OPTIMISING STEM INDUSTRY-SCHOOL PARTNERSHIPS:

INSPIRING AUSTRALIA'S NEXT GENERATION

ISSUES PAPER

December 2017

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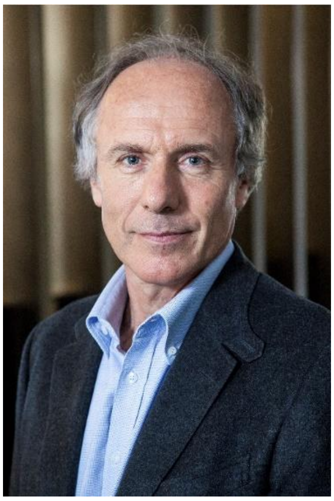
Note from the Chair



The enemy of our future prosperity is complacency. Past investments in skills development have underpinned our strong economy and enviable lifestyle, which in turn have diminished our sense of urgency. While our school system remains above average among OECD countries, the achievement of our students across science, literacy and numeracy is declining.

Australian employers are concerned. To meet the challenges of ever more sophisticated international competition in advanced products and services, employers need to be able to access an increasingly skilled workforce, whose skills include traditional sciences and mathematics, facility with information and communications technologies (ICT), and the 21st century skills that prepare our youth for a lifetime of unfolding career opportunities.

There is much to be done. The STEM Partnerships Forum acknowledges its place among the reforms and reviews that are currently underway. Our specific focus is on how industry can help. Help to build the enthusiasm of students and their teachers. Help parents to understand their role and the opportunities that will unfold for their children in the years to come. Help to provide the tools that will support teachers and leaders in schools. Help to implement robust measurement systems so that we better understand what works and what doesn't.

Employers worry that school leavers are not sufficiently ready for the apprenticeships or jobs that are available. They likewise worry about university and vocational education graduates. Their concerns are partly fuelled by awareness that in the era of mass tertiary education the minimum entrance scores across the Australian university system are lower than in the past. It is a matter of simple arithmetic – because the ATAR is a rank, not a mark. Accepting a larger proportion of the academically-ranked population necessitates lowering the minimum entrance scores. The key challenge is to ensure that lower ranked students are nevertheless well prepared for further study. We need to invest early, in primary and secondary schooling, to ensure that all students are supported to turn around the decline measured in international tests and that those admitted to universities and vocational education have the best preparation for success.

The work of the Forum has been guided by the following key principles.

1) National prosperity depends on a highly skilled workforce
2) Teachers are central
3) Industry has a role; it is not a passive recipient
4) Program outcomes should be specified in advance and measured for the long term
5) The recommendations in our final report must be actionable in the near term and have a foreseeable impact

These principles will continue to guide the Forum's work as we refine the observations and provisional recommendations contained in the following pages for our final report to COAG Education Council in the first half of 2018.

To complete our task, we need help. If you are reading this issues paper you are someone who cares about the modernisations and improvements that our school system needs. You have an interest in ensuring that all of our youth have basic science and mathematics competencies and that a substantial fraction develop the foundational STEM skills that will prepare them for STEM based careers. You recognise that the historical association of lifelong jobs with linear education is over, so that 21st century skills are as important as discipline skills. You can help us, and we look forward to hearing from you.

I take this opportunity to thank the Forum members for volunteering their time and energy for this important work. I also thank the friends of the Chair who willingly shared their wisdom with me. Lastly, I thank the taskforce and the members of my office who contributed to the heavy lifting.

Alan Finkel
Chair
STEM Partnerships Forum

14 December 2017

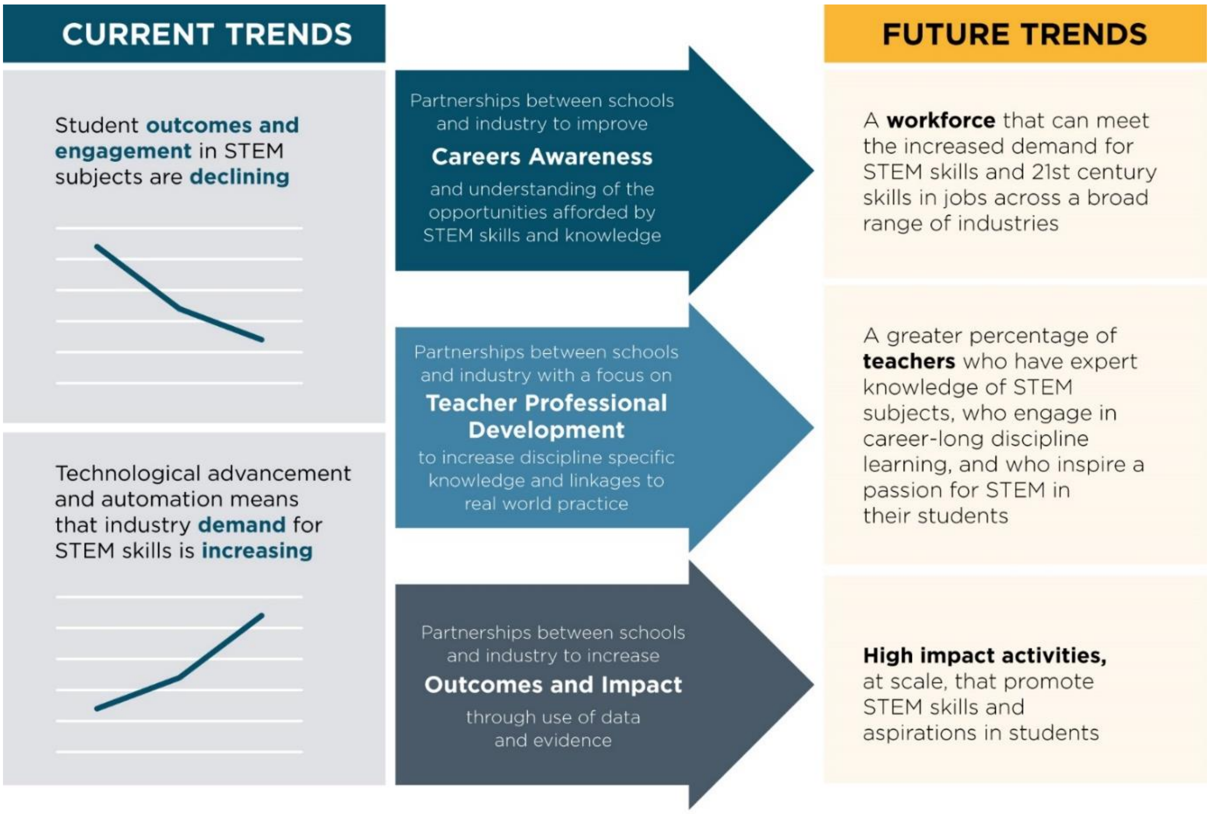
Observations and Provisional Recommendations

A nation's future prosperity is determined by the quality of its workforce. Of the many factors required, STEM skills and literacy are increasingly critical. Our primary and secondary schools are not equipping our students in STEM subjects as well as in years past. Students are increasingly opting out of STEM subjects and when they do take them, their performance shows an alarming trend towards mediocrity.

Simply mandating STEM subjects will not work. A better solution is to make these subjects so compelling, so stimulating and so exciting that the student cannot help but be inspired to take up these subjects. This will require teachers who are confident in their discipline and are supported by their school leaders and system. If it can happen in other countries, it can happen here too.

Industry is in a privileged position to inspire and lead students. Industry's role is not just as an employer, it can play a greater role in developing a skilled workforce by connecting the concepts taught in our classrooms to real-world applications.

The STEM Partnerships Forum (the Forum) has focused on three areas – Careers Awareness, Teacher Professional Development and Outcomes & Impact. Targeted action by industry, government and other stakeholders in these areas will lead to improved STEM outcomes for students as demonstrated in the diagram below.



The observations and provisional recommendations below outline the scope of the challenge and possible solutions in key focus areas. These solutions include:

- High quality, discipline specific teacher professional development informed by the latest trends in industry
- Industry's role in communicating to parents, teachers and students the careers and opportunities afforded by studying STEM subjects
- Adopting a unique student identifier to enable the linking of key national data assets to provide the evidence for better policy, and
- Calling on universities to provide the right signals to students through prerequisites in STEM subjects for courses that need them.

Chapter 1: STEM in Education and Work

1.1 The Forum believes increasing globalisation, automation and flexibility should be seen as an opportunity rather than a threat, with STEM skills, in particular ICT skills and digital technologies skills, needed to make the most of this opportunity.

1.2 Demand for STEM skills is not just about the need for more workers in STEM jobs, but rather about the benefits and transferability of STEM and ICT skills across all careers and in life generally.

1.3 Emphasising STEM skills early in education may help motivate students in later years to continue to engage in STEM disciplines.

1.4 An increasing focus on STEM skills should build on strong foundations in literacy and numeracy and be a part of a rich school education.

1.5 The development of 21st century skills such as critical thinking, communication and digital skills can be gained through study not only in STEM, but across other fields, such as humanities and the arts.

1.6 In recent years, Australian student performance in international testing has slipped and the number of high achieving students has declined.

1.7 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.

1.8 While there is not an achievement gap between boys and girls in STEM disciplines, there is a gap in engagement and aspiration.

1.9 Over the past two decades, participation in challenging STEM subjects in Australian schools has declined by up to 10 percentage points in some subjects.

1.10 Diminished discipline-specific university prerequisites have removed important incentives for the study of challenging STEM subjects in senior secondary school.

Provisional Recommendation

1 Universities should reinstate prerequisites for university entry with the aim of ensuring students study STEM subjects in senior secondary school so that they are well prepared for further study and work.

Chapter 2: The Role of Industry

2.1 The objectives of different types of businesses, including those of differing size and location, will vary in school-industry partnerships. Having a strong understanding of the objectives and outcomes being sought is an essential first step in any education partnership.

2.2 Further clarity is needed around the demand for 'STEM skills' – whether employers are looking for STEM discipline knowledge, ICT skills, digital technologies skills, 21st-century skills or a combination of these.

2.3 While 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, the proliferation and varying quality of these activities can create confusion for both schools and industry.

2.4 Industry should focus on supporting or building the scale and impact of existing, effective partnership models rather than start competing initiatives.

Provisional Recommendation

2 The key elements of effective, scalable school-industry partnerships should be identified by the Forum to help industry target its engagement towards programs that make a difference and to assist local businesses leverage their local connections.

Chapter 3: Teacher Professional Development

3.1 School-Industry partnerships with a focus on teacher professional development should be led by educators, and supported by industry.

3.2 To keep up with the latest developments in their field, teachers of STEM education in both primary and secondary school would benefit from an increased emphasis on discipline-specific professional development.

3.3 The Forum supports the Australian Teacher Workforce Data Strategy being led by the Australian Institute for Teaching and School Leadership (AITSL) for the COAG Education Council. This strategy is an essential first step to better understanding the level of training and qualifications of those teaching STEM disciplines.

Provisional Recommendations

3 There should be a greater emphasis on discipline-specific professional development for teachers of STEM education, with a role for industry in connecting teachers with the latest developments in the field.

4 A practical model outlining the key elements of successful school-industry partnerships for teacher professional development and support should be developed by the Forum.

Chapter 4: Solving Real-world Problems – Careers Awareness

4.1 Perceptions about the study of STEM subjects being difficult and complex have a negative impact on student engagement with these subjects in school, and subsequent consideration of STEM related careers.

4.2 Use of language around skills and work and the messaging it carries is important. Talking about 'what problems do you want to solve?' and 'how can I be part of this, what skills do I need and what is the pathway?' is more appealing and relevant than simply talking about STEM related careers.

4.3 Consideration should also be given to the use of the term 'STEM' and whether it is a barrier to some audiences. Simpler language such as science or mathematics may sometimes be more appropriate.

4.4 There are a range of groups that influence the career decisions of young people, including parents, teachers and careers advisers.

4.5 Parents play a particularly important role as the most significant influence on students' decisions about their future and should be a focus for information about the career opportunities that STEM education can open for young people.

4.6 Girls, Aboriginal and Torres Strait Islander students, students from low socio-economic backgrounds and 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.

4.7 Engaging in conversations about solving real-world problems with STEM skills early in life, particularly with students from these underrepresented groups, will enable young people to remain open to and make more informed choices about pathways to STEM careers.

4.8 The Forum will consider how it can support and build on recommendations arising from the development of a National Career Education Strategy.

Provisional Recommendations

5 Governments and industry should focus the public narrative on the prospect of well-paid jobs and the increasing importance of STEM skills and 21st century skills in the future economy.

6 Industry should develop communication activities to illustrate real-world problems and change perceptions of STEM careers for students and parents.

7 Industry should contribute to positive perceptions of STEM careers through hosting site visits, supporting events and collating and distributing relevant materials for teachers and students.

8 Industry should be encouraged to showcase the success of underrepresented groups in STEM related careers as role models in their engagement with primary and secondary schools.

Chapter 5: Outcomes and Impact

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

5.2 Efforts to improve understanding of the impact of STEM initiatives should take into account existing frameworks and portals, such as the STARportal, and build on these where possible.

5.3 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.

Provisional Recommendations

9 Governments should prioritise and accelerate the introduction by 2020 of a national lifelong Unique Student Identifier to promote a more sophisticated analysis and understanding of student achievement in Australia.

10 Industry and industry associations should develop and provide data about future workforce needs, including vacancies and the skills required of employees both in STEM specific areas and areas where STEM skills are valued. This data should be collected in a centralised national repository and made freely available to maximise its use.

11 A STEM evaluation tool to gauge the success of school-industry partnerships should be developed by the Forum.

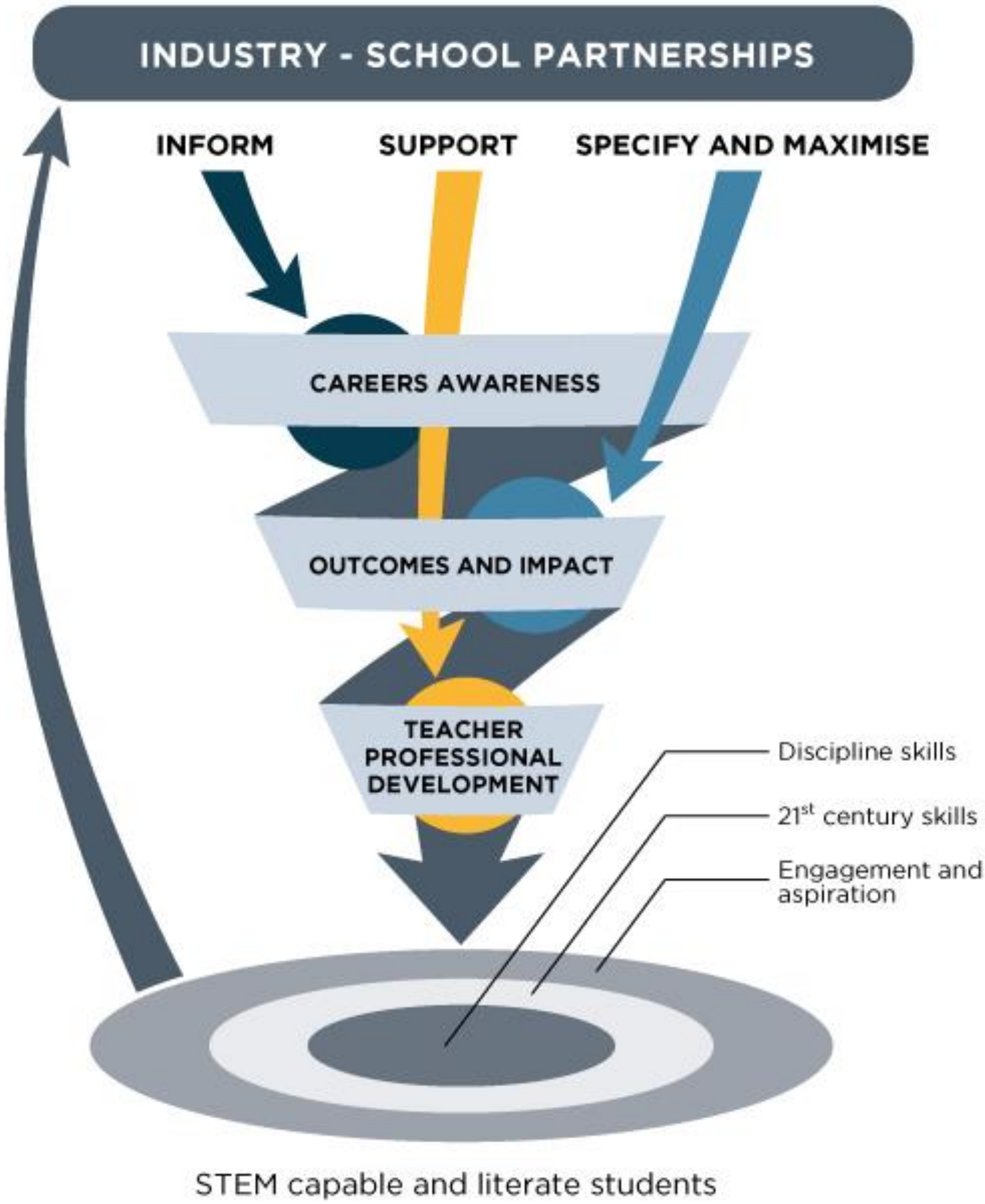


Figure 1. A visual representation of how industry-school partnerships can lead to improved STEM outcomes for students through a focus on Careers Awareness, Outcomes & Impact and Teacher Professional Development.

Questions for Consultation

The questions below have been developed out of the Forum's discussions to date and are intended to guide consultations and assist in refining our observations and provisional recommendations. The questions should be seen as prompts. Respondents should not feel obliged to answer all questions or be constrained by their specific formulation.

The Forum would appreciate any information that stakeholders think would be beneficial in contributing to successful school-industry partnerships for improved engagement, aspiration, capability and attainment of students in STEM.

<u>Chapter 1: STEM in Education and Work</u>

1.1 *What are the STEM skills the future workforce will need and that industry would like to see strengthened?*

1.2 *What are the ICT and digital technologies skills the future workforce will need and that industry would like to see strengthened?*

1.3 *Should industry focus its efforts on strengthening discipline-specific knowledge, or developing 21st century skills? Why?*

1.4 *Are 21st century skills fundamentally different and more challenging than 20th century skills?*

1.5 *Are NAPLAN, PISA and TIMSS appropriate for measuring achievement in the skills we are aiming to teach? If not, what assessment tools would be better?*

1.6 *Is the ATAR sending the wrong signals to schools and students about choosing science and mathematics subjects appropriate for anticipated university courses? What is the evidence for this and how can this be addressed?*

1.7 *Do you agree with the premise that the lack of prerequisites for entry into university courses sends the wrong signals to schools and students? What is the evidence for this?*

<u>Chapter 2: The Role of Industry</u>

2.1 *The Interim Report has focused on a) Teacher Professional Development, b) Careers Awareness and c) Outcomes and Impact. Are there areas outside these that should be a focus?*

2.2 *Can you please provide one or more examples of school industry partnerships in STEM areas that are working well? What are the key elements of the partnership that make it successful?*

2.3 *What are the barriers to creating effective school industry partnerships?*

   a) *What actions could schools take to encourage industry to develop partnerships and support STEM education in schools?*

   b) *How can universities and vocational training institutions help industry to develop partnerships and support STEM education in schools?*

   c) *How can governments help?*

   d) *What actions can employers take to increase their ease of involvement in school partnerships?*

2.4 *What resources or guidance materials would be most useful to encourage, or improve the quality of, industry partnerships with schools?*

Chapter 3: Teacher Professional Development

3.1 What role should industry and tertiary institutions play in supporting teachers of STEM disciplines in their ongoing professional development? What should they avoid doing?

3.2 How can industry and tertiary institutions best support professional development in STEM discipline-specific knowledge, applied practice in industry and focused on 21st century skills?

3.3 What resources can industry make available for teachers? How can industry help teachers link what they are teaching to job opportunities?

3.4 Would work experience or mentoring programs for teachers be valuable and feasible? Please provide successful examples, and also examples of challenges.

3.5 What role could industry play in supporting out-of-field STEM teachers to gain deeper subject knowledge?

3.6 What role could industry play in supporting teachers of STEM education in rural, regional and remote areas?

3.7 What role should industry play in supporting the ongoing Professional Development of careers advisers?

Chapter 4: Solving Real-World Problems – Careers Awareness

4.1 Language is important:

- *a) Is the term 'STEM' a barrier to reaching a diverse audience? If so, what terms would be more appropriate?*
- *b) Instead of promoting 'STEM related careers' should we be asking young people what skills and knowledge they will need to solve real-world problems in a technology-rich world?*

4.2 How can schools and industry work together to help young people understand the ways that STEM skills can be used to solve real-world problems and prevent any mismatch between what a student studies and what they need to study to fulfil their career aspirations in STEM and non-STEM occupations:

- *a) What information about solving problems using STEM skills and STEM careers could industry provide to schools?*
- *b) Would a greater focus on work exposure or experience in STEM areas increase future participation in STEM disciplines?*

4.3 How can industry communicate best with parents so that they can have informed conversations with their children about the benefits of STEM and STEM related careers?

4.4 How can industry best assist teachers, career advisers and other influencers of student career aspirations?

4.5 How can schools and industry work together to provide support, increase confidence and raise aspirations for all students in STEM related education and STEM-related careers, particularly from the following under-represented groups?

- *a) Girls*
- *b) Aboriginal and Torres Strait Islander students*
- *c) Students from low socio-economic backgrounds*
- *d) Students from regional, rural and remote areas*

Chapter 5: Outcomes and Impact

5.1 *How do schools make decisions about embarking on a partnership with industry?*

5.2 *How does industry identify opportunities to partner with schools and decide which partnerships to embark on?*

5.3 *How do schools evaluate the outcomes from their partnerships with industry?*

5.4 *How does industry evaluate the outcomes from their partnerships with schools?*

5.5 *How can industry identify target outcomes before they commence a partnership or program? How do they measure success? Are there good examples?*

5.6 *Does industry collect data in relation to their partnerships with schools that would be worth sharing?*

5.7 *What are the barriers to implementing a unique student identifier and how can they be overcome?*

5.8 *Is there any workforce data industry can contribute to improve our understanding of the STEM pipeline, for example around workforce planning or recruitment activity?*

5.9 *How do different funding arrangements for school-industry partnerships impact on their success, for example are there benefits of long term or short term arrangements?*

Introduction

The future will be shaped by what and how we teach

Australia is blessed with fertile land and abundant resources. We have enviable industries that are among the best in the world. We have transitioned to a predominantly services economy while preserving GDP growth for a world record 26 consecutive years.

There are many factors that have contributed to this record but none more important than our excellent education system that has shaped and taught the professionals, tradespeople, researchers and leaders who have built our economy, embraced our multicultural society and preserved our environment.

Our collective futures will continue to be shaped by the quality and effectiveness of our education system. What and how we teach our children has a fundamental impact on every part of society – our living standards, our aspirations, our environment and our community. It is a topic worthy of our serious attention.

There is a growing concern that training the skilled workforce of the future will present challenges for our education system.

There are many reasons for this concern.

As our industries change, so do the skills they require. There is a rising discourse about what automation means for the human workforce. Once the realm of science fiction, artificial intelligence and robots are now actively displacing and re-shaping jobs. Digital technology is sweeping every aspect of our lives and a growing portion of the existing workforce will struggle to adapt.

The policy response by the developed world is to invest heavily in education, research and commercialisation. What this means for Australia is that we must also adapt, not only to increase our competitiveness but also to maintain our current standards. If the treadmill is moving faster, then so must we or we risk falling off.

International tests present a picture of declining achievement in our schools across science, mathematics and literacy, and the number of high achievers is also falling. Increases in school funding have not reversed the trend, suggesting that school funding needs to be better targeted.

The schooling system has also been influenced by broader changes to the university sector. Growing societal expectations and the 'massification' of our university system has led to perverse outcomes in our schooling system. As more students are encouraged to commence university, universities have dropped their prerequisites and lowered their entry standards with a result that fewer students are choosing to enrol in challenging subjects in senior secondary school.

Whilst we need to be alert to the workforce challenges, we should not over-react

History has shown that as jobs disappear new jobs are formed. The reasons are complex, ranging from societal drivers, changing consumer interests, human ingenuity, rapid changes in technology, emerging opportunities and the fundamental interest of well-educated people to find challenging occupations.

Australians are capable, adaptable and flexible. We have experienced and successfully adapted to the enormous transition of 24.1% of the workforce being employed in farm industries in 1911 to fewer than

2.5% today. We have coped with the massive decline in the numbers employed in manufacturing since the Second World War. We have created new industries such as computer software development. In some industries such as banking there has been reinvention leading to increased net employment despite disruptive changes to business models.

Likewise, we should not under-react.

The STEM Partnerships Forum (the Forum) was constituted to bring together industry and education leaders to address the challenges and capture the related opportunities. Industry has always played an important role in the education system.

The focus of the Forum is school education, but it is important to remember that tertiary education institutions (including higher education and vocational education and training) are a vital part of the STEM education pipeline with the expertise required to help schools communicate important messages about STEM to their students and teachers. Work that the Forum undertakes needs to consider how these institutions can influence, share their expertise and partner with schools to achieve this aim.

Our education system should not simply aim to produce future workers – education is essential in developing well-rounded individuals who have the skills to lead full and productive lives.

This Forum aims for industry, schools and policy makers to work together to ensure that the students of today and tomorrow are equipped with the knowledge and skills they will need in the workforce.

What is STEM? Tricky terms in science education

In developing this issues paper, it has become obvious that there are a range of different approaches to describing 'STEM' and the sorts of skills students need for the future. The Forum has used the following terms and definitions throughout this paper:

STEM disciplines

Used when referring to all the STEM disciplines (Science, Technology, Engineering and Mathematics).

STEM education

A general term to mean the disciplines, an integrated approach that increases interest in STEM related fields and improves students' problem solving and critical analysis skills.

Individually by discipline name: Science, Technology, Engineering, Mathematics

When referring to a specific discipline.

STEM skills

Skills and capabilities developed directly through the study of the disciplines of Science, Technology, Engineering and Mathematics.

Information Communication Technology (ICT) skills

Used to describe the skills needed for navigating the technological world. The ability to use a range of digital platforms and programs to communicate, market, transact, find information, solve problems or complete tasks. ICT is also about knowing how to act safely and respectfully online.

Digital technologies skills

Skills that move beyond ICT skills; designing and creating digital solutions that solve problems. The knowledge and skills of the underlying concepts of information systems, data, and computer science. Digital technology skills include coding, networks, robotics, algorithms, and computational thinking.

21st century skills

Generic term to encompass all the general capabilities, transdisciplinary skills, personal attributes and employability skills such as communication, creativity, critical thinking, personal and social capability, ethical understanding, collaboration and team work.

Skills for the 21st century – "everything must change so that everything can stay the same"

It is believed the Italian novelist Giuseppe di Lampedusa first said 'everything must change so that everything can stay the same'. We look around and everything seems to be changing. Demands in the workplace, subject choices at school, classroom technologies and near infinite information at the click of a smartphone button. The one thing we want to stay the same is the best possible outcomes for Australia's children. If we do not change to meet emerging challenges, our quality of life, and the ability of young people to capitalise on future opportunities will be compromised.

The skills needed by our young people in primary and secondary school today are evolving. Youth are exhorted to be flexible, agile, good problem solvers and critical thinkers. Our challenge is to translate these demands into skills that students can acquire, that teachers are able to teach and that the system is able to assess.

The evolving skills requirements are often erroneously called out as a need to abandon the investment in teaching the fundamental disciplines of English and mathematics in favour of other skill sets.

This would be a mistake because, in our rapidly changing world, the fundamentals are more important than ever. The fundamentals are the foundation for everything else. The evolving industrial landscape and the accompanying change in required skill sets overlay the fundamentals and are visible in the needs of the everyday workforce.

Beyond the basics of literacy and numeracy, the flexibility to adapt knowledge to new problems comes from a confidence in one's knowledge of a discipline. This confidence can only be acquired through a thorough understanding of the basic principles and core knowledge underlying the discipline.

An able student of mathematics will be able to apply mathematical principles whether faced with designing a new financial product or a 3D printed part for a medical application.

Likewise, a capable student of English literature will be able to analyse and interpret classical literature in our current context and deliver a speech on the state of our education system.

The Forum is convinced that the underpinning requirement for ensuring a strong and fair economy in Australia with worthwhile jobs is to train our future workforce to have both discipline knowledge and the skills to use and expand this knowledge.

Our teachers and our system must encourage and support our students to have and realise high aspirations. This will partly be achieved by opening their eyes to the real-world problems to be solved and the job opportunities that await them as technology evolves. We must avoid discouraging them by focusing on the jobs that will disappear.

We must provide our young students with deep knowledge, continuous learning skills, cooperation skills and facility with evolving digital technologies.

Teachers are central

If the education system is a complex machine comprised of many interconnected parts that, working in concert, provide the student with the education that they require, then teachers are the central cog around which all else revolves.

It is by teachers' application of the right combination of discipline knowledge and pedagogy that the student is able to internalise information, convert it to knowledge and apply it to the desired context. Teachers can inspire students and nurture their spark.

This role of imparting knowledge and inspiring interest requires the teacher to be confident in his or her discipline and teaching practice, and to maintain that knowledge through continuous improvement and training. To this effect, the system must support our teachers with high-quality professional development.

We must further support our teachers by providing them with accessible information repositories to help them navigate the deluge of information.

Industry already helps. There are an enormous number of ways in which firms across Australia, ranging in size from individuals to the largest employers in the country, are contributing already.

Industry contributes through the provision of resources, providing work experience opportunities and a vast range of programs supporting schools, teachers and students.

Improving the quality of STEM education will depend on governments, industry and schools having a shared understanding of our national workforce needs. Being able to translate this into a local context will ensure both schools and industry get the greatest return on their investment of time and resources.

Industry's contribution can be optimised through a national approach to engagement and through the development of tools and resources that will contribute to the design of STEM initiatives and activities, evaluation and delivery. These tools should be optional, to help where appreciated. If they were to become compulsory they would equally stifle innovation in some cases as they support it in others.

Investment in educational excellence is required across all disciplines. This report is focussed on the STEM disciplines but this focus should not be interpreted as a statement of relative importance as a strong understanding of humanities and arts is vital to help young people navigate a rapidly evolving world.

And within the STEM disciplines, this report is focussed on the contribution that industry can make. We acknowledge that successful education of our students is much broader than this.

It is useful to see how other countries are benefiting from taking action.

For example, in the UK in 2017, in the final two years of secondary school (known as A-Levels) 33% of all students are studying STEM subjects including relatively new subjects such as computing, up from 25% a decade ago. Mathematics is the most popular A-level subject.

Contributing factors are the promise of well-paid jobs, the pitch by successive governments and businesses that STEM skills will be increasingly needed in the future economy, and curriculum reform that has made the subjects tougher rather than easier. That is, by raising the bar, they raised aspirations.

Scope and Impact

The observations contained within this paper are broad and go beyond the realm that industry can directly support. They are included here because they contribute to the overall picture of STEM education and the overarching need for a well-educated, well-rounded future workforce. These observations help us understand the context in which we must operate.

Provisional recommendations within this report focus on areas where industry can make a direct or indirect contribution to STEM education and engagement. These provisional recommendations are intended to have measurable outcomes and impact.

The questions in this report will be used to guide consultations, help us to further understand the context and to refine the recommendations so that they address the needs of all stakeholders.

Chapter 1: STEM in Education and Work

STEM skills and knowledge will unlock the jobs of the future

Jobs in STEM fields and skills developed though the STEM disciplines are of critical importance to Australia's future prosperity, with a recent report into Australia's fastest growing industries highlighting the need to improve Australia's STEM capability.[1] It is important to note, however, that the discourse should not just be about the need for more workers in STEM careers but rather about the importance of ICT skills and STEM skills across all careers.

STEM skills are a vital component of research and development and emerging knowledge-based industries. They ensure that established industries, such as agriculture, provide a competitive advantage. Messages about the shortfall of STEM workers, however, are often based only a shortage in some of the fast-growing technology fields such as data analytics, cloud computing and computer security, rather than in STEM disciplines across the board.[2]

What is not always clear is that STEM skills are more broadly beneficial and transferable across industries, from agriculture to mining and art to medicine, with employers calling for more employees with digital technology skills and knowledge and valuing 21st century skills such as the ability to think critically and solve problems.[3]

Another common theme in discussion on the future of the workforce is the risk of automation. A UK study famously stated that 47% of US jobs are at high risk of being replaced by machines in the next decade or two.[4] However, a more recent study, sharing a co-author with the original, revised this down to 19%, and an OECD study estimates this at nine percent for OECD countries.[5] While these numbers still signify an important change in the future of work, we should focus on how jobs will change, not worry about wholesale job loss. Automation will affect the nature of work in Australia, and our education system must respond.

> Predictions about how different the future labour market will look can be a source of anxiety for some, however, the Forum believes increasing globalisation, automation and flexibility should be seen as an opportunity rather than a threat.

Interestingly, a national survey of Australian youth conducted in April 2017 found 49% of young people don't feel threatened at all by automation and 44% don't feel threatened at all by outsourcing.[6] This indicates a level of optimism, but also perhaps a lack of accurate information about future job markets.

[1] National Centre for Vocational Education Research (NCVER) 2014, *Readiness to meet demand for skills: a study of five growth industries,* NCVER, Adelaide. p.27

[2] Steve Lohr 2017, Where the STEM Jobs Are (and Where They Aren't [Online] New York Times. Available at: www.nytimes.com/2017/11/01/education/edlife/stem-jobs-industry-careers.html [Accessed 8 November 2017].

[3] Foundation for Young Australians (FYA) 2017, *The New Work Smarts: Thriving in the New Work Order,* FYA, Melbourne. p.23

[4] Frey, C, Osborne, M 2013, *The Future of Employment: How Susceptible are Jobs to Computerisation*, Oxford University

[5] Arntz, M, Gregory, T, & Zierahn U 2016, 'The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis', *OECD Social, Employment and Migration Working Papers, No. 189*, OECD Publishing, Paris; Bakhshi, H, Downing, J, Osborne, M. and Schneider, P 2017, *The Future of Skills: Employment in 2030*. Pearson and Nesta. London.

[6] Bisson, R & Stubley, W, 2017, *After the ATAR – Understanding how GenZ Transition into Further Education and Employment*, Year13, Australia. p. 30

Better information about future job markets could therefore significantly affect the career decisions of young people.

Flexibility will be increasingly required in emerging careers, and it is expected that today's young people will change jobs 17 times across five different careers in their working lives.[7] The ability to make these transitions will depend, in part, on the skills that young people acquire at school. Given the diversity of skills young people will require to thrive in the future workforce, it is essential that we educate them about the transferability of STEM discipline skills across many different careers and the opportunities they can help unlock.

The demand for STEM skills is not just about the need for more workers in STEM jobs, but rather about the benefits and transferability of STEM and ICT skills across all careers and in life generally.

Working together to improve STEM education in schools

A common message from media, industry, governments and school systems is the need for Australia to improve STEM education. In December 2015 all education ministers endorsed the *National STEM School Education Strategy 2016-2026* to lift foundational skills in STEM disciplines, develop mathematical, scientific and ICT skills, and promote the development of the 21st century skills of problem solving, critical analysis and creative thinking. [8]

The Forum was established by the COAG Education Council to facilitate more efficient and effective partnerships between schools, industry and the tertiary education sector as a national action under the strategy. The Forum includes members from schools, business and industry, and the tertiary education sector.[9]

While studying STEM subjects can assist in the development of 21st century skills such as critical thinking, communication and digital skills, the Forum has chosen to focus on discipline knowledge in STEM subjects, noting that these skills can also be gained through study in other fields, such as humanities and the arts.

How are Australian students performing in STEM education?

National and international assessment data show a concerning and consistent long term trend of student achievement in STEM disciplines either stagnating or declining.

[7] FYA 2017, *The New Work Smarts: Thriving in the New Work Order,* FYA, Melbourne p.3
[8] Further detail on the *National STEM School Education Strategy 2016-2026* is at Appendix A.
[9] A full list of Forum members is at Appendix B.

Nationally, the 2016 National Assessment Program Literacy and Numeracy (NAPLAN) results show no general increase in the rate of student improvement between Years 3, 5, 7 and 9 in numeracy, although some isolated student cohorts and year levels in some states and territories show slight increases.[10]

Students from families with limited education perform less well than those whose parents have a degree, the gap being around 10 months in Year 3, growing to two and a half years by Year 9.[11]

Internationally, Australian 15 year olds participating in the Organisation for Economic Cooperation and Development (OECD) Programme for International Student Assessment (PISA) showed a significant decline in mathematical literacy between 2003 and 2015 from 524 points to 494 points.[12] As well as an overall decline, the proportion of low performers increased from 14% to 22% over this time period, and the proportion of high performers decreased from 20% to 11%.[13]

Mathematics results for Australian Year 4 students participating in the 2015 Trends in International Mathematics and Science Study (TIMSS), conducted by the International Association for the Evaluation of Educational Achievement (IEA), were similar to results in 2007, and Year 8 results were no different from the corresponding score in 1995.[14] The declining mathematics performance in PISA was not replicated in TIMSS, but there has instead been stagnation over two decades.

In science, PISA results declined significantly in scientific literacy between 2006 and 2015, with a drop in the performance of Australian students from 527 points to 510 points.[15] Again, the proportion of low performers increased, from 13% to 18% over this time period, and the proportion of high performers decreased from 15% to 11%.[16] Science results from TIMSS 2015 for Year 4 and Year 8 students were not significantly different to that of TIMSS 1995[17]. Once again, the decline in science performance seen in PISA was not replicated in the TIMSS results, but results have remained stagnant.

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' socio-economic status compared to the OECD average of 12.9%.[18] Australia's rate of improvement in relation to equity is well below the OECD average.[19]

Put another way, 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.

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[10] Australian Curriculum, Assessment and Reporting Authority (ACARA) 2016, *National Assessment Program – Literacy and Numeracy Achievement in Reading, Writing, Language Conventions and Numeracy: National report for 2016,* ACARA, Sydney. p.357

[11] Goss, P, Sonnemann, J, Chisholm, C, Nelson, L, 2016, Widening gaps: what NAPLAN tells us about student progress, Grattan Institute, pp. 26-27

[12] Thomson, S, De Bortoli, L & Underwood, C 2016, *PISA 2015: A first look at Australia's results,* ACER, Victoria. p.21

[13] Thomson, S, De Bortoli, L & Underwood, C 2016, *PISA 2015: A first look at Australia's results,* ACER, Victoria. p.23

[14] Thomson, S, Wernert, N, O'Grady, E & Rodrigues, S 2016, *TIMSS 2015: A first look at Australia's results*, ACER, Victoria. p. vi

[15] Thomson, S, De Bortoli, L & Underwood, C 2016, *PISA 2015: A first look at Australia's results,* ACER, Victoria. p.11

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

[17] Thomson, S, Wernert, N, O'Grady, E & Rodrigues, S 2016, *TIMSS 2015: A first look at Australia's results*, ACER, Victoria. p.49 & p.67

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

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

More worryingly, fewer disadvantaged Australian students are high performers than a decade ago.[20] This is not just a factor of student background: disadvantaged schools in Australia report having fewer resources than advantaged schools. This disparity in Australia is much higher than the OECD average, and no country in the OECD reports a bigger difference in the availability of adequately qualified staff between advantaged and disadvantaged schools.[21]

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.

Results from the latest TIMSS shows the achievement of Indigenous Australian students lags significantly behind that of non-Indigenous Australian students, and that this gap has changed little over 20 years. In Year 4 mathematics in 2015, 61% of Indigenous Australian students did not achieve the Intermediate international benchmark, compared to 28% of non-Indigenous Australian students.[22] A similar gap is reflected in Year 4 science achievement where 53% of Indigenous Australian students did not achieve the Intermediate international benchmark compared to 23% of non-Indigenous Australian students.[23]

Sixty eight percent of Indigenous students did not achieve the Intermediate international benchmark for Year 8 Mathematics in 2015, compared to 34% of non-Indigenous students, and 58% of Indigenous students compared to 30% of non-Indigenous students did not achieve the Intermediate international benchmark for Year 8 Science.[24]

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.[25] 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.[26]

There does not appear to be a significant overall achievement gap between girls and boys in STEM in Australia, with girls and boys achieving similar results in STEM subjects in PISA, TIMSS and NAPLAN. The bigger issue for girls seems to lie in aspiration and engagement: girls, including top performers, are less likely than boys to expect to work in a science-related occupation.[27]

[20] Organisation for Economic Cooperation and Development (OECD) 2016. *PISA 2015 Results (Volume I): Excellence and equity in education*. OECD Publishing, Paris, p.222
[21] Organisation for Economic Cooperation and Development (OECD) 2016. *PISA 2015 Results (Volume I): Excellence and equity in education*. OECD Publishing, Paris, p.231
[22] Thomson, S, Wernert, N, O'Grady, E & Rodrigues, S 2016, *TIMSS 2015: A first look at Australia's results*, ACER, Victoria. p.24
[23] Thomson, S, Wernert, N, O'Grady, E & Rodrigues, S 2016, *TIMSS 2015: A first look at Australia's results*, ACER, Victoria. p.61
[24] Thomson, S, Wernert, N, O'Grady, E, Rodrigues, S 2017, *TIMSS 2015: reporting Australia's results,* ACER, Victoria. p.xviii & p. xx
[25] Thomson, S, De Bortoli, L & Underwood C 2017. *PISA 2015: Reporting Australia's results*. ACER, Victoria. p.51
[26] Thomson, S, De Bortoli, L & Underwood C 2017. *PISA 2015: Reporting Australia's results*. ACER, Victoria, p.51
[27] OECD. 2016. *PISA 2015 Results (Volume I): Excellence and equity in education*. PISA, OECD Publishing, Paris, p.116

How engaged are Australian students in STEM education?

There are a number of factors associated with students' aspirations for STEM careers, 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 in primary education positively influences later participation in STEM, particularly at senior secondary years.[28]

TIMSS 2015 results noted that in general, students who indicated they liked mathematics or science, were confident learning it, valued it and felt they were taught in an engaging way, scored more highly than students who did not.[29]

PISA 2015 results also showed that in Australia, males tended to be more interested in science, to enjoy science and to have higher self-efficacy in science compared to female students. Males were four times more likely to expect to work in science, engineering or information and communication technology professions than their female peers.[30]

The Australian Council for Educational Research has noted a decline in the number of STEM-qualified female students who decide to follow through on their education to enter STEM professions.[31]

Senior Secondary STEM discipline enrolments

Senior secondary (Year 11 and Year 12) enrolment data provide a rich source of information about the status of engagement with STEM in Australia. Enrolment rates in mathematics and science learning areas have remained steady from 2010 to 2013:

- **Mathematics participation** declined from 77% of Year 12 enrolments in 2002 to 73% in 2006, and from 2006 to 2013 has remained steady at around 73%.
- **Science participation** increased from 55% in 2002 to 60% in 2004, then decreased to 53% in 2008. Enrolments in science remain steady at 51% from 2010 to 2013.[32]

This data also shows a higher proportion of males undertaking mathematics than females (around five percent more males than females), while a higher proportion of females than males are participating in science (between three and five percent more females than males).[33]

Using different datasets, analysis of science and mathematics participation at the subject level shows, between 1992 and 2012, while the total number of students in Year 12 increased by around 16%, participation rates for most science and mathematics subjects fell, with the exception of Earth Science and entry level Mathematics. Most of this decline occurred prior to 2001.[34]

It is important to note that the data in Tables 1 and 2 below show enrolments at the subject level rather than the learning area level. Students may be enrolled in more than one subject within a learning area,

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

[29] Thomson, S, Wernert, N, O'Grady, E & Rodrigues, S 2016, *TIMSS 2015: A first look at Australia's results*, ACER, Victoria. p.xxiii

[30] Thomson, S, De Bortoli, L & Underwood C 2017. *PISA 2015: Reporting Australia's results*. ACER, Victoria p.223

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

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

[33] 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]

[34] 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

for example physics and chemistry in the science learning area, or elementary and advanced mathematics in the mathematics learning area. The participation rates for the learning areas reported above only count students once per learning area.

Table 1: Proportion of Year 12 enrolments in Science 1992-2012[35]

Subject	1992	2012
Biology	35%	25%
Chemistry	23%	18%
Physics	21%	14%
Earth Sciences	1.3%	1.6%

Table 2: Proportion of Year 12 enrolments in Mathematics 1997-2012[36]

Subject	1997	2012
Elementary (estimated)	39%	52%
Intermediate	27.2%	19.6%
Advanced	13.6%	9.5%

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 subjects that students are enrolling in.

The concern that students are electing to study less challenging STEM subjects (particularly mathematics) is echoed by the Australian Mathematical Sciences Institute.[37]

Optimising an Australian Tertiary Admissions Rank (ATAR)

The ATAR is a rank awarded to students who complete their senior secondary certificate (in all states except Queensland) and is used to determine university entry. Students are often more concerned about getting into the university of their choice than being adequately prepared for the degree.[38] Universities are autonomous and determine the ATAR score required for each one of their courses and any subject pre-requisites.

Of the 40% of students who gain entry to university following secondary school, around three quarters do so via an ATAR.[39] The Australian Government's university reforms will look in part at improving the transparency of admissions processes of universities.

Our concern here is 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

[35] 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

[36] Wienk, M 2017. *Discipline Profile of the Mathematical Sciences 2017,* AMSI (University of Melbourne), Melbourne, p.21

[37] Wienk, M 2016. *Discipline Profile of the Mathematical Sciences 2016,* AMSI (University of Melbourne), Melbourne, p.12

[38] 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

[39] Department of Education and Training, Selected Higher Education Student Data, unpublished.

the time demands of studying intermediate mathematics.[40] 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 Years 11 and 12 subjects students need 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 at the school level when providing advice to students and their families about subject choices. These issues are heightened by the lack of pre-requisites for entry into some university STEM discipline courses as this also sends negative messages to schools, career advisers and parents on the need to study more difficult subjects.

Vocational Education and Training for secondary students

Another way of measuring student engagement with STEM education is by looking at the proportion of secondary school students who are undertaking vocational education and training (VET) in a STEM subject. Students can study VET as part of their school education program. VET enables students to gain credit points towards their Senior Secondary Certificate of Education, while at the same time gaining or working towards a nationally recognised qualification. Some states and territories also allow credit points from VET subjects to count towards a student's ATAR.

VET students can gain a nationally recognised qualification for many types of employment, and specific skills to help them in the workplace. However, VET education is heavily misunderstood by youth and the people and groups that influence them. VET is often perceived as a trade-focused education system and many young people are unaware of the breadth of subjects and courses VET offers. With schools, career advisers and parents encouraging students to work towards university, VET is often forgotten, despite the fact that VET courses can provide a more specialised education than some university degrees.

The proportion of secondary school students undertaking one or more VET subjects in a STEM related discipline increased between 2011 and 2016. The highest proportional increase was in the Information Technology field, as shown in the graph below.

[40] Nocholas, 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, Pg. 39.

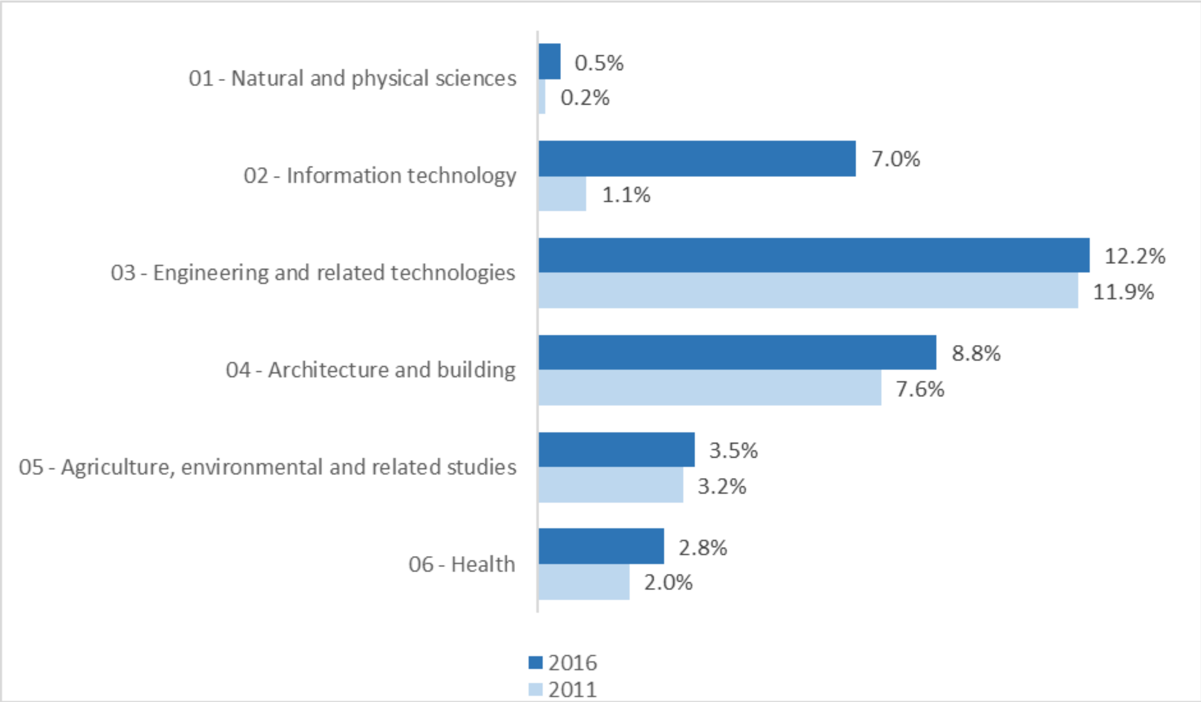


Figure 2: Proportion of 15-19 year old Secondary Student enrolments in VET subjects by STEM related field of education 2011-2016[41]

There are higher proportions of remote secondary students undertaking VET in STEM related fields of education at 46% compared to 29% in major cities.[42]

The research also indicates a higher proportion of males than females who take VET subjects in secondary school do so in STEM related fields of education, with the exception of Health. The proportions are particularly obvious in engineering and related technologies and architecture and building, as shown in the graph below.[43]

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

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

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

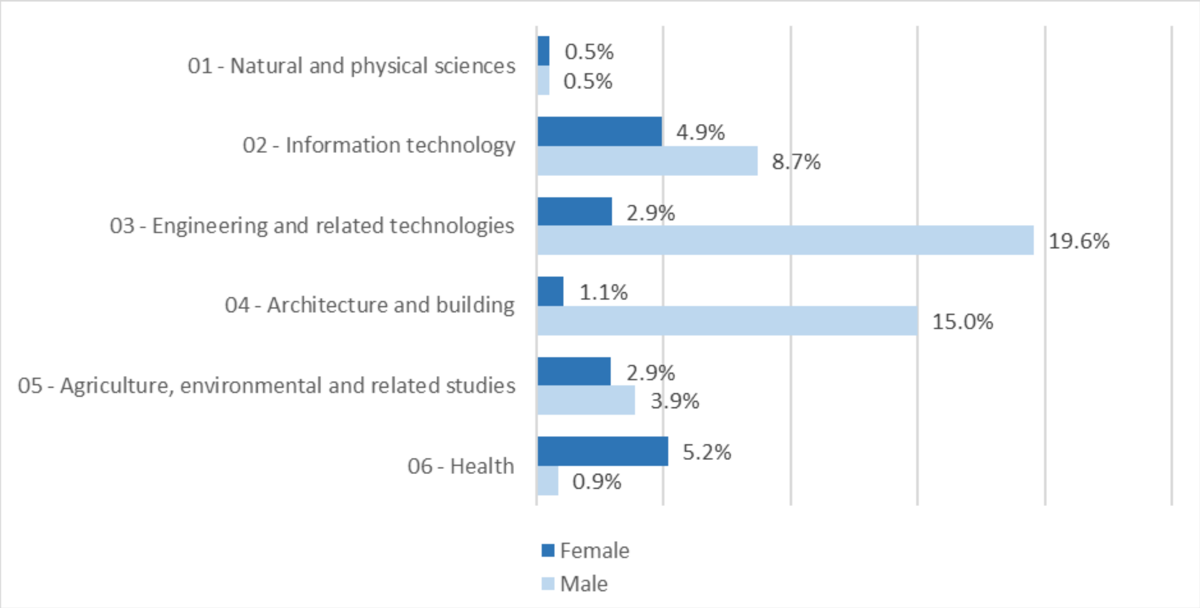
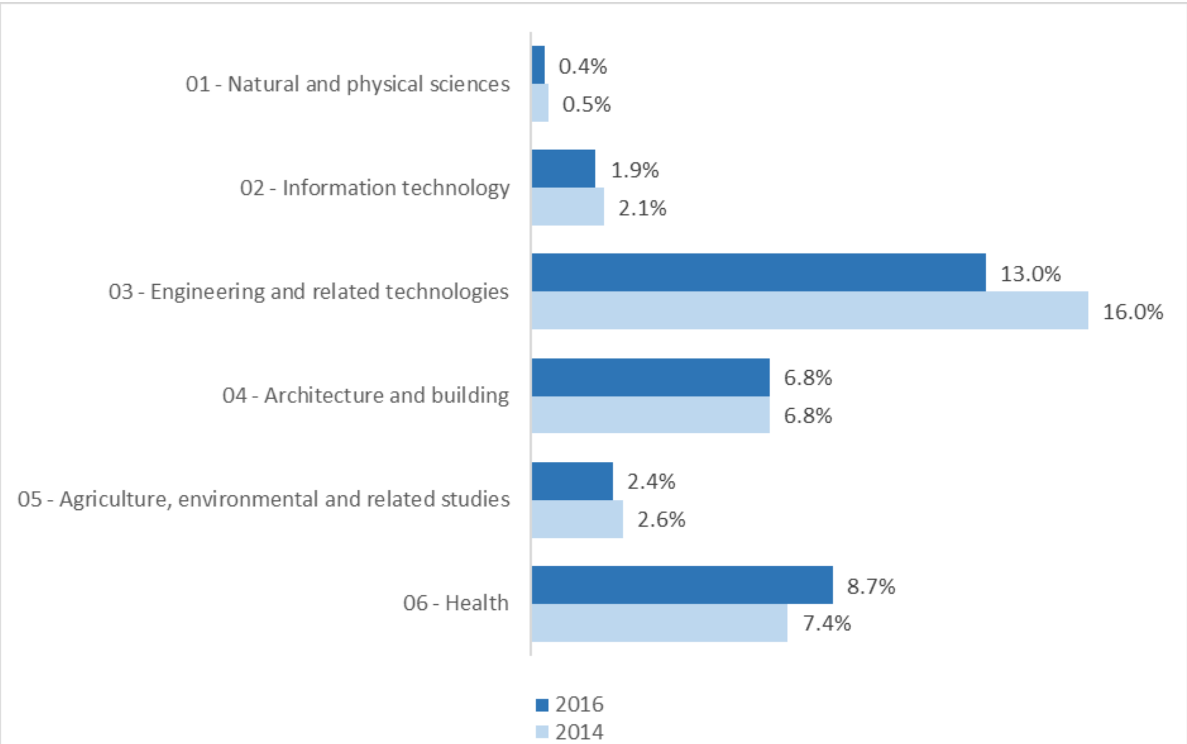


Figure 3: Proportion of 15-19 year old Secondary Student enrolments in VET subjects by STEM related field of education by gender in 2016[44]

What does this mean for tertiary education and training?

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.

Noting that data for total VET activity was not collected until 2014, between 2014 and 2016 the proportion of VET enrolments declined slightly in all STEM related fields of education, with the exception of health, as shown in the graph below.[45]



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

[45] NCVER 2017, *Australian vocational education and training statistics: Total VET students and courses 2016,* NCVER, Adelaide. p.16

Figure 4: Change in proportion of enrolments in the Total VET sector (excluding secondary school VET) by STEM related field of education 2014-2016[46]

Between 2011 and 2016, the proportion of university enrolments in STEM related fields of education increased in natural and physical sciences, information technology and health, but decreased in architecture and building and agriculture, environmental and related studies, as shown in the following graph.[47]

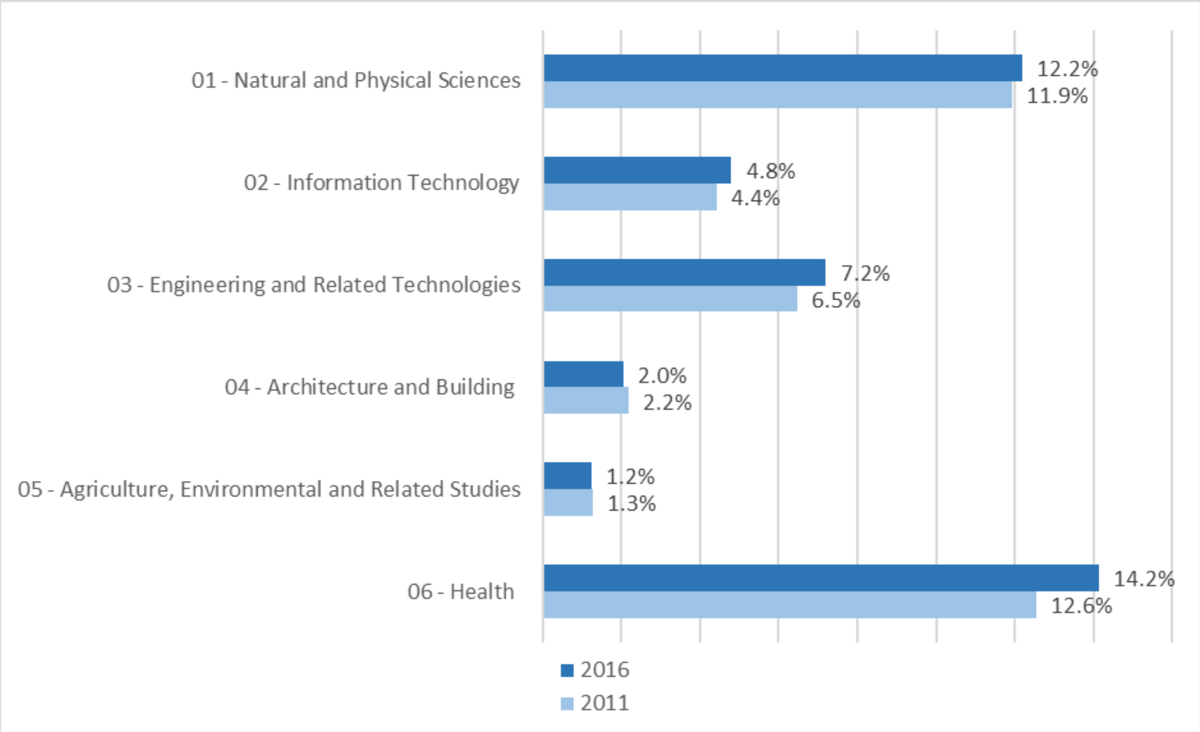


Figure 5: Change in proportion of enrolments (measured by Equivalent Full Time Study Load) in higher education by STEM related field of education 2011-2016[48]

[46] NCVER, *National VET in Schools Collection 2016* and *National VET Provider Collection 2016, VOCSTATS* [Online] Available at: http://www.ncver.edu.au/resources/vocstats.html. [Accessed: 22 November 2017]

[47] Australian Government Department of Education and Training, Higher Education Student Data [Online] Available at: https://www.education.gov.au/student-data. [Accessed: 13 October 2017]

[48] Australian Government Department of Education and Training, Higher Education Student Data [Online] Available at: https://www.education.gov.au/student-data. [Accessed: 30 November 2017]

Chapter 2: The role of industry

In 2015-16 large businesses in Australia invested a total of nearly $3 billion in education and research.[49] While this covers tertiary education and research as well as school education, the scale of this investment is significant. Ensuring it is invested strategically has the potential to make a real difference to student outcomes.

Effective school-business relationships provide mutual benefit by enhancing career aspirations, work readiness and skills development, creating skilled labour resources, as well as providing opportunities for staff development.[50] However, depending on the size, location and particular industry sector of a business wishing to enter into a partnership with schools, their objectives may differ. For the partnership to be effective for the participating partners, the purpose must be clearly identified.

The objectives of different types of businesses, including those of differing size and location, will vary in school-industry partnerships. Having a strong understanding of the objectives and outcomes being sought is an essential first step in any education partnership.

Industries already partner with schools to achieve great things

There are a large number of existing projects funded by business and industry with a focus on boosting STEM engagement and participation in schools.

The Office of the Chief Scientist recently launched the STARportal, an online one-stop-shop for parents and teachers that houses over 450 STEM activities for students developed by the Australian Government, state and territory and non-government education authorities, and the private sector. Many activities are free, and range from extra-curricular STEM competitions to co-curricular activities for use in class.

The STARportal was developed in partnership with industry. The partners are the Australian Mathematical Sciences Institute, BHP Billiton Foundation, the Commonwealth Bank of Australia, Engineers Australia and Telstra.

On a larger scale, funding from industry can be instrumental in developing effective, relevant and engaging STEM programs for students, with the most effective models also being sustainable and scalable. For example, the seed funding Google provided to the University of Adelaide was critical in establishing the highly successful massive open online courses for primary and secondary school teachers on implementing the Australian Curriculum subject Digital Technologies. The success of this initiative led the Australian Government to fund its expansion under the National Innovation and Science Agenda.

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[49] Burns, W, Wang, S & Arias, D 2017, *Business Giving and Volunteering. Giving Australia 2016,* Department of Social Services, Canberra. p.36

[50] PhillipsKPA Pty Ltd, Department of Education, Employment and Workplace Relations 2010, *Unfolding opportunities: a baseline study of school-business relationships in Australia, Final Report,* PhillipsKPA, Victoria, pp.1-3

There are many existing models of industry partnerships with schools. As well as funding promising initiatives, industry can also offer expertise in their field and a knowledge of the real-world applications of STEM disciplines. Some partnerships are benefitting from involvement with the tertiary education sector, drawing on their expertise in both education and research and development. One example of interest is a recently announced partnership between RMIT and Apple, which will see the university offer courses in app development to school students, teachers and university students using Apple's SWIFT programming language.

Building on existing activities

The Forum's work builds on a wealth of existing research and effort to bring schools and industry together. The work of the School-Business Roundtable in 2012, for instance, provides an excellent basis for building a more strategic national approach to school industry partnerships that will support improved student outcomes and deliver a more capable workforce that can meet the challenges of the future.

The Roundtable developed a useful foundation for best practice engagement between individual schools and businesses, undertaking a baseline study of the types and scope of existing relationships, and looking at how to increase and improve the quality of relationships. It identified guiding principles for these relationships and provided accessible advice to schools and businesses on how to evaluate the impact of these relationships.[51]

> While 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, the proliferation and varying quality of existing activities can create confusion for both schools and industry.

The Forum's recommendations will shift the focus from individual schools and businesses to ensuring the plethora of existing activity is undertaken in a strategic way that aligns with the broader needs of the education system and the future workforce at a national level. The intention is to focus on quality, supporting proven programs and initiatives and filling genuine gaps in the educational landscape.

Outcomes from bringing industry and educators together

The biggest impact on student engagement, participation and achievement in STEM and the flow on effects in the future labour market will be achieved by tertiary institutions and education authorities working together with industry to maximise and amplify these efforts.

The Forum has met a number of times since it was established in May 2017, including face to face meetings and smaller teleconferences. Members have discussed overarching principles to guide their work and the long term outcomes to which their work should contribute. Given the many different

[51] Business-School Connections Roundtable 2013, *Realising Potential: Businesses Helping Schools to Develop Australia's Future*, 2013, Department of Education, Employment and Workplace Relations, Canberra. pp.5-6

contexts of industry such as type, size and location, it is important the Forum focus on a small number of recommendations with scale and impact that can be implemented in the short to medium term.

Forum members recognise the central importance of teachers and the need for genuine, equal partnerships between schools and industry. The long term outcomes the Forum is working towards include:

- improving the way Australians look at and think about STEM,
- a highly skilled-workforce that is deeply STEM literate,
- setting students up for success in the careers of the future,
- retaining and energizing future STEM leaders, and
- meaningful engagement between industry and parents, teachers and students.

Workstream areas and how they interconnect

At the inaugural meeting of the Forum in May 2017, members agreed to progress work across three areas, including:

- teacher professional development,
- careers awareness, and
- outcomes and impact.

Each of the workstreams has a discrete purpose, however they are all inter-related, having important synergies and connections. The following chapters outline the initial observations and issues identified by each of the workstream areas and inform the questions for consultation and provisional recommendations.

Chapter 3: Teacher Professional Development

Given that teachers are the biggest in-school influence on student achievement, the Forum has identified teacher professional development and support for teachers as a key avenue for industry to contribute to improving the quality of STEM education.

While industry have the expertise that teachers and schools require to ensure real-world links in education, they are not education experts, and any partnerships to promote teacher professional development need to be led by educators with the relevant knowledge of curriculum and the demands of teaching in the classroom.

School-Industry partnerships with a focus on teacher professional development should be led by educators, and supported by industry.

Strengthening the pipeline: initial teacher education reforms

In order to become qualified in Australia, a teacher must complete at least four years of university study, including an accredited initial teacher education program.[52]

A major review of initial teacher education was undertaken in 2014 with the resulting report, *Action Now: Classroom Ready Teachers*, forming the basis of a sustained reform effort across Australia to improve the quality of teacher training. As a result of this, in 2015 all Australian governments agreed to new Standards and Procedures for the *Accreditation of initial teacher education programs in Australia.* These Standards set out mandatory content requirements for secondary school teachers, including discipline specific requirements 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. This means new primary school teachers will have additional depth of understanding in their chosen learning area, with expert content knowledge, pedagogical content knowledge and highly effective classroom teaching in their area of specialisation.

Staying up to date in the classroom

Once teachers obtain full registration with their relevant state or territory education authority, they are required to renew it periodically. The process for maintaining and renewing registration, including the time period for renewal and the number of hours of professional development required, differs between jurisdictions.

All Australian governments have acknowledged the importance of professional development in improving the knowledge and practice of teachers through the *Australian Charter for the Professional*

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[52] Australian Institute for Teaching and School Leadership (AITSL) [Online] Available at: www.aitsl.edu.au/teach/start-your-career/registration/nationally-consistent-teacher-registration. [Accessed: 27 September 2017].

Learning of Teachers and School.[53] The Charter, endorsed in 2012, seeks to change professional practice in ways that improve the learning, engagement and wellbeing of every Australian student.

While all jurisdictions require teacher professional development to align to the *Australian Professional Standards for Teachers*, there is no requirement for teachers of particular subjects, such as mathematics or science, to undertake a specified number of hours of professional development in these areas. Generally, it is up to the teacher, in the context of the school plan and priorities, to identify what professional development they will undertake.

Strategic directions for teacher professional development 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. State and territory governments may invest in large scale programs to meet specific needs, for example, roll-out of a curriculum area or ICT training.

The need for discipline-specific professional development

While it is important that teachers are able to undertake professional development that supports their needs in the context of school priorities, STEM disciplines are rapidly changing. This makes it difficult for teachers to stay informed of the latest research without dedicated time to update their discipline-specific skills. Opportunities for teachers of VET in secondary school settings to maintain their industry currency are similarly important to keep VET courses relevant to the modern workplace. Discipline specific professional development also has the potential to engage and reignite the passions of teachers.

The importance of discipline specific professional development is reinforced by international experience, with a 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."* [54]

High quality STEM discipline professional learning is desirable for all teachers teaching STEM subjects, across primary and secondary schools. However, support may need to be targeted in different ways depending on a range of factors including the teacher's level of knowledge and training in the discipline.

The Australian Council for Educational Research estimates that around 38% of mathematics teachers are teaching out-of-field.[55] There is some evidence that teaching out-of-field is more common in remote schools, schools in low socio-economic status areas and for early career teachers. Out-of-field teaching

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

[54] 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

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

is also reported to be more common in Years 7-10 than Years 11-12.[56] 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. Unless these teachers have continued to engage in discipline-specific professional development, they 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.[57]

The Forum believes that to keep up with technological changes, there should be a greater emphasis on high quality, discipline-specific professional development for teachers of STEM disciplines.

What makes professional development high quality?

To be effective, teachers need deep subject knowledge and knowledge of how to help students learn the specific content.[58] Teachers need to be clear that what they are learning is relevant to the classes they teach and will help improve student outcomes.

Teacher professional development can cover a wide range of activities, such as 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, and progressing through structured material online or face-to-face.

Large scale international studies indicate that while subject matter-focused professional development can improve the disciplinary knowledge of teachers, the most effective forms of professional development also emphasise the way such content can be taught. These types of curriculum-focused and pedagogy-focused approaches include practical strategies for how to organise and deliver the subject matter to students. In other words, it is important to have a good balance between content and practice knowledge.[59]

Research has consistently shown that not all types of professional development are equally effective. Teacher professional development is deemed to be high quality when it includes opportunities for active learning and interaction with colleagues, is for an extended time period and comprises collective

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

[57] Education and Training Committee, Parliament of Victoria 2006, *Inquiry into the promotion of mathematics and science education Final Report*, Parliament House, East Melbourne.

[58] Jensen, B, Roberts-Hull, K, Magee, J & Ginnivan, L 2016, *Not So Elementary: Primary School Teacher Quality in High-Performing Systems*, National Center on Education and the Economy, Washington. p.4

[59] Barrera-Pedemonte, F 2016, 'High-Quality Teacher Professional Development and Classroom Teaching Practices: Evidence from Talis 2013', *OECD Education Working Papers*, No. 141, OECD Publishing, Paris. p.14

learning activities (e.g. communities of practice) or research with other teachers.[60] International studies have shown that traditional forms of professional development such as attendance at short workshops and seminars are more prevalent across countries than innovative and high quality approaches. [61] Innovative and high quality approaches more likely to lead to a change in teaching practice can include teachers' networks, mentoring, classroom observations or building professional learning communities.

What are the barriers to high quality professional development?

The US-based Center on International Education Benchmarking has found that in top-performing international education systems, teachers do not stop learning once they have completed induction and training. School schedules in high performing systems such as Shanghai and Singapore, for example, offer teachers sufficient time to plan, observe one another, collaborate and seek out professional development opportunities that contribute to their ongoing growth.[62] In Australia, lack of time can be an impediment due to timetabling and face-to-face teaching hours. Shanghai is structurally very different to Australia. While they commit significant resources to teacher professional development, their efforts are aided by the average teaching load being only 10-12 hours per week compared to Australia's average teaching load of around 19 hours[63], generally with much larger average classrooms sizes of 34 to 40 students.[64]

Overcoming barriers to accessing and engaging with professional development is an important consideration. In the Australian Council for Educational Research (ACER) report, *Australian teachers and the learning environment: An analysis of teacher response to TALIS 2013,* a lack of incentives for participation in professional activities was identified as a barrier.[65] Having all teachers attend the same training also presents challenges for schools when training occurs during class time.

For rural and remote teachers, geographical isolation may be a barrier in accessing relevant professional development. In these locations, cost, time away from schools and availability of relief staff may place additional pressure on the teacher and school. [66]

What is already happening?

States and territories are all engaged, to varying degrees, with work to progress student engagement with STEM subjects. This occurs through various levels of investment in teacher professional development, scholarships, awards and internships for students and teachers.

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[60] OECD 2017, *How can professional development enhance teachers' classroom practices? Teaching in Focus*, No. 16, OECD Publishing, Paris. P.1

[61] Freeman, C, O'Malley, K & Eveleigh, F 2014, *Australian teachers and the learning environment: An analysis of teacher response to TALIS 2013*, ACER, Melbourne. p83; Schleicher, A. 2016 *Teaching Excellence through Professional Learning and Policy Reform: Lessons from Around the World,* OECD publishing, Paris. p.43

[62] Center on International Education Benchmarking, *Top Performing Countries* [Online] Available at: www.ncee.org/what-we-do/center-on-international-education-benchmarking/top-performing-countries/. [Accessed: 27 September 2017].

[63] OECD 2014, *A teacher's Guide to TALIS 2013: Teaching and Learning International Survey, TALIS,* OECD Publishing, Paris. p.10

[64] Jensen, B, Sonnemann, J, Roberts-Hull, K, & Hunter, A 2016, *Beyond PD: Teacher Professional Learning in High-Performing Systems, Australian Edition,* National Center on Education and the Economy, Washington DC. p30; Liang, X, Kidwai, H & Zhang, M 2016, 'How Shanghai Does It: Insights and Lessons from the Highest-Ranking Education System in the World', in *Directions in Development*, World Bank Group, Washington, DC. p.7

[65] Freeman, C, O'Malley, K & Eveleigh, F 2014, *Australian teachers and the learning environment: An analysis of teacher response to TALIS 2013: Final Report,* ACER, Melbourne. p.92

[66] Australian Human Rights Commission. *Rural and Remote Education Inquiry Briefing Paper: 10. Professional Development* [Online] Available at: https://www.humanrights.gov.au/publications/rural-and-remote-education-inquiry-briefing-paper-22#10.2. [Accessed: 26 October 2017].

According to a recent survey of state and territory teacher regulatory authorities, the Australian Capital Territory offers accredited professional development in STEM education, with 68 programs being offered over 2016 and 2017. In Queensland, online coaching modules have been developed to enhance teacher effectiveness in priority areas including mathematics and science. These modules will be made available to all teachers and pre-service teachers Australia-wide.

Under Education Council's *National School STEM Education Strategy 2016-2026*, Queensland is leading the establishment of a STEM professional learning exchange in partnership with universities and industry. This will support schools and school systems to share best practice and identify areas to help boost teacher confidence and capacity. Queensland has also commenced work on a collection of online exemplar teaching modules in partnership with industry and universities, to assist in the delivery of best practice STEM teaching.

In April 2017, Education Council agreed that the Australian Institute for Teaching and School Leadership (AITSL), in consultation with regulatory authorities and other key stakeholders, would consider a broader evidence base and options for improving the quality of professional development for teachers, including possible national criteria aligned to the *Australian Professional Standards for Teachers*. In undertaking this work, AITSL is taking into account existing state and territory efforts to improve teacher professional development, so that the development of approaches to help guide teacher professional development will complement progress jurisdictions have made so far.

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. Work has commenced in this area, with Education Council asking AITSL 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.

Where can industry further support teacher professional development?

To deliver an effective model of industry-supported professional development in STEM disciplines it will be important to build on existing professional development programs that have already demonstrated a positive impact or elements of success. High quality professional learning with opportunities for ongoing support, collaboration, interaction, connections and communities of practice will be the most successful elements in industry partnerships.

> Industry should focus on supporting or building on existing, effective partnership models with scale and impact.

The University of Adelaide's Digital Technologies Massive Open Online Courses (MOOCs) is a successful example of effective industry supported professional development. 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.

Case Study 1: University of Adelaide's Digital Technologies MOOCs

Initiated by seed funding from Google Australia, the University of Adelaide's Digital Technologies Massive Open Online Courses (MOOCs) offers free online professional development 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 development.

The rate of completion of these MOOCs at 61% is higher than for traditional MOOCs. As of July 2017, 6447 teachers had completed or were actively engaged in a MOOC. Recently, the Australian Government has funded expansion of the program including face-to-face professional learning in every state and territory and a National Lending Library that gives access to equipment for use in the classroom.

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 teacher professional development should be led by educators and supported by industry.

Schools may need guidance on how better to engage with industry. The challenge is that there is no 'one size fits all' approach in partnerships and there are different roles for industry within these partnerships, depending on whether 'industry' means a local business wanting to support a local school, or a larger organisation wanting to make an impact at a national scale to strengthen the quality and qualification of the future workforce.

Industry also 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 subject within the Australian Curriculum. A number of resources in this area already exist, including recent work by the Australian Council of Deans of Science, in partnership with AiGroup, on principles governing successful school-STEM partnerships. The Forum will undertake further work on the tools and resources that will be most useful to schools and industry in the coming months.

Students from lower socio-economic backgrounds, regional areas and underrepresented groups are a priority for Forum members. Therefore, consideration should be given to the types of support or professional development that may be most beneficial and appropriate for teachers of these students. In addition, targeted, culturally aware strategies may be required to engage students from these cohorts.

Meaningful ways in which industry can contribute to professional development include provision of time and funds for professional development, teacher release, and funding teaching fellowships or association memberships. Teacher professional associations and universities can play a key role in discipline specific professional development and can work together with industry to find the best ways to support teachers.

There is scope for industry to contribute much more within their areas of expertise by highlighting where to look for examples of real-world practice. One very practical way that industry can contribute is by providing opportunities for teachers to visit their places of work so that teachers are informed about the real ways in which STEM skills are used in the workforce. They could also provide resources that assist teachers to link real-world practice to lesson content.

The CSIRO's STEM Professionals in Schools program is an example of a successful initiative that facilitates opportunities for industry and schools to achieve a link between the classroom and real-world practice.

Case Study 2: STEM Professionals in Schools Program

Since 2007, the CSIRO have partnered teachers with STEM professionals to enhance teaching practice and help to deliver engaging education in Australian schools. Through this program, Elline, a chemical engineer at Sydney Water, has been partnered with Tanya, a primary school teacher, for three years. Elline visited the school to work with the teachers on a range of entertaining learning activities and to share how the STEM disciplines directly impact the teachers and students' everyday lives.

The pair have collaborated on a range of activities including a robotics project. Elline is able to explain how Sydney Water is using drones to monitor the quality of waterways. These activities have increased Tanya's knowledge in STEM activities and the students' level of engagement and learning outcomes. "... Elline's expertise has been invaluable." Says Tanya.

A further 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 3: STEM X Academy

The Australian Science Teachers Association, Questacon and CSIRO work together to provide STEM X Academy, a five-day residential teacher professional development program. Over five days, teachers experience a diverse range of presentations by scientists and researchers that explore current research, and participate in hands-on workshops about problem solving as a STEM professional.

Following the program teachers can become members of an alumni-led STEM X network. Here they can use their training to continue to develop, implement and share inquiry-based classroom activities.

Recently, a regional model of the program has been trialled to allow regionally-based research organisations to provide teachers with access to genuine STEM-driven research activities.

The STEM X Academy is supported by numerous STEM industry organisations including through scholarships to support teachers who find it difficult to access the program.

Chapter 4: Solving Real-world Problems - Careers Awareness

A central goal of the Forum is to increase awareness not only of the opportunities in STEM related careers, but the opportunities that can be unlocked in other careers by those with STEM skills and knowledge.

Given the challenges in overcoming the negative stereotypes of lab coats and stuffy university lecture halls that the term 'STEM careers' evokes, the Forum believes a more effective approach is to ask students what real-world problems they want to solve, rather than 'what careers they want to pursue'. The discussion can then shift to considering what careers would contribute to solving the problems, and finally consideration of the skills and knowledge students should be learning so that they can aspire to relevant tertiary study. This also takes into account the changing work environment and uncertainty about the nature of future jobs.

Ensuring young people understand the skills and the knowledge required to take advantage of these careers is essential to ensure their aspirations can become reality.

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.[67]

Who wants to be a scientist when they grow up?

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 under-representation of girls, with boys more likely to aspire to a STEM related career than girls.[68]

The research also found that students with an Aboriginal and Torres Strait Islander background were significantly less likely to express interest in a STEM discipline related career compared to other students. In addition, students from a low socio-economic status (SES) background are less likely to aspire to a STEM discipline related career.

This gap is reduced for students who have higher levels of academic achievement. Aboriginal and Torres Strait Islander and low socio-economic students having relatively high prior achievement in reading and numeracy are just as likely to aspire to a STEM discipline related career compared to other students.[69] For girls, however, a lack of aspiration towards a STEM discipline related career exists even when their achievement levels are comparable to boys.

[67] 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

[68] 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

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

A 2012 South Australian study of girls participating in STEM education, found many girls studying engineering, ICT and physics in secondary school but do not aspire to study these subjects in university. 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.[70] Underrepresentation, an absence of female role-models, poor sense of belonging, and poor relative pay create career barriers, and decrease the incentives for women to continue in these fields.[71]

Research has found that as early as Year 4, the vast majority of students expressed interest in 'real' occupations demonstrating career aspirations start early in life. The challenge is achieving and maintaining these early aspirations in STEM careers so they become a reality. Interestingly, primary school students were significantly less tentative about careers they might pursue than students in secondary school.[72] 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.[73] 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.[74]

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.[75]Further research supported the notion of early engagement to enable students to make informed choices about STEM disciplines. It was noted many first year university female students had difficulty obtaining information from their school teachers, career advisers and family or friends about the right academic path to take. In addition, 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.[76] There is a similar theme across other underrepresented groups which include Aboriginal and Torres Strait Islanders, low socio-economic and students in regional and remote areas.[77]

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

[70] South Australia, Department of Further Education, Employment, Science and Technology, *Female participation in STEM study and work in South Australia 2012,*

[71] Office of the Chief Scientist, 2016, *Australia's STEM workforce: science, technology, engineering and mathematics*. Australian Government, Canberra.

[72] 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, p. 171 & 172

[73] 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. p. 183 & 194

[74] 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, pg. 5

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

[76] 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*

[77] 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

industry, schools and community to provide girls with authentic STEM education opportunities, and quality career advice highlighting the diversity of STEM-based career possibilities.[78]

How do young people make career decisions?

Some students lack the knowledge to make informed decisions about work and study, do not know what careers they would like to undertake, what skills they need or even what their options are. A national survey of Australian Youth conducted in April 2017 found young people don't think school prepares them for the real-world at all, with one student noting school does not teach you how to do a tax return, how to get a job or how to pay your bills.[79]

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 14-15 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. [80]

These findings are consistent with other surveys such as the *Mission Australia's Youth Survey Report.*[81]

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 discipline related careers.[82] Parents need to know how to help their children understand what STEM 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.

The need to develop and implement career-planning programs that are inclusive of or directed to parents has been recognised through previous Australian and international evidence. Programs directed at low socio-economic status families are particularly beneficial to help parents to guide at-risk children into positive pathways.[83] Programs directed at parents should aim to assist parents to understand careers and the labour market, know how to access and use resources that support transitions from

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[78] 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, pg. 5

[79] Bisson, R & Stubley, W, 2017, *After the ATAR – Understanding how GenZ Transition into Further Education and Employment*, Year13, Australia. p. 31

[80] 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

[81] 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

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

[83] Australian Institute of Family Studies, 2016, *The Longitudinal Study of Australian Children, Annual statistical report 2016*, pg. 30

school to further study or work, understand their influence in the transition process, and engage with and support children in a positive way.[84]

Targeting families in disadvantaged cohorts is especially important to overcoming a lack of access to career advice. Only 68% of children aged 5 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.[85]

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 to oppose the fear being generated in media about future jobs.

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.

Research indicates there are two effective ways in which subject teachers can deliver careers content. It can be integrated into lessons delivered by the teacher e.g. pupils studying a play in English learn about the role of a graphic designer and design a theatre program. Alternatively, careers content can exist beside the curriculum in the form of field trips to work places, talks and enrichment programs delivered by others and integrated into the curriculum.[86]

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.

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.

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[84] Bedson, L, Perkins, D, 2006, *A positive influence: Equipping parents to support young people's career transitions, Evaluation of the PACTS program*, Brotherhood of St Laurence, Victoria. p.iii

[85] 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].

[86] Teach First, *Careers education in the classroom: The role of teachers in making young people work ready*, TeachFirst, UK pg. 12

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

A study by the UCL Institute of Education in London 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.[87]

It can be argued that one of the focuses for schools should be keeping students' aspirations on track. Effective intervention strategies are likely to include 'High-quality careers advice, work experience and work-related learning'.[88]

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 and parent stakeholders has identified three areas where national consistency and leadership can support students make informed choices through:

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

Access to career education resources

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 include articles about and links to careers information.

There are also numerous existing 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

[87] 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

[88] Menzies, L. 2013, *Educational aspirations: How English schools can work with parents to keep them on track*, Joseph Rowntree Foundation, York. p.3

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.

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 understanding of work, careers and post-school destinations. Tasmania is currently the only state that has mandated this unit, with broader implementation across other states and territories unclear.

Innovative pathways and partnerships

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.

Case Study 5: 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 Geelong, Newcomb Secondary College has partnered with Barwon Health, Bendigo Bank, GMHBA, Opteon Property Group and Tribal. The first cohort of P-TECH students are studying Certificate III courses in laboratory skills, information technology or business finance. Students undertake fortnightly industry visits and meet with their industry mentors to undertake real work projects.

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

Work-based learning is a strong feature of VET qualifications which employ a learning model suited to teaching skills in real or simulated workplaces, in close collaboration with industry and employers.[89] 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. One such approach is the Australian Government's P-TECH Pilot with schools and industry working closely.

Victoria is also in the process of implementing the Tech Schools initiative that will see the construction of 10 Tech Schools across the state, with two in operation and the remainder to open in 2018. [90]

[89] Siekmann, G & Korbel, P, 2016, *Defining 'STEM'skills: review and synthesis of the literature- Support Document 1, NCVER, Adelaide. p. 51*
[90] Victoria State Government 2017, Tech Schools Ambassador [Online] Available at: http://www.education.vic.gov.au/about/programs/learningdev/techschools/Pages/techschoolambassador.aspx

Case Study 6: TECH Schools - Chatbot a thon, Microsoft

Tech Schools are local STEM learning hubs that deliver programs to students from government and non-government secondary schools and expose students to immersive learning experiences using high end technology informed by strong industry connections. Hosted on TAFE or university campuses, they introduce students to the tertiary education environment and smooth their pathways into further education and training. Tech School programs present students with real life challenges from industry to solve, linked to the curriculum.

Recently Microsoft partnered with Banyule-Nillumbik and Whittlesea Tech Schools in a two day Chatbot a thon. Chat bots are a type of artificial intelligence that can be tailored to work on platforms such as Skype, twitter and websites and are most often seen in the context of a Question and Answer functionality. Students worked with employees from Microsoft to understand the technology behind Chat Bots. Students created a Chat Bot that is able to answer questions asked via the Tech Schools website. Working in teams the students gave the Chat bots personalities then presented the Chat bots back to the group, as they would if they were in a real workplace. The selected Chat bot will reside on the Tech Schools website.

When students attend Tech Schools they work on problems that industry want solved, rather than on a theoretical exercise. By exposing high school students to real world problems, they understand why studying STEM subjects is important and they will be motivated to learn.

Role for industry

The challenge for increasing participation in STEM disciplines is building aspiration. This can be done through building awareness of the role STEM skills play in solving real-world problems and highlighting the breadth of STEM related careers.

Industry has a role to play in increasing the flow of reliable information about careers and communicating about the changing labour market, focusing on opportunities rather than job losses through automation.

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

Consideration needs to be given to the best medium to increase awareness. We know parents are the primary influence on young people, however research also indicates nearly 70% of young people are influenced by the internet when making post-school plans.[91] This is supported by the experience of the Australian Defence Force's defence careers campaign which shifted from traditional marketing to focus on inspiration and opening social media channels. The outcome was that those who made a connection through social media took less time to move from considering to actually joining the Australian Defence Force.

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.

[91] 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.

> Use of language around skills and work and the messaging it carries is important. Talking about ‘what problems do you want to solve’, ‘why are STEM skills part of solving these problems?’ and ‘how can I be part of this, what skills do I need, and what is the pathway’, is more appealing and relevant than simply talking about STEM related careers.

Partnerships where educators and industry work together to link specific curriculum content to real-world examples of work would help teachers support students to understand the value of taking on more advanced mathematics and science subjects in school.

Chapter 5: Outcomes and Impact

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

While many activities and resources may have some form of evaluation, there is no nationally consistent evaluation framework to determine and compare how successful these initiatives are. 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.

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

A further challenge in ensuring the strategic investment of time and resources to promote STEM programs lies in understanding the supply and demand of STEM skills in the education system and labour market.

While a number of rich datasets exist across the schooling, VET and university sectors, these are not presented in a cohesive, easily accessible form that allows a good understanding of the STEM education pipeline.

The Forum has identified two priorities in this area, to:

a) enhance outcomes evaluation of STEM initiatives, and
b) build an evidence base and improve longitudinal analysis of the impact of STEM education.

What is currently happening?

Monitoring and evaluation of STEM initiatives

A number of states and territories have their own evaluation tools and there are a range of approaches applied. 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 (the 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. The Toolkit aims to provide guidance for principals, teachers and schools on how to use their resources to improve educational outcomes for their students, particularly those from low-income families.

Building an evidence base of the impact of STEM education

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.

There are 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 have acknowledged the practical complexities of connecting these datasets.

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.

Forum members consider that a Unique Student Identifier 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 new state of territory, or change their name. By integrating data sets and providing a single complete view of the data, we will derive better insights into the effectiveness of policies and programs, and enable better analysis of the STEM education pipeline.

To more fully understand the pipeline of STEM students from school through to tertiary education and on to employment, there are several existing longitudinal datasets, such as the Longitudinal Surveys of Australian Youth (LSAY) and the Graduate Outcomes Survey (GOS), which are also valuable.

LSAY follows young people as they move from school to further study and employment. The survey collects information about participation in STEM subjects during school years, as well as tertiary entrance scores, main area of study or training, employment status and income. The survey also collects demographic information which may improve understanding of factors that contribute to differences in STEM participation.

The GOS is a survey of higher education graduates, conducted annually since 1972. New graduates from all Australian universities, and a number of other higher education institutes and colleges are invited to complete surveys around four months and also three years after they graduate. Data collected includes degree completed, occupation employed in after graduation, and median starting salary by study area.

How can industry help?

Monitoring and evaluation of STEM initiatives

The expertise of industry lies in its understanding of the knowledge and skills required to be successful STEM professionals. Forum members agreed that it is important for industry to consider intended educational outcomes, and intended 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 education outcomes and impacts in the initial program planning stages, practical and accessible guidance on how to establish new, and evaluate existing, STEM education programs would be welcome by most businesses.

Case Study 7: Development of a National STEM Evaluation Tool

The Australian Government has commissioned the development of a National STEM Evaluation Tool. It will be used to evaluate the success of STEM initiatives and industry programs, and the extent to which they meet their intended objectives. It will be a useful resource for industry, schools (primary and secondary) and policy makers to determine which initiatives are the most effective, deliver the best outcomes for students and provide value for money.

The tool will also serve as a guide to designing and establishing new STEM education initiatives, and while it will have a clear STEM focus, it will be developed in such a way that it might be possible to apply it to education initiatives and programs that are broader than STEM in the future.

It is anticipated the tool will be available online and will include links to external resources to provide further information to schools and industry on best practice in STEM education.

A prototype of the National STEM Evaluation Tool is expected to be ready for testing in 2018.

Building an evidence base of the impact of STEM education

The Australian Government has access to some useful datasets in relation to student participation and achievement in STEM education and further analysis could offer greater insights into the STEM education pipeline.

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, 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.

Existing advisory groups could monitor and provide strategic advice on data gaps, and can consider opportunities for potential improvements to existing datasets to create a holistic understanding of the STEM education pipeline. For instance, an updated and more detailed analysis of student participation in beginning versus advanced subjects, and the impact this may have on further study and employment outcomes, could help determine if there is cause for concern with students choosing less challenging STEM subjects.

APPENDIX A: National STEM School Education Strategy

With an increasing focus on the need for STEM knowledge and skills, Governments across Australia recognised the need for action in relation to STEM education. In December 2015 all education ministers endorsed the National STEM School Education Strategy 2016-2026.

The Strategy is focused on action that lifts foundational skills in STEM learning areas, develops mathematical, scientific and technological literacy, and promotes the development of the 21st century skills of problem solving, critical analysis and creative thinking. It recognises the importance of a focus on STEM in the early years and maintaining this focus throughout schooling. The Strategy sets out two goals:

- Goal 1: Ensure all students finish school with strong foundational knowledge in STEM and related skills
- Goal 2: Ensure that students are inspired to take on more challenging STEM subjects.

The Strategy includes five areas supported by specific actions to be implemented collaboratively by all Australian governments:

1. Increasing student STEM ability, engagement, participation and aspiration
2. Increasing teacher capacity and STEM teaching quality
3. Supporting STEM education opportunities within school systems
4. Facilitating effective partnerships with tertiary education providers, business and industry
5. Building a strong evidence base

STEM Partnerships Forum

Establishing the STEM Partnerships Forum was the first national collaborative action implemented under the National STEM School Education Strategy. The Forum is intended "to facilitate more efficient and effective partnerships between schools, industry and the tertiary education sector" including consideration of:

- best practice models of partnerships
- increasing student involvement in effective school-based partnerships
- increasing industry involvement in effective school-based partnerships
- alignment of initiatives to raise awareness of the importance of STEM education
- the best approach to careers advice on the importance and relevance of STEM skills
- facilitating greater engagement between industry and STEM teachers.

The Forum includes representatives from schools, business and industry, and the tertiary education sector.

APPENDIX B: STEM Partnerships Forum

Terms of Reference

Purpose

The STEM Partnerships Forum (the Forum) will bring together leaders from industry and the education sector (schools, higher education, VET) to facilitate a more strategic approach to school-based partnerships with businesses and industry across Australia in order to develop the engagement, aspiration, capability and attainment of students in STEM.

Roles and responsibilities

The Forum is responsible and accountable to Education Council via Australian Education Senior Officials Committee (AESOC).

The ongoing oversight and the exercise of its function is the responsibility of Schools Policy Group (SPG).

To facilitate more efficient and effective partnerships between industry and the education sector, the Forum will:

- Engage with industry and community stakeholders to support strategic co-ordination and make recommendations for the improvement of new and existing partnerships;
- Coordinate information available on STEM education partnerships, help identify gaps in partnership efforts, and contribute to efforts to facilitate new partnerships;
- Contribute to efforts to build a stronger evidence base around effective partnership models and where possible, identify best practice models that can be expanded; and
- Avoid duplication of work of other national STEM-related advisory councils and bodies.

In exercising its functions, the Forum will promote the core principles of good public sector governance.

Deliverables

To facilitate a more strategic approach to school-based STEM education partnerships across Australia, the Forum will:

- Oversee guidance and support materials for best practice models of partnerships, including mentoring and outreach activities that are relevant, engaging and support STEM learning outcomes (specific examples include ‘how to guides’, examples of best practice);
- Promote industry involvement in effective school-based partnerships;
- Facilitate greater alignment of initiatives to raise awareness of the importance of STEM education for all;
- Provide advice on the best approach to careers advice on the importance and relevance of STEM skills, particularly for primary students and their teachers;
- Facilitate greater engagement between industry and STEM teachers, for example, industry work placements and programmes for pre-service teachers;
- Provide advice as requested to Education Ministers via SPG and AESOC on matters relating to schools-based STEM partnerships with industry; and
- Provide an annual report to Education Ministers on the progress of the Forum via SPG and AESOC.

The Forum will be constituted for an initial two-year period.

Composition and tenure

The Forum comprises **17 members**, including the Chair. Forum members will be appointed by SPG for two years. Members are appointed both for their expertise as individuals, as well as being representatives of their specific business, industry or education sector. The inaugural chair is Dr Alan Finkel AO, Chief Scientist of Australia.

The Forum's membership includes the following requirements:

- Chair
- Deputy Chair (Industry representative)
- SPG representatives (1 Australian Government representative and 4 others)
- CSIRO (the Commonwealth Scientific and Industrial Research Organisation) (1 representative)
- Eminent industry / business representatives (4 representatives)
- Eminent educator / academic from the schooling education sector (1 representative)
- Eminent educator / academic from the higher education sector (1 representative)
- Eminent educator / academic from the vocational education sector (1 representative)
- Australian Primary Principals' Association (APPA) (1 representative)
- Australian Secondary Principals' Association (ASPA) (1 representative)

The Forum membership will also include a balance of state and territory members, gender, and individuals with a knowledge of underrepresented groups in STEM E.g. Aboriginal and Torres Strait Islander peoples, people from culturally and linguistically diverse and low-socio-economic backgrounds.

Where a member cannot attend a meeting, members from particular organisations may nominate another person at the Executive Level of their organisation to attend on their behalf. Industry / business representatives and educators / academics from different sectors may nominate personal replacements to attend meetings.

Other experts may attend meetings at the invitation of the Chair based on subject matter under consideration. Observers may also attend at the invitation Chair, including via teleconference or videoconference facilities.

A quorum will consist of a minimum of **nine** Forum members (or their representatives).

Reporting

The Forum will report to Education Ministers, through SPG and the AESOC, on at least an annual basis and as requested.

The Forum meeting times and outcomes will be made publicly available on the Education Council website (www.educationcouncil.edu.au).

Administrative arrangements

Meetings

The committee will meet up to four times per year (two face-to-face and two via teleconference). A two-year work plan will be developed by the Forum and endorsed by SPG, and will include key tasks, deliverables, consultations and timelines.

Secretariat

Secretariat services will be provided by the Australian Government.

Where possible the Secretariat will circulate an agenda and supporting papers at least a week prior to each Forum meeting. The Secretariat will maintain and circulate the outcomes and minutes within two weeks of every meeting to Forum members, via email.

The Secretariat will provide minutes for each Forum meeting to the SPG within four weeks.

Consultations

To minimise duplication of effort, the Forum must ensure consultation is undertaken with:

- Established key teacher representative groups;
- Relevant commonwealth, state and territory government bodies;
- Relevant industry associations;
- Higher education institutions; and
- VET providers.

Review

SPG will review the operations of the Forum before the end of the initial two-year term and will report to AESOC and Education Council.

Forum Membership

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

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

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

Ms Vittoria Shortt, Group Executive, Marketing and Strategy Commonwealth Bank of Australia

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

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

Mr Innes Willox, CEO, AiGroup

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

Ms Meg Brighton, Deputy Director-General ACT Education Directorate

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

Dr David Howes, Assistant Deputy Secretary VIC Department of Education and Training

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

Ms Mary Mulcahy, Director of Education and Outreach CSIRO

Professor Brian Schmidt AC, Vice Chancellor ANU

Professor Jo Ward, Dean of Science Curtin University

Ms Jodi Schmidt, CEO QLD TAFE

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

Mr Geoff Williamson, Principal Huonville High School