the biggest barrier to developing national STEM education data sets.

By integrating data sets and providing a single complete view of the data, we can gain better insights into the effectiveness of policies and programs and provide better analysis of the STEM education pipeline. Forum members consider that a national Unique Student Identifier (USI) used through all years of education is required so that data can be connected across state boundaries and preserved over time, even if students switch between government and non-government schools, move to a different state or territory, or change their name.

A national USI would make available two types of data: aggregated de-identified data for research and evaluation purposes, and student level data that will have strict access and privacy controls. For their individual data sets, students should have the right to decide what information is shared with teachers and other professionals.

Some jurisdictions have already implemented a student identifier. For example, the ACT, Western Australia and Victoria currently use an identifier across government and non-government schools, and Queensland currently has an identifier for students in government schools.[93] However, implementation at a state or territory level has limited value, as information cannot be aggregated at a national level.

The VET sector has already introduced a USI for the purposes of tracking students within the VET sector.

92 Goss, P., Sonnemann, J., 2016, *Widening gaps: What NAPLAN tells us about student progress*, Grattan Institute, pp. 41
93 Productivity Commission (2017) *National Education Evidence Base, Inquiry Report*. p. 128

Case Study: VET Unique Student Identifier

The VET sector has implemented a USI for students studying a VET subject. The current VET USI links all previous and future nationally recognised VET training (including VET undertaken in secondary school) to a single transcript. The VET USI has several benefits for students, governments and VET providers.

- **Students** can access their training history to verify training with employers and support the transition between institutions, while at the same time building a digital portfolio.
- **Governments** can use the data to analyse the level of VET activity and achievement to monitor performance and for evaluation purposes.
- **Training providers**, with student's permission, can use the USI to streamline administrative processes by recognising previous training, assisting with enrolment details, and assisting with skills development.

Privacy concerns have been addressed by appointing a Student Identifiers Registrar under the *Student Identifiers Act 2014*, which is bound by the Australian Privacy Principles in the *Privacy Act 1988*. All information is collected with the consent of the student and used only for the purposes detailed in the legislation.

The proposed national USI would link the datasets of current systems in different states and territories so a student's learning outcomes can be tracked through school, VET and higher education.

Privacy, access and control

While being broadly supportive of a national USI, stakeholders were clear that privacy, access and control issues would need to be addressed in its development and implementation.

In the VET sector, privacy concerns have been addressed by binding privacy aspects of the USI to the Australian Privacy Principles in the *Privacy Act 1988*, as well as appointing a Student Identifiers Registrar. Education Council could decide that the national USI proposed herein could be developed as an extension of the VET USI, or if an independent approach were preferred it could adopt a similar approach to the VET USI to ensure that student data is protected and that there are penalties for the misuse of data.

Like an electronic health record where patients can control who has access to their information, access to an individual student record would require the consent of the student or their parent or carer. For example, a major benefit to the student of a national USI would be that if they move to a different state their new teacher could, with permission, see the student's record of learning outcomes and where they are in their learning progression. Importantly, the Forum recommends that this not be an automatic process. A student or their parent or guardian could choose to limit the information passed between schools to ensure a student was able to restrict access to certain records. The student record would not be available to employers, or to universities or VET providers for admission purposes without the informed consent of the student.

Benefits of a USI

A national USI would offer a range of benefits for governments, teachers, students and parents, with a flow on benefit for industry in better understanding where to target their efforts in partnerships and what approach would be most effective to meet their objectives.

Students will benefit as they are able to access richer records of their schooling and have these records follow them as they transition between schools.

Teachers would be able to retrieve a longitudinal record for individual students, which would be particularly valuable when students move between school sectors or between states. It would also improve the value of longitudinal national assessment outcomes information and contribute to Australia's educational research capacity and capability.

Evaluating impact on a national scale, with data that can be disaggregated by a range of factors, would be a powerful tool to target investment in programs that lift education outcomes. In the longer term, a USI would have the added benefit of reducing duplication and cost of data collection and reporting.

Adoption of a national USI might also reduce administrative burden for schools, teachers and parents. Currently parents provide the same information in several instances over the course of their child's education. This can be avoided and accuracy improved if, with permission from the parent, a school is able to import student data from the previous school.

A national STEM education dashboard

As part of the National School STEM Education Strategy, Education Ministers have committed to a national collaborative action to build national reports to chart national change in a range of STEM data indicators, for example, STEM participation and attainment (including a focus on girls, low SES, and Aboriginal and Torres Strait Islander students), university commencements and graduate outcomes, and employment outcomes.

The Forum supports this action and the need for a richer understanding of student performance in STEM disciplines and would suggest this be expanded to include industry demand for STEM skills. This was a key theme in consultations.

> ***"The real question is how to measure education success in STEM – which must be broader than disciplinary knowledge given the premise around why STEM is important is based on 21st Century skills such as creativity, creative thinking and problem solving (which includes expert thinking), collaboration and complex communication".***
> ***[Monash University]***

Noting the current data limitations outlined throughout this report, an indicative dashboard design has been developed to support the accelerated implementation of this action and is provided below. While care has been taken to provide a rich set of measures using currently available data as an example, further work is required to ensure the measures included in the final dashboard are sufficiently robust and regularly maintained.

Indicative STEM Education Dashboard Design

The dashboard on the following page should be read in conjunction with the Explanatory Notes at Appendix 4.

International performance data

		Australia's performance (%)	Average for top 5 performers (%)	Country rank for overall performance
1	**PISA – percentage of high performing students in Bands 5 and 6 – 2015 (2006 baseline)**			
1.1	Science	11% (15%)	17% (17%)	14 of 72 (8 of 57)
1.2	Mathematics	12% (16%)	28% (27%)	25 of 72 (13 of 57)
2	**TIMSS – Year 8 students performing at or above the advanced benchmark (2007 baseline)**			
2.1	Science	7% (8%)	26% (22%)	17 of 39 (13 of 49)
2.2	Mathematics	7% (6%)	42% (36%)	17 of 39 (14 of 49)

National performance data

		Current	Baseline
3	**Year 9 NAPLAN numeracy – percentage of students above the national minimum standard in Bands 7, 8, 9 and 10 – 2017 (2008 baseline)**	82%	76%
4	**Year 12 – percentage of students studying advanced mathematics – 2016 (1992 baseline)**	9.5%	16.0%
4.1	Males	12.1%	N/A
4.2	Females	7.0%	N/A
5	**Year 12 – percentage of students studying science by subject – 2012 (1992 baseline)**		
5.1	Biology	25%	35%
5.2	Chemistry	18%	23%
5.3	Physics	14%	21%
6	**VET delivered to secondary students – percentage of enrolments by fields of education - 2016 (2006 baseline)**		
6.1	STEM	23%	28%
6.2	Architecture and Health	12%	6%
7	**Equity measures – years behind the national average in Year 9 NAPLAN numeracy - 2017 (2008 baseline)**		
7.1	Indigenous students (years behind)	2.8	3.5
7.2	Low-SES students (years behind)	2.2	2.2
7.3	Remote students (years behind)	1.9	2.5
8	**Teacher workforce – percentage of teachers teaching out-of-field in secondary schools - 2013**		
8.1	Mathematics	21%	N/A
8.2	Biology	8%	N/A
8.3	Chemistry	8%	N/A
8.4	Physics	22%	N/A
8.5	Information Technology	34%	N/A
9	**Higher Education and VET enrolments - percentage by field of education - 2016 (using 2006 baseline for higher education and 2014 baseline for VET)**		
9.1	Higher Education – STEM	20.8%	21.3%
9.2	Higher Education – Architecture and Health	20.5%	15.7%
9.3	Total VET – STEM	18.2%	21.4%
9.4	Total VET – Architecture and Health	15.1%	13.9%
10	**STEM Workforce – percentage of graduates in full-time employment in any occupation - 2017 (2011 baseline)**		
10.1	Higher Education undergraduates (3 years after graduation) – STEM	88%	93%
10.2	Higher Education undergraduates (3 years after graduation) - Architecture and Health	92%	95%
10.3	VET (employed after training)– STEM	78.8%	N/A
10.4	VET (employed after training)– Architecture and Health	81.3%	N/A

Conclusion

While there is a concerning decline in Australian students' engagement and outcomes in STEM subjects, despite increasing demand for STEM skills from industry, there are plenty of reasons to be optimistic for the future.

Throughout the Forum's consultations and discussions, it was clear that considerable energy and expertise is being invested by Australian industry and educators to build STEM capabilities in this country. For each case study and exemplar of school industry partnerships noted in the preceeding chapters, there are many more happening in schools every day.

The Forum sees the potential to refine and build on these efforts to increase the overall impact of school-industry partnerships and make a genuine difference to student engagement and attainment in STEM disciplines.

We acknowledge that we have adopted a broad view of our mandate. However, the recommendations are based on the expertise of Forum members and insights provided by industry and education experts. All relate to ensuring Australia has the skilled workforce it needs for the future.

In drafting this report there were a range of issues raised that did fall outside the scope of the Forum's work, from teacher qualifications to university bridging courses. The need to increase the focus on the VET system to deliver the targeted, applied qualifications that companies in STEM related fields increasingly seek in a rapidly changing environment was a consistent theme. This would be a separate piece of work to ensure the VET system is capable of meeting this demand, but also that school students see VET as a worthwhile pathway for a career in a STEM related field.

The Forum has limited its recommendations to 10 key actions that can be implemented in the short to medium term, and that will have a genuine impact on the quality of activity around school industry partnerships.

If adopted, the Forum's recommendations will ensure maximum benefit is achieved from the substantial investments of time and resources being put into this work every day. This will assist by schools, teachers and industry to improve student engagement and attainment in STEM disciplines, and ensure Australia is able to face the future with confidence.

APPENDICES

Appendix 1 – List of Forum members

Dr Alan Finkel AO, Australia's Chief Scientist (Chair) Office of the Chief Scientist

Ms Maureen Dougherty President (Deputy Chair) Boeing Australia, New Zealand and South Pacific

Ms Sara Caplan, CEO, PwC's Skills for Australia

Professor Andrew Cuthbertson AO, Chief Scientific Officer, Head of Research and Development CSL Limited

Ms Laura Tyler, Head of Geoscience, Chief of Staff to the CEO BHP Billiton

Mr David Whiteing, Group Executive, Enterprise Services & Chief Information Officer, Commonwealth Bank of Australia

Ms Sally-Ann Williams, Head of Engineering Community & Outreach, Google Australia

Mr Innes Willox, CEO, AiGroup

Ms Meg Brighton, Deputy Director-General ACT Education Directorate

Mr Tony Cook PSM, Associate Secretary Australian Government Department of Education and Training

Ms Sharyn Donald, Assistant Deputy Secretary Victorian Department of Education and Training

Mr Lindsay Hale, Executive Director, State-wide Services WA Department of Education

Ms Mary Mulcahy, Director of Education and Outreach CSIRO

Dr Lee-Anne Perry AM, Executive Director Queensland Catholic Education Commission

Professor Brian Schmidt AC, Vice Chancellor ANU

Professor Jo Ward, Dean of Science Curtin University

Mr Geoff Williamson, Principal Huonville High School

Mr Dennis Yarrington, President Australian Primary Principals Association (APPA)

Appendix 2 – Existing guides and resources

Schools-industry partnership framework
http://www.aced.edu.au/downloads/Schools-Industry_Partnership_Framework.pdf
Framework developed by the Australian Council of Deans of Science, Australian Council of Engineering Deans and Ai Group, for STEM related school, community and industry partnerships.

Preparing Secondary Students for Work – Framework
http://www.pssfw.myskills.gov.au/the-framework/
The *preparing secondary students for work – framework* sets out a framework for vocational learning and VET delivered to secondary students, and is accompanied by practical documents and resources for specific audiences including schools and employers.

Guiding Principles for School-Business Relationships
https://docs.education.gov.au/system/files/doc/other/partnerships_for_schools_businesses_and_communities_guiding_principles_0.pdf
A set of guiding principles for business school relationships. They are aspirational, describing benchmarks which individual school-business relationships can aim to achieve over time
The guiding principles have a general description, a description of what they might look like in practice, and questions to consider to evaluate a partnership's adherence to a particular principle.

STEM Professionals in Schools – Support and Resources
https://www.csiro.au/en/Education/Programs/STEM-Professionals-in-Schools/Partnership-support/Support-and-resources
Resources and materials developed to support the STEM Professionals in Schools program includes how to guides, case studies and useful information on considerations for working with schools.

How to guide for School Business Partnerships
http://www.nhscholars.org/School-Business%20How_to_Guide.pdf
A 'How to Guide' for Schools Business Partnerships produced by The Council for Corporate and School Partnerships (USA)

Guide to industry visits for school groups
https://www.iop.org/education/higher_education/stem/resources/file_44403.pdf
A guide to Industry Visits for School Groups from the Institute of Physics (UK), containing recommendations for schools, teachers and industry wanting to implement industry visits, based on an industry visits scheme that allowed students to see physics in a practical context and introducing them to a wide range of career opportunities.

Appendix 3 – Blueprint for a National STEM Resources Toolkit

WHY STEM?

- Describes what STEM is
- Explains why STEM is important
  - Includes the current state and potential future of STEM talent in Australia
  - Outlines the potential for education's role to change Australia's future in STEM

WHY USE THIS TOOLKIT?

- Describes what the Toolkit is for, i.e.:
  - Wanting to understand what has worked
  - Wanting to get involved in STEM education
  - Wanting to know whether an existing initiative is working
- Explains how to use the Toolkit
- Describes who the Toolkit is for (highlights sections schools or industry would find especially useful)

I WANT TO KNOW ABOUT STEM EDUCATION

- Describes the current understanding of best practice in key areas. Draws on national and international research and examples of STEM initiatives
- Designed for users who want to explore or be inspired by current ideas on best practice

What do STEM education initiatives try to achieve?
Understand aims for engagement. achievement, equity and excellence

Which school students need STEM education?
Challenges for different age groups and specific demographic groups

What works best when teaching STEM?
Nine principles for STEM education and 13 different types of initiatives to consider

How can schools and businesses partner for STEM education?
Benefits of partnerships, types of partnerships and principles for doing them well

I WANT TO SET UP AN INITIATIVE

- Provides key questions for users to set up an initiative (whether this is adapting or building on something existing or starting from scratch), with guidance on approching different tasks and real-life examples
- Designed for users who know they want to be involved in STEM education, but are unsure about exactly what to do, or the process to follow, in both schools and industry

Decide what you want to achieve:
Determine the problem or opportunity you are addressing, and what success would look like

↓

Pick who you want to target
Identify your target population

↓

Choose the best option:
Understand what works in STEM education. Consider what already exists and what is possible. Compare and analyse options

↓

Think about how it will work:
Identify who will be involved and how and consider your next steps

↓

Plan to evaluate:
Determine when you should measure success, and consider how you will do that

I WANT TO EVALUATE AN INITIATIVE

- Guides users through the key steps to evaluate an initiative, including introducing users to a common evaluation framework and explaining how thay can apply it
- Designed for users who want to evaluate an initiative, or users who want to understand what would be involved (e.g. those still running an initiative)

Why evaluate?
What evaluation does for you, and for others. How this Toolkit overcomes common barriers to evaluating STEM education initiatives

↓

Identify the purpose of your evaluation
Determine how you will use the conclusions of your evaluation

↓

Pick who needs to be involved and how:
Determine your stakeholders. Allocate roles for the evaluation. Tips to make your evaluation independent

↓

Build your evaluation framework:
Understand the STEM Toolkit evaluation framework and how to use it. Customise the framework for your specific initiative

↓

Gather the evidence you need:
Identify existing evidence or collect your own (e.g. surveys, interviews)

↓

Develop your conclusions:
Bring your evidence together to build conclusions

↓

Make decisions, share the news:
Make recommendations, and consider how to communicate them

Note: Additional detail and content has been developed for use on a national online resource once established.

Appendix 4 – STEM Education Data Dashboard metrics

International performance data

1 PISA - PERCENTAGE OF HIGH PERFORMING STUDENTS (BANDS 5 AND 6)	
Definition	The percentage of 15 year old students that are high performers in the Programme of International Students Assessment (PISA) survey and Australia's rank. **High Performers** Students who are proficient at Level 5 or Level 6 are considered to demonstrate high levels of skills and knowledge and are highly proficient in the assessment domain.
Additional information	**The Programme of International Student Assessment (PISA)** is a triennial international, stratified, random sample survey that provides reliable estimates about the population of 15 year old students. The goal of PISA is to measure how well 15 year olds, who are nearing the end of their compulsory schooling, are prepared to use the knowledge and skills in particular areas to meet real-life opportunities and challenges. PISA has six proficiency levels for both scientific and mathematical literacy. The levels of proficiency can be described across four categories. **Low performers** are students that perform below Level 2 proficiency, **Middle Performers** at students who are proficient at Level 2, Level 3 or Level 4. The **PISA baseline proficiency** Level 2 is considered the international baseline proficiency level. Australia sets a **National Proficient Standard** for PISA between Level 2 and Level 3. This level has been identified as the baseline because it represents a "challenging but reasonable" expectation of student achievement at a year level. In 2015, 72 countries and economies (all 35 OECD countries and 37 partner countries and economies) participated in PISA. In Australia, approximately 14,500 students from 760 schools participated, from all jurisdictions and all sectors of schooling. Data were gathered between July and early September 2015. **Australia's performance** In science, Australia's performance was significantly lower than that of 9 countries (Singapore, Japan, Estonia, Chinese Taipei, Finland, Macao (China), Canada, Vietnam, and Hong Kong (China)). In mathematics Australia's performance was significantly lower than 19 countries (Singapore, Hong Kong (China), Macao (China), Chinese Taipei, Japan, B-S-J-G (China), Korea, Switzerland, Estonia, Canada, the Netherlands, Denmark, Finland, Slovenia, Belgium, Germany, Poland, Ireland and Norway).
Source	Thomson, S., De Bortoli, L., 2006, *PISA 2006 survey of students scientific, reading and mathematical literacy skills*, Australian Council for Educational Research, pages 63, 66, 196, 200. Thomson, S., De Bortoli, L., and Underwood, C. 2017. *PISA 2015: Reporting Australia's results*. Australian Council for Educational Research, pages 28, 31, 160 and 162

2 TIMSS - YEAR 8 STUDENTS PERFORMING AT OR ABOVE THE ADVANCED BENCHMARK	
Definition	The percentage of Year 8 students that performed at or above the advanced benchmark in science and mathematics in the Trends in International Mathematics and Science Study (TIMSS) survey, and Australia's rank. **Advanced benchmark** Students at the Advanced level can apply their understanding and knowledge in a variety of relatively complex situations and explain their reasoning. They can solve a variety of multi-step word problems involving whole numbers. Students at this level show an increasing understanding of fractions and decimals. They can apply knowledge of a range of two- and three-dimensional shapes in a variety of situations. They can interpret and represent data to solve multi-step problems.
Additional information	**The Trends in International Mathematics and Science Study (TIMSS)** is an international, stratified, quadrennial random sample survey that provides reliable estimates about Year 4 and Year 8 students student achievement. The goal of TIMSS is to provide comparative information about educational achievement across countries in order to improve teaching and learning in mathematics and science. TIMSS is designed broadly to align with the mathematics and science curricula used in the participating education systems and countries, and focuses on assessment at Year 4 and Year 8. The stratification of the sample ensures that the TIMSS sample is representative of the Australian Year 4 and Year 8 populations (according to jurisdiction, school sector, geographic location of each school and socioeconomic category for the area of each school). TIMSS measures performance at four levels: **Advanced, High, Intermediate** and **Low**. In Australia, the proficient standard for TIMSS mathematics and science is **Intermediate** which represents a 'challenging but reasonable' expectation of student achievement. In 2015, forty-nine education systems tested at Year 4 level and 39 tested at Year 8 level. Within Australia, 287 primary schools and 285 secondary schools participated in the data collection for TIMSS. **Australia's performance** In 2015, in **science**, Australian Year 8 students were outperformed by students in 14 other countries, including Canada, the United States, England, Ireland, Singapore, Japan, Chinese Taipei, Korea, Slovenia, Hong Kong, the Russian Federation, Kazakhstan, Hungary and Sweden. In 2015, in **mathematics**, Australian Year 8 students were outperformed by students in 12 other countries, including Canada, Ireland, England, the United States, the Russian Federation, Kazakhstan, Slovenia, Singapore, Korea, Chinese Taipei, Hong Kong and Japan.
Source	Thomson S, Wernert, N., Underwood, C., Nicholas, M., 2007, *TIMSS 07: Taking a closer look at mathematics and science in Australia*, Australian Council for Educational Research, pages 53, 57, 95 and 99 Thomson S, Wernert, N., O'Grady, E., Rodrigues, S, 2015, *TIMSS 2015, A first look at Australia's results*, Australian Council for Educational Research, pages 27, 28, 65 and 66

National performance data

3 YEAR 9 NAPLAN NUMERACY – PERCENTAGE OF STUDENTS ABOVE THE NATIONAL MINIMUM STANDARD (BANDS 7, 8, 9 AND 10)	
Definition	The percentage of Year 9 students that performed above the national minimum standard in the NAPLAN numeracy test. **Above the National Minimum Standard** Students in Year 9 who perform at Band 7, 8, 9 and 10 perform above the National Minimum Standard.
Additional information	**The National Assessment Program – Literacy and Numeracy (NAPLAN)** is an annual national assessment for all stud..ents in Years 3, 5, 7, and 9. All students in these year levels are expected to participate in tests in reading, writing, language conventions (spelling, grammar and punctuation) and numeracy. The assessment is not mandatory and does not replace, nor count towards, the ongoing assessment of student achievement. NAPLAN assesses literacy and numeracy skills that are essential for every child to progress through school and life and can determine whether or not young Australians have the literacy and numeracy skills that provide the critical foundation for other learning and for their productive and rewarding participation in the community. Results across the Years 3, 5, 7 and 9 literacy and numeracy assessments are reported on a scale from Band 1 to Band 10. The achievement scale represents increasing levels of skills and understandings demonstrated in the assessments. Six bands are reported for each year level for each test. The Year 9 report shows bands 5 to 10, with band 6 representing the national minimum standard. The tests provide parents and schools with an understanding of how individual students are performing at the time of the tests. They also provide schools, states and territories with information about how education programs are working and which areas need to be prioritised for improvement. Individual student performance is shown on a national achievement scale for each test. A result at the national minimum standard indicates that the student has demonstrated the basic literacy and numeracy skills needed to participate fully in that year level. The performance of individual students can be compared to the average performance of all students in Australia. The second lowest band on the achievement scale reported for each year level represents the national minimum standard expected of students at that year level. The national minimum standard is the agreed minimum acceptable standard of knowledge and skills without which a student will have difficulty making sufficient progress at school. Students whose results are in the lowest band for the year level have not achieved the national minimum standard for that year.
Source	Australian Curriculum, Assessment and Reporting Authority, National Assessment Program Literacy and Numeracy, 2017. p. 238. Australian Curriculum, Assessment and Reporting Authority, National Assessment Program Literacy and Numeracy, 2008.

4 YEAR 12 - PERCENTAGE OF STUDENTS STUDYING ADVANCED MATHEMATICS

Definition	The percentage of students studying advanced mathematics in Year 12, noting students can be enrolled in multiple mathematics subjects. **Advanced Mathematics** Advanced mathematic subjects are generally regarded as 'difficult' and chosen by the most capable students. Advanced mathematics subjects are recognised differently in each state and territory. Terms used for advanced level mathematics: • VIC/QLD/NT/SA/WA: Specialist mathematics • NSW: Mathematics Extension 1 and 2 • TAS: Maths Specialised Level 4 • ACT: Specialist Mathematics, Specialist Methods and ANU Extension Mathematics.
Additional information	The Australian Curriculum, Assessment and Reporting Authority (ACARA) manages a data portal that provides interactive access to a number of national data sets, including Year 12 enrolments by learning area. The data is not disaggregated to the subject level within the learning area. Therefore, data on advanced level mathematics subjects is not publicly available. In 2017 the Australian Mathematical Sciences Institute released a report that includes a breakdown of Year 12 mathematics by subject area in Australia. The report provides information on the proportion of students doing Advanced, Intermediate and Elementary mathematics from 1992 to 2016. Research indicates that students undertaking advanced mathematics subjects in Year 12 are better prepared for further study in those STEM related fields that required advanced mathematics.
Source	Australian Mathematical Sciences Institute, 2017, *Discipline Profile of Mathematical Sciences*, 2017, pages 21-23.

5 YEAR 12 – PERCENTAGE OF STUDENTS STUDYING SCIENCE BY SUBJECT

Definition	The percentage of students studying biology, chemistry or physics in Year 12, noting that students can be enrolled in multiple science subjects.
Additional information	The Australian Curriculum, Assessment and Reporting Authority (ACARA) manages a data portal that provides interactive access to a number of national data sets, including Year 12 enrolments by learning area. The data is not disaggregated to the subject level within the learning area. Therefore, data on advanced science subjects within the science learning area is not publicly available. In 2017 the Australian Mathematical Sciences Institute released a report that includes a breakdown of Year 12 science by subject area in Australia. The data provides information on the proportion of students doing science subjects from 1992 to 2012.
Source	Australian Mathematical Sciences Institute, 2017, *Discipline Profile of Mathematical Sciences*, 2017, pages 21-23.

6 VET DELIVERED TO SECONDARY STUDENTS – PERCENTAGE OF ENROLMENTS BY FIELDS OF EDUCATION

Definition	The percentage of enrolments for 15-19 year old secondary students undertaking VET in the STEM, or Architecture and Building, and Health, related fields of education. **Program Enrolments** Enrolments are counted for each VET subject a student is enrolled in. A student may be enrolled in multiple VET subjects. **STEM** The following fields of education are recognised as STEM related: • Engineering and related technologies • Information technology • Natural and physical sciences • Agriculture, environmental and related studies The Architecture and Building, and Health fields of education are reported separately as 'Architecture and Health' are not considered to be pure STEM disciplines but they have significant elements of mathematics and science.
Additional information	The *National VET in Schools Collection* collects data for VET undertaken by school students as part of their senior secondary certificate of education, where training is nationally recognised or delivered by schools or other training providers. Data are collected and reported annually via the senior secondary assessment authority in each state or territory to the National Centre for Vocational Education and Research. **Field of Education** The Australian Classification of Education (ASCED) is used for field of education. This is an Australian Bureau of Statistics classification that describes the broad area of study related to a qualification or subject in which a student was enrolled (ABS Catalogue No. 1272.0).
Source	National Centre for Vocational Education Research, NCVER VOCSTATS <https://www.ncver.edu.au/resources/vocstats.html>

7 EQUITY MEASURES – YEARS BEHIND THE NATIONAL AVERAGE IN YEAR 9 NAPLAN NUMERACY	
Definition	The Grattan Institute has developed an Equivalent Year Level (EYL) tool that can be applied to average NAPLAN scores to calculate how many years behind disadvantaged students are compared to non-disadvantaged students. The data dashboard reports the number of years behind the following categories of disadvantaged students are in Year 9 numeracy: • Indigenous students • Low-SES students • Remote students The EYL tool estimates the equivalent school year level for student groups using the national mean NAPLAN score of metropolitan non-Indigenous students as the benchmark. Once the EYL has been derived, the number of years behind in learning can be calculated.
Additional information	Calculation for low socio-economic status uses parent educational level of Year 11 (i.e. neither parents finished Year 12).
Source	Grattan Institute, 2017, Equivalent Year Level tool as used in Grattan Institute submission to the *Review to Achieve Educational Excellence in Australian Schools.* Goss, P., Sonnemann, J., 2016 *Widening gaps: What NAPLAN tells us about student progress*, March 2016, Grattan Institute https://grattan.edu.au/wp-content/uploads/2016/03/937-Widening-gaps.pdf

8 TEACHER WORKFORCE – PERCENTAGE OF TEACHERS TEACHING OUT-OF-FIELD IN SECONDARY SCHOOLS

Definition	The percentage of teachers teaching out-of-field in mathematics, biology, chemistry, physics and information technology in secondary schools, Years 7 to 12. In-field teaching is defined according to the definition agreed in 2007 by the *Staff in Australia's Schools* (SiAS) steering committee: To be in-field for the purposes of SiAS, a teacher had to have: *either* studied the subject at second year tertiary level or above, or trained in teaching methodology for that subject at tertiary level. **Out-of-field** Based on the above definition for in-field teaching, out-of-field teachers would be considered those that have neither studied the subject at second year tertiary level or above, nor received training in teaching methodology for that subject at tertiary level.
Additional information	To analyse the characteristics and profiles of teaching in selected learning areas in primary and secondary schools, the Staff in Australian Schools Survey was designed. It was designed to provide a detailed picture of the Australian teacher workforce, and to gather information to assist in future planning. The last survey was conducted in 2013. A sample of 511 secondary schools and 10,349 secondary school teachers (Years 7-12) completed the survey, resulting in an overall response rate of 31.4%. The SiAS was conducted in 2013 on a stratified sample of teachers whose characteristics are approximately the same proportion as they appear in the population. • The design of the survey was supported by a steering committee with representatives from the Australian Government, government education authorities from all states and territories, the National Catholic Education Commission, the Independent Schools Council of Australia, the Australian Bureau of Statistics and other peak primary and secondary education bodies. • The definition of out-of-field teaching was developed and used for the purposes of the SiAS survey only - that is, it is not an agreed Australian Government definition. The survey was developed with states and territories. • Results from the survey indicate over 80% of the secondary teachers teaching Mathematics, Biology, Chemistry, Physics, and General Science have undertaken at least one semester at second year tertiary study in the area or training in teaching methodology in that field. There would appear to be relatively little out-of-field teaching in these areas. There has been a general decline in out-of-field teaching since 2010. (page 64) • There is currently no national, comprehensive data available on out-of-field teaching.
Source	McKenzie, P., Weldon, P., Rowley, G., Murphy, M., McMillan, J., *Staff in Australia's Schools 2013: Main Report on the Survey*, 2013, Australian Council of Educational Research, April 2014 https://research.acer.edu.au/cgi/viewcontent.cgi?article=1021&context=tll_misc Weldon, P., 2016, *Policy Insights, Out-of-Field Teaching in Australian Secondary Schools*, June 2016, Australian Council of Educational Research https://research.acer.edu.au/cgi/viewcontent.cgi?article=1005&context=policyinsights

9.1 AND 9.2 HIGHER EDUCATION ENROLMENTS – PERCENTAGE OF DOMESTIC UNDERGRADUATE ENROLMENTS IN A STEM FIELD OF EDUCATION

Definition	The percentage of Higher Education domestic undergraduates who were enrolled a STEM related field of education or Architecture and Building, and Health. **Enrolment** A domestic undergraduate student who is enrolled in a course of study at a higher education institute. **Field of Education** **STEM** The following fields of education are recognised as STEM related: • Engineering and related technologies • Information technology • Natural and physical sciences • Agriculture, environmental and related studies The Architecture and Building, and Health fields of education are reported separately as 'Architecture and Health' are not considered to be pure STEM disciplines but they have significant elements of mathematics and science. The Australian Classification of Education (ASCED) is used for field of education. This is an Australian Bureau of Statistics classification that describes the broad area of study related to a qualification or subject in which a student was enrolled (ABS Catalogue No. 1272.0). For field of education enrolments, the data takes into account the coding of Combined Courses to two fields of education. The Department of Education and Training manages a comprehensive set of statistics referred to as the Higher Education Statistics Collection. Data included in the Higher Education Statistics Collection is compiled annually and collects information about students including, but no limited to, courses, income, completions and employment status. The data is published on the department's website.
Additional information	The Department of Education and Training manages a comprehensive set of statistics referred to as the Higher Education Statistics Collection. Data included in the Higher Education Statistics Collection is compiled annually and collects information about students including, but no limited to, courses, income, completions and employment status. The data is published on the department's website.
Source	Department of Education and Training – Higher Education Statistics –uCube – Higher Education Data Cube http://highereducationstatistics.education.gov.au/

9.3 AND 9.4 VET ENROLMENTS – PERCENTAGE BY FIELD OF EDUCATION

Definition	The percentage of VET students who were enrolled a STEM related field of education, or Architecture and Building, and Health. **Enrolment** VET program enrolments include a record for each qualification, course or skill set associated with the enrolment. It counts enrolments at all training providers delivering nationally recognised training. **Field of Education** **STEM** The following fields of education are recognised as STEM as STEM related: • Engineering and related technologies • Information technology • Natural and physical sciences • Agriculture, environmental and related studies The Architecture and Building, and Health fields of education are reported separately as 'Architecture and Health' are not considered to be pure STEM disciplines but they have significant elements of mathematics and science. The Australian Classification of Education (ASCED) is used for field of education. This is an Australian Bureau of Statistics classification that describes the broad area of study related to a qualification or subject in which a student was enrolled (ABS Catalogue No. 1272.0).Data is derived from the National VET Provider Collection and the National VET in Schools Collection. Students may be enrolled in more than field of education.
Additional information	The National Centre for Vocational Education and Research manages a comprehensive set of statistics for all VET activity, referred to Total VET Activity. Registered Training Organisations are required to report all VET activity annual. The data is collected by the NCVER and reported through annual publications on the NCVER website. The information collected includes, but is not limited to, field of education, industry group, course level, demographics, equity groups, age and gender. The data is published on the department's website.
Source	National Centre for Vocational Education Research, 2017, *Total VET Students and Courses, 2014*, pages 11 www.voced.edu.au/content/ngv%3A70611 National Centre for Vocational Education Research, 2017, *Total VET Students and Courses, 2016*, pages 16 https://www.ncver.edu.au/__data/assets/pdf_file/0026/796211/Total-VET-students-and-courses-2016.pdf

10.1 AND 10.2	STEM WORKFORCE – PERCENTAGE OF GRADUATES IN FULL-TIME EMPLOYMENT IN ANY OCCUPATION – HIGHER EDUCATION UNDERGRADUATES
Definition	The percentage of undergraduate domestic graduates who studied in a STEM related field of education, or Architecture and Building, and Health, related fields of education, who were in full-time employment 3 years following graduation. **Full time employment** Graduates who were usually or actually in paid employment for at least 35 hours per week. **Graduate** A student who has completed an undergraduate degree at an Australian University or non-university higher education institute. **Field of Education** **STEM** The following fields of education are recognised as STEM related: • Engineering and related technologies • Information technology • Natural and physical sciences • Agriculture, environmental and related studies The Architecture and Building, and Health fields of education are reported separately as 'Architecture and Health' are not considered to be pure STEM disciplines but they have significant elements of mathematics and science.
Additional information	The Graduate Outcomes Survey is an annual Survey that provides information about labour market outcomes and further study activities of graduates. The 2017 Graduate Outcomes Survey – Longitudinal (GOS-L) measures the medium-term outcomes of higher education graduates based on a cohort analysis of graduates who responded to the 2014 Australian Graduate Survey (AGS). 55 institutions chose to participate, including 39 universities and 16 non-university higher education institutions (NUHEIs). The GOS-L achieved a 42.2% response rate overall, representing 38,591 completed surveys. **Field of Education** The Australian Classification of Education (ASCED) is used for field of education. This is an Australian Bureau of Statistics classification that describes the broad area of study related to a qualification or subject in which a student was enrolled (ABS Catalogue No. 1272.0). Data has been provided by the Higher Education Performance and Analysis Team in the Department of Education and Training using raw data from the GOS-L.
Source	Quality Indicators for Learning and Teaching, 2017, *2017 Graduate Outcomes Survey – Longitudinal – Medium-term graduate outcomes*, 2017 https://www.qilt.edu.au/docs/default-source/gos-reports/2017-gos-l/2017-gos-l-national-reportbb518791b1e86477b58fff00006709da.pdf?sfvrsn=2bb9e33c_2

10.3 AND 10.4 STEM WORKFORCE – PERCENTAGE OF GRADUATES IN FULL-TIME EMPLOYMENT IN ANY OCCUPATION – VET

Definition

The percentage of VET graduates who studied in a STEM related field of education, or Architecture and Building, and Health, who were in full-time employment following training.

Full time employment

A person was employed full-time if they usually worked 35 hours or more per week in their main job during the reference period.

Graduate

A student who has gained a qualification through their training. Qualifications include Bachelor's Degree or higher, Advanced Diploma, Associate degree, Diploma, Certificate I, II, III or IV.

Field of Education

STEM

The following fields of education are recognised as STEM related:

- Engineering and related technologies
- Information technology
- Natural and physical sciences
- Agriculture, environmental and related studies

The Architecture and Building, and Health fields of education are reported separately as 'Architecture and Health' are not considered to be pure STEM disciplines but they have significant elements of mathematics and science.

Additional information

The National Student Outcomes Survey is an annual survey that collects information on vocational education and training (VET) students' reasons for training and their employment outcomes, satisfaction with training and further study outcomes. Students included in the survey are those who completed their training in the previous calendar year.

Each year the National Centre of Educational Research (NCVER) randomly selects a sample of students (graduate and subject completers) from the National VET Provider Collection. The sample is stratified by state/territory of student, residence provider type and funding source.

In 2016, 362,629 graduates were invited to participate in the survey. The survey achieved a 37% response rate overall, representing 133,770 completed surveys.

Field of Education

The Australian Classification of Education (ASCED) is used for field of education. This is an Australian Bureau of Statistics classification that describes the broad area of study related to a qualification or subject in which a student was enrolled (ABS Catalogue No. 1272.0). VET figures include private training and community education providers.

- The collection of Total VET activity, including data on VET students attending Government funded and private providers did not commence until 2014. The 2016 data is the first collection of Total VET Activity for VET Student Outcomes.
- Students supply information in May with results published late November/early December each year, once fieldwork is completed in August.
- Results of the Student Outcomes Survey are published late November/early December each year, once fieldwork is completed in August.

Source	National Centre for Vocational Education and Research, *VET Student Outcomes 2017, Australian vocational education and training statistics* https://www.ncver.edu.au/__data/assets/pdf_file/0018/1304901/VET-student-outcomes-2017.pdf https://www.ncver.edu.au/__data/assets/pdf_file/0029/1305659/National-Student-Outcomes-Survey-2017-technical-notes.pdf https://www.ncver.edu.au/__data/assets/pdf_file/0027/1305666/VET-student-outcomes-2017-terms-and-definitions.pdf

Appendix 5 – List of Submissions

To support the work of the Forum, consultations were undertaken in each state and territory with experts from education and industry invited to respond to observations, provisional recommendations and questions. A total of 152 people attended 18 meetings over 7 weeks.

In addition to this, 53 written submissions (including 2 informal submissions) were provided in response to the Forum's Issues Paper. A list of submissions received is below:

1 Association of Heads of Independent Schools of Australia
2. Australasian Curriculum, Assessment, and Certification Authority
3. Australian Academy of Science
4. Australian Academy of Technology and Engineering (ATSE)
5. Australian Association of Mathematics Teachers
6. Australian Business and Community Network
7. Australian Catholic University
8. Australian Council of Deans of Education
9. Australian Council of Engineering Deans & Australian Council of Deans of Science
10. Australian Institute for Teaching and School Leadership
11. Australian Mathematical Sciences Institute
12. Australian Parents Council
13. Australian Primary Principals Association
14. Australian Science Teachers Association
15. BHERT
16. Catholic Education Diocese of Parramatta
17. Catholic School Parents Australia
18. Chamber of Minerals and Energy of Western Australia
19. Deakin University
20. Dr Jane Hunter
21. Earth Science Western Australia
22. Education Services Australia
23. Emeritus Prof Mark Hackling
24. Engineers Australia
25 In2science
26. Innovation and Science Australia
27. Isolated Children's Parents' Association of Australia
28. Loreto Kirribilli
29. Mag-Net
30. Minerals Council of Australia
31. Monash University
32. Prof P John Williams
33. Queensland Catholic Education Commission
34. Questacon
35. Refraction Media
36. Royal Institution of Australia
37. Australian Schools Plus

38. ScopeIT Education
39. Skilling Australia Foundation
40. SLAM Education
41. Social Ventures Australia
42. STEM X Alumni
43. Teacher Earth Science Education Programme
44. The Education Consultancy
45. The Warren Centre for Advanced Engineering
46. University of Melbourne Faculty of Science
47. University of Queensland
48. University of Queensland Faculty of Science
49. WA Department of Education
50. Westpac
51. Wyndham Tech School/Innovation HUB
52. Informal Submission
53. Informal Submission

Appendix 6 - Acknowledgements

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