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Optimising STEM Industry-School Partnerships

Submission to the STEM Partnerships Forum

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Optimising STEM Industry-School Partnerships: Submission to the STEM Partnerships Forum

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1. Introduction

About Engineers Australia

Engineers Australia is the peak body of the engineering profession. We are a member-based professional association with over 100,000 individual members. Established in 1919, Engineers Australia is a not-for-profit organisation, constituted by Royal Charter to advance the science and practice of engineering for the benefit of the community.

The association's experience with STEM in schools

The association's submission is informed by its long history in public policy development and advocacy on issues that affect the development of a strong pipeline of professional engineers. This pipeline begins at the school level with the study of preparatory subjects like advanced maths, physics and chemistry, which are all enablers for a successful transition to university studies in engineering.

In 2017, Engineers Australia released a report, *Engineers Make Things Happen* which explains the association's perspective on the importance of Science, Technology, Engineering and Maths (STEM) subjects to the engineering profession. It also highlights a looming crisis in STEM and severe degrees of difficulty in finding enough young men and women able to study engineering at university. A copy of the full report and summary is available on our website: https://www.engineersaustralia.org.au/Government-And-Policy/Policy-Reports.

This submission is further informed by Engineers Australia's experience delivering *EngQuest*. EngQuest is provided free of charge to Australian schools, and has had more than 100,000 students participate every year since 2014. The program encourages lower primary, primary and middle years students to work in teams and apply their problem-solving skills to design, construct and test exciting engineering projects. More information is available online: http://www.engquest.org.au.

Finally, STEM Partnerships Forum members may be aware that Engineers Australia is a key partner in the *STARportal*, Australia's first centralised national portal for exciting and engaging STEM activities from around the country.

The respective roles of the Commonwealth and states/territories

The STEM Partnerships Forum was formed in response to a proposed action in the *National STEM School Education Strategy* which was endorsed by the Council of Australian Governments (COAG) Education Ministers in late 2015. Engineers Australia supports the strategy and urges the Commonwealth, state and territory Ministers to work together to achieve the strategy's goals. To do this, it is important for the Commonwealth and other non-government stakeholders to acknowledge the leading role played by the state and territory Governments in the funding of school education, training, employment and development of teachers, and on-the-ground delivery of education.

The Commonwealth has a vital role in the provision of funding, and an important function is to act as a coordinator or broker for consistent state/territory efforts. It is also in a key position for managing more general action to raise public understanding of the need for quality STEM education. This can include working closely with industry, professions and their respective representative associations to enable nationally-aligned industries to integrate with state-based education systems and schools.

1.1 Contact details

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2. STEM in Education and Work

The following is a response to selected Issues Paper questions for Chapter 1, "STEM in Education and Work."

2.1 Response to questions 1.1 and 1.2

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?

A diverse range of skills need to be exhibited by the Science, Technology, Engineering, and Mathematics population, with a minimum threshold of both technical and generic skills being essential. Engineering, in particular, is reliant on the integration of the other STEM disciplines (as well as some human and social sciences). Engineering is responsible for the energy efficiency, manufacturability, sustainability, robustness, public safety and maintainability of physical and information-based systems.

Skills essential to the future of industry include expertise with novel materials, advanced manufacturing, Artificial Intelligence (AI), data science and coding. Future industry trends are being described in terms of the Internet of Things (IoT) and the 4th Industrial Revolution. Engineers also have to deal with interfaces between physical and information-based systems and human, bio and social systems—all of which points towards the importance of a cross-disciplinary approach to education.

With these factors in mind, it is imperative that school children embrace the fundamental subjects of advanced mathematics, physics and chemistry, combined with studies in the humanities and social sciences.

In a crowded school curriculum, individuals—especially at the secondary level—will need to determine their own subject choice with an eye to potential careers that are attractive to them. For example, physics may be chosen by students seeking careers in civil engineering, while those interested in bioinformatics engineering may instead select chemistry. The final choices will rest on individual aspirations.

Value of education at primary school

Much of the discussion around STEM in schools tends to focus on the high school years but the importance of primary schooling should also be noted. It is at the early years of education that the groundwork for attitudes to STEM subjects is laid. If girls and boys lose confidence in those subjects at a young age, it can be difficult to re-engage them in later school years. Primary school is also important for developing the foundational skills for life and the further study of STEM subjects at high school.

For this reason, investment in the STEM skills of primary school teachers is very important, and industry engagement with schools should include all stages of the curriculum.

2.1.1 Engineering-specific courses at school

At the Foundation to Year 10 (F-10) stages, the national curriculum for Technologies (with its components in Design & Technologies and Digital Technologies) can play a role in helping students understand the real life applications of the fundamental mathematics and science subjects. The Design & Technologies curriculum includes principles and applications of engineering systems thinking. It has the potential to develop skills and interests for later subjects as well as influence career choices. For the senior secondary years, "engineering studies" is offered in some states as the engineering-specific extension to the F-10 Technologies curriculum.

The use of "STEM" (and therefore the inclusion of 'E' for engineering) as the short-hand for subjects that students need to study could lead students, parents and careers advisors to misunderstand the value of the "engineering studies" course offered for years 11 and 12. It is noted that universities provide information about assumed prior knowledge for engineering degrees but, to the uninitiated, the role and value of a high school subject called "engineering studies" may be misunderstood.

The engineering studies curriculum on its own will not provide students with the fundamental STEM skills that act as the building blocks for a life and career in engineering.

As stated earlier, the school curriculum is a crowded space. In terms of STEM subjects and subsequent pathways for engineering careers, it is most important that the fundamental subjects of mathematics (especially advanced mathematics), physics and chemistry are given priority. Students should also continue to be encouraged to study English and at least one other humanities or social sciences subject such as a language, history or economics.

With this in mind, in the senior secondary years, the engineering studies course is best used by two types of students: those who have already self-selected out of an engineering career pathway and study lower-level maths, but who still wish to attain a deeper understanding of how mathematics and science subjects are applied 'in the real world'; and, students who are committed to a career in engineering and related disciplines and wish to immediately use their fundamental mathematics and science studies in broader and a more practical contexts, rather than taking extra humanities and social science subjects.

2.2 Response to question 1.7

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?

A response to this question first requires a basic understanding of the Engineers Australia role in maintaining the high quality of engineering education at Australian universities.

2.2.1 Accreditation of engineering programs

Engineers Australia is the trusted accreditation authority for tertiary engineering education in Australia and overseas at the levels of Professional Engineer, Engineering Technologist and Engineering Associate. Professional accreditation of entry to practice engineering programs is normally carried out every five years.

Accreditation ensures academic institutions consistently meet national and international benchmarks. The Washington, Sydney and Dublin Accords recognise the substantial equivalence of accreditation systems and accredited programs across international boundaries and provide greater international graduate mobility through mutual recognition of accredited programs.

The primary objectives of the accreditation process are the maintenance of internationally benchmarked standards, the promotion and dissemination of best practice and encouraging innovation and diversity in engineering education.

Assessment of any particular academic program for accreditation is based on the following criteria:

- the teaching and learning environment
- the structure and content of the program
- the quality assurance framework

A generic framework for developing specific education outcomes for programs is provided in the generic attributes requirement of the Engineers Australia Accreditation Policy, and more specifically in the Stage 1 Competency Standards. The generic attributes recognise the broad nature of professional engineering practice in today's world.

The accreditation process does not prescribe detailed program objectives or content, but requires engineering education providers to have in place their own mechanisms for validating outcomes and continually improving quality. Accreditation does, however, judge the appropriateness of educational objectives and targeted graduate capabilities, the integrity of the educational design and review processes and the means employed to deliver and monitor outcomes.

In other words, accreditation of engineering programs is focussed on graduate outcomes rather than student inputs.

More information is available on the Engineers Australia website: https://www.engineersaustralia.org.au/About-Us/Accreditation.

2.2.2 Prerequisites for entry to university

Most universities currently provide information to prospective students about "assumed prior knowledge." The University of Sydney is notable for its forthcoming re-introduction of mathematics prerequisites for engineering and other courses from 2019 (it retains advice to students about other assumed prior knowledge).

Students who do not have suitable mathematics, physics or other subjects for entry to an engineering program are strongly encouraged to complete a bridging course. Advice received by Engineers Australia from members in the university education sector is that the use of bridging courses is an effective means for enabling students, who do not have the high school-based assumed knowledge, to successfully study and graduate from engineering at university.

In support of this view, Engineers Australia is aware that a former Australian Council of Engineering Deans (ACED) president undertook a study in his 'Group of 8' university. They found that students who did an additional catch-up mathematics unit (because of lower maths entry) progressed (after two years of study) with no significant differences from the whole cohort.

Furthermore, while top tier universities like The University of Sydney will probably always be able to attract a full cohort of students with suitable prerequisites, smaller providers and regionally-based universities draw on a pool of students with a much wider range of educational attainment. For those universities, the ability to take on students and put them through bridging courses is important for two reasons: (a) course viability, and (b) as a pathway to higher education for regional or lower economic status students who, on average, have lower STEM attainment than metropolitan or high economic status students.

That second factor highlights a much more important issues which is the variation in mathematics attainment across the nation and between different social-economic groups. Until that issue is resolved, rigid implementation of prerequisites will have an unintended consequence of unnecessarily blocking large cohorts of young Australians from pursuing their higher education and career goals.

It is also worth noting that (in 2016) less than 60 per cent of students commencing a bachelor degree in engineering used their Australian Tertiary Admission Rank (ATAR) to gain acceptance to their program. This proportion has declined over the past decade.

Instead of university prerequisites, there may be value in conducting a study to determine the merit of requiring every school student to do at least one mathematics subject plus one other STEM subject. Such requirements would be in addition to the current requirement to study English. A change like this would hinge on other factors such as sufficient supply of skilled STEM teachers and fostering a culture that values STEM studies. Without these, forcing students into STEM subjects is likely to have very mixed results.

The STEM Partnerships Forum is encouraged to consult the Australian Council of Engineering Deans (ACED) on the matter of university prerequisites. Information about ACED and contact details are available online: https://www.engineersaustralia.org.au/aced.[1]

[1] Note that although the ACED website is hosted by Engineers Australia (EA), it is not a member of ACED. Instead, Engineers Australia is a key stakeholder and has agreed to act as host for the ACED website.

3. The Role of Industry

The following is a response to selected Issues Paper questions for Chapter 2, "The Role of Industry."

3.1 Response to questions 2.2-2.4

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?

An example of a successful industry partnership from Engineers Australia is the recently launched STARportal.edu.au. The portal provides teachers, parents and students access to Australia's first truly national online database of STEM based activities. Activities include, amongst others, school excursions, after school and vacation care activities.

The success of this project was due to it having clear objectives and a defined purpose. In collaboration with the Office of the Chief Scientist, a steering committee was formed comprising of industry partners, government, education and academia, all working together to achieve the desired outcome. As the peak professional body for engineering, Engineers Australia has no direct involvement in schools and therefore our leadership position was not influenced by any specific area of STEM, only a common goal of increased participation in STEM based learning as the basis for engineering qualifications.

Engineers Australia successfully worked as facilitator alongside industry partners like BHP Billiton Foundation, Commonwealth Bank and Telstra and involving education, academia and government departments to meet individual stakeholder requirements and encourage an outcome driven focus, successfully delivering the resource on time and to expectations.

Industry's role in this program was incredibly important. The first was financial support; without it, the portal project would not have eventuated. The second was expert input to the development of the portal itself, using their respective resources and shared experience to ensure the highest quality offering. Additionally, the support through their individual networks, in this instance both professional and consumer, to promote both participation and awareness was crucial to the portal's success.

2.3: What are the barriers for 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?

There is no lack of enthusiasm from industry to support school partnerships and programs. The challenge is that there are many different programs at national, state and local levels, which target different aspects of STEM education, at different levels and age groups. Industry is paralysed by choice, which leads to a need for a consolidated, coordinated national approach. This would encourage broader participation and deliver measurable outcomes which will, in turn, lead to longer term engagement and involvement by industry.

A national program that involves organisations of any size at national, state or local level, coordinated across all disciplines of STEM, available to all schools regardless of metropolitan, regional or remote location, socio-economic status or size. A dedicated career program where industry could highlight their best and brightest talent, career opportunities, work experience options, mentoring and school and site visits is needed. A centralised digitally based program would allow industry from all locations, sizes and disciplines to engage with the target audience of students, parents and teachers while adhering to a prescribed model, which would help to ensure consistency of messaging across the country.

Universities and vocational training centres could work with industry, education and government to train the participants and produce the supportive material required. The Commonwealth Government would need to lend its support and promote to the program nationally, and engage and state education departments to promote their involvement.

Engineers Australia is well positioned to lead a representative panel to develop opportunities and explore perspectives, process and programs that are already in existence.

4. Solving Real-World Problems—Careers Awareness

The following is a response to selected Issues Paper questions for Chapter 4, "Solving Real-World Problems—Careers Awareness."

4.1 Response to questions 4.1 and 4.2-4.5

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?**

In the development of the STARportal we identified, in collaboration with the Department of Education, 10 areas of interest that users can select from a drop-down menu. These were required so that providers could tag their programs suitably and deliver quality search results to the user.

Also available on the activity search page is a free-text search box, where users can enter their own search terms. Late March 2018 will see the STARportal launch an analytics dashboard which will provide a range of valuable data relating to searches performed by users on the site. Included is the ability to rank the top areas of interest searched from the drop-down menu along with, and more importantly, the top free text search terms used. These search terms will give us some insight into the language used by students, parents and teachers regarding STEM topics. The dashboard will have the ability to look at these results at both a national and state level.

We suspect, however, that the term STEM will be noticeably absent from the free text results in the dashboard, as it's an industry related term and not one that has gained penetration into the community. In February 2017, Engineers Australia commissioned a study into our student and graduate market. It involved both quantitative and qualitative research and the objective was to gauge awareness and engagement relating to Engineers Australia amongst engineering students. During the research, a group of engineering students were asked anecdotally if they study a STEM subject, the response was 'no, we study engineering'.

The term STEM needs to be used with the right audience. When talking about it in school programs, the reference to STEM skills need to be delivered to students in context. The role of industry is to demonstrate 'how' these skills were adapted into problem solving solutions in the real world. Our young people need to know why these skills will benefit them in their future and what they will be able to achieve. The focus needs to move away from the specifics of the subjects and put the skills they learn via those subjects in context. Industry are solving problems and innovating every day. The ability to bring that to life by working with schools will be invaluable.

The analytics dashboard will be made available to the Forum to assist in the development of appropriate terminology.

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, careers advisors 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

There is opportunity for industry to have the greatest impact on our future workforce through career awareness.

A national program that involves organisations of any size at national, state or local level, coordinated across all disciplines of STEM, available to all schools regardless of regional or remote location, socio-economic influence or size. A dedicated career program where industry could highlight their best and brightest talent, career opportunities, work experience options, mentoring and school and site visits is needed. This centralised digitally based program would allow industry stakeholders from all locations, sizes and disciplines to engage with the target audience of students, parents and teachers adhering to a prescribed model, no matter the method of delivery (ie: face to face, skype, webinars, site visits etc) to ensure consistency of quality and messaging across the country.

The current 'STEM Professionals in Schools' offering by the CSIRO is delivering on some of these requirements, however the model could be evolved to increase engagement and outcomes.

The current approach is volunteer led, where professionals actively volunteer their time to participate. The issue with this approach is the attraction of 'end of career' professionals, those who are semi-retired or retired that are available to attend recruitment meetings and other time-intensive commitments.

Our proposed approach, however, is to attract industry's 'best and brightest talent', who are able to excite, engage and educate their audiences. These professionals are generally too busy to attend information evenings, yet are the very ones that need to be in front of students, teachers and parents, sharing their experiences and discussing the possibilities for the future.

Industry support and involvement would be key in putting forward their best and brightest talent for the program. Participants on this program would be individually selected, trained in presentation skills, given a toolkit and key messaging to deliver consistency across the board. Through this selection process, we could ensure that appropriate representation from women and Aboriginal and Torres Strait Islander groups to target messaging and increase engagement from those students.

Our most talented STEM professionals, whilst leaders in their field, are understandably not always as equally strong as speakers and presenters. Introducing a selective panel of STEM experts into an industry school partnership program would lend itself to those employees that qualify and deliver within the program to receive recognition from their employer by way of additional CPD hours/peer recognition/incentives/increased responsibility etc. This could develop into a sought-after program for young professionals, adding participation to their CV and helping build their professional brand.

It is imperative that we promote industry's best and brightest STEM professionals through the narrow window of opportunity available to influence our youth into STEM based careers.

Engineers Australia welcomes the opportunity to workshop our suggested approach further with the Forum and the CSIRO.

5. Outcomes and Impact

The following is a response to selected Issues Paper questions for Chapter 5, "Outcomes and Impact."

5.1 Response to questions 5.2, 5.4 and 5.9

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

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

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?

Engineers Australia can comment on this point by sharing our experience with the development and delivery of the STARportal.

The industry partnerships aligned with the portal were crucial, and it was a requirement that the partners were involved in each stage of the process. This enabled us to share progress metrics, but also draw from the wealth of experience within our partners' businesses. Clear objectives and defined outcomes were communicated to all partners, delivering full transparency into the value of the partnership. This enables partners to measure the success of their investment upon conclusion of the contract period.

The experience with the STARportal would suggest that a minimum five-year commitment with measurable milestones along the way would be the desired arrangement. This allows time for the partnership to be introduced, implemented and some measurable outcomes delivered over time. A period of five years is substantial enough for both industry and education to evaluate the benefit of the program and guide further partnership arrangements if successful. This also gives educators the time required to implement the program and maximise participation within the classroom.

5.2 Response to question 5.8

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?

In 2018, Engineers Australia will produce a report that examines the engineering profession through the prism of the three census in 2006, 2011 and 2016. The use of three census periods provides an opportunity to show how the profession has changed over the past ten years, plus offer some insight to trends into the future.

The report will look at demographic factors such as the numbers of engineers, their education level and employment rates, and also industry-specific trends. Together, these data will indicate the extent to which Australia has enough engineering capability, and the degree to which that capability is being efficiently utilised. It will also show which industries are declining, which are growing, and indicate the extent to which as-yet-unclassified industries and engineering disciplines are emerging.

As stated earlier in this submission, in 2017, Engineers Australia released a report, *Engineers Make Things Happen,* which explains the association's perspective on the importance of STEM subjects to the engineering profession. It also highlights a looming crisis in STEM and severe degrees of difficulty in finding enough young men and women able to study engineering at university. This report includes a large amount of data on school education trends, and also skilled migration as the other component to Australia's engineering skills and capability supply pipeline.

A copy of the full *Engineers Make Things Happen* report and summary is available on our website: https://www.engineersaustralia.org.au/Government-And-Policy/Policy-Reports.

The report made particular note of the stark gender imbalance of the engineering profession. About 12 per cent of all engineers are female, and female engineers are much less likely than male counterparts to actually work in engineering jobs. There are many factors that may influence the low number of women entering the profession and remaining in engineering-related employment. The Forum could investigate collaboration with the *Male Champions*

of Change in STEM[2] to explore the data and insight to how action at the school level may lead to greater involvement of women in engineering and other STEM-based professions.

More information about the association's perspectives on gender diversity in engineering is also available: https://www.engineersaustralia.org.au/Diversity-Strategy.

A range of government agencies already collect information on employment rates and job vacancy numbers as a proxy for changes in skills demand. The Department of Education and Training provides statistics on university demand and graduation outcomes that are useful for determining the health of the current skills supply. Engineers Australia analyses these and produces reports that are available online, here: https://www.engineersaustralia.org.au/Government-And-Policy/Statistics.

It is noted that various government agencies will utilise this same data (and perhaps other) to build their own understanding of skills and labour supply and demand. One notable example is the work conducted by the Commonwealth in cooperation with various agencies, industry and professional associations to review skills demand to inform decisions on the skilled migration program. It is recommended that the Forum review this and other government material.

Finally, the Innovation and Science Australia 2030 Strategy on Innovation includes good information on how the future of work may change over the next decade.

[2] For more information on the Male Champions of Change for STEM, visit their website: http://malechampionsofchange.com/welcome-to-the-stem-male-champions-of-change.

6. Conclusion and contact details

Thank you for the opportunity to contribute to the STEM Partnerships Forum's efforts to improve industry-school cooperation. Engineers Australia supports the COAG National STEM School Education Strategy and the work of the STEM Partnerships Forum. The Strategy has the potential to transform the STEM capability of the nation, and the Forum will play a central role in bringing industry and schools together.

Engineers Australia is keen to stay engaged with the Forum over the longer term. To discuss the content of this submission or future issues, please contact:

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