THE WARREN CENTRE

Optimising STEM industry-school partnerships: Inspiring Australia's Next Generation

Submission to the STEM Forum

12 February 2018

About the Warren Centre for Advanced Engineering

The Warren Centre brings industry, government, and academia together to create thought leadership in engineering, technology, and innovation. We constantly challenge economic, legal, environmental, social, and political paradigms to open possibilities for innovation and technology to build a better future.

The Warren Centre advocates for the importance of science, technology and innovation. Our 30 years' experience of leading the conversation through projects, promotion, and independent advice drives Australian entrepreneurship and economic growth.

The Warren Centre is pleased to have an opportunity to make the submission to the Chief Scientist and the STEM Forum.

Background

The Warren Centre for Advanced Engineering has catalysed and has engaged in many decades of discussion on STEM education and its role to drive better innovation and economic outcomes. Appendix 1 summarises previous history and our most recent submissions to various inquiries.

Key Issues / Current Situation

Teachers:

- The option for Australian secondary students to discontinue maths and sciences in years 11 and 12 has yielded a generation of teachers who themselves discontinued maths and sciences at a relatively early stage in education and lack a firm foundation in STEM subjects essential to teach with confidence. In primary schools, recent studies indicate a very small fraction of teachers

The Warren Centre for Advanced Engineering Ltd
School of Information Technologies Building J12
University of Sydney NSW 2006
T: (02) 9351 3752 F: (02) 9351 2012

E: warrenc@sydney.edu.au W: thewarrencentre.org.au
twitter.com/thewarrencentre facebook.com/thewarrencentre

ABN: 27 132 821 688

specialised in science or mathematics.[1] The issue was reviewed in the *Inquiry into innovation and creativity: workforce for the new economy report* issued in 2017. One researcher described the declining participation rate in STEM subjects among prospective teachers as "deeply concerning, with the potential to create a vicious cycle of declining engagement with maths in NSW."[2]

- Teacher specialisation in STEM subjects, even beginning at primary and early childhood education, would improve teaching skills and emphasis.
- Ongoing teacher professional development and lifelong learning are essential.
- Workshops, conferences, networks and exposition of best STEM practices could significantly support teachers. There may be a role by industry partners and tertiary education to support this.
- Teacher engagement with industry and the developing future technology trends could improve awareness of career paths to inform parents and guide students.
- Teachers are at times required to teach "off-discipline" such as from industrial arts to engineering studies. In some cases there is a greater disconnect between the subjects a teacher is required to teach. In most instances, teachers are left without sufficient training or expertise to confidently manage this transition. In many cases these expectations for subject shift are made with limited notice, creating unreasonable time pressure for teachers to familiarise themselves with the subject matter in order to deliver it effectively.
- For subjects that require equipment, training and competent handling expertise, teachers may lack support, resources or time. Evidence suggests this is particularly true in teaching engineering and design & technology.

<u>Students:</u>

- Urgently need recognition and incentives to study so called more difficult STEM subjects.
- Our study and discussion with teachers clearly indicates that the ATAR system creates perverse incentives and encourages students to avoid more advanced maths and STEM subjects.
- Career dialogue must extend beyond single disciplines that define a student by their qualification (e.g. a dentist). Emphasis should be placed on a career as being a multifaceted journey with a focus on the importance of core skills and transferable skills
- Need an accurate vision of future possibilities
- Need compelling and exciting imagination towards the STEM subjects cluster and potential career value of STEM skills.

<u>Social equity:</u>

- The school system and industry should seek opportunities to enhance and demonstrate the value of diverse and inclusive environments. These should be reinforced through industry-education partnerships, programs and engagement.

- Underrepresentation of women in the STEM workforce represents a talent shortage in the economy. Poor participation by females is an economic loss across Australia. For individuals, it is potential exclusion from entire sectors of highly paid STEM skilled careers. Teaching must demonstrate gender- and ethnic-diverse examples in role models, case studies and lesson plans.
- Chapter 1 of this discussion paper and observation/provisional recommendation 1.8 may fail to acknowledge unwelcoming and isolating secondary school environments as a critical problem. This misleads the observer to conclude that the problem of low participation is simply the choice of girls not to participate in STEM subjects. The true situation is far more complex.
- Poor STEM performance in rural areas may worsen future hardships as structural economic changes occur with deep automation of the economy.
- Inadequate engagement and education with the Aboriginal and Torres Strait Island communities is a very troubling gap that deserves special focus.

<u>Industry's role</u>

- For some years, the industry sector has raised a shortage of STEM skills to support growth of the Australian economy. The gaps are real, and the 'pain' felt by the industry sector is real.
- It is acknowledged that although industry has real world technical expertise that teaching children is indeed its own specialisation of education and pedagogy (p. 33 of discussion paper). Educators understand the curriculum and how young minds develop. Any industry partnerships towards teacher professional development should be led from within the education sector.
- In terms of the international competitiveness of Australia's workforce, industry is at the leading edge of exposure to rapidly changing global dynamics. The impact of declining STEM participation and declining STEM attainment might be felt first by industry, if only anecdotally. It is acknowledged that STEM partnership programs have proliferated. Quality is variable. Perhaps that proliferation reflects the enthusiasm of dedicated industry professionals willing to come forward to help and to convince individual businesses and industry associations to support solutions from outside the education sector. At a time of increased globalisation and rapid increase in technology skills among other nations in the Indo-Pacific region, Australian skills have stagnated or fallen. Declining PISA scores are a lagging indicator behind the anecdotes from industry leaders that performance in this generation of students has declined compared to a decade ago. The education sector has been slow to recognise the sliding performance, and although education researchers have recently identified causes, education research is also slow. Leadership actors in the education sector (school administrators, curriculum writers, and government policy-makers) have been slow to respond. The proliferation of programs is

partially the result of frustration from some well-intentioned industrialists who worry about national skills decline at a time of obvious increasing skills among economic competitors. The enthusiastic support of industry groups, distinct companies and individual STEM professionals is a valuable national resource to be harnessed in the quest of community support towards Australia's improvement efforts. The Warren Centre applauds the work of the STEM Partnerships Forum and hopes it might be a durable bridging forum for industry, schools, government and the tertiary sector.

- The school system and industry should seek opportunities to enhance and demonstrate the value of diverse and inclusive environments. These should be reinforced through industry-education partnerships.
- In summary, industry's role is to provide: feedback on skills gaps; economic signals from competitive globalised markets (international STEM bellwether); and practical experience to guide and complement pedagogy and careers advice.

Value of STEM beyond just industrial and primary economic benefits

- Although economic development is the prime driver, additional reasons justify enhanced STEM education. Disturbing recent global trends demand reorientation towards a society enlightened by the scientific method. Adopting science-based and statistics-validated thinking protects against superstition, hoax and outright fraud. STEM savvy citizens will be more resilient to fraudulent science promulgated through social media. An informed citizenry is resilient to climate scepticism, anti-vaxxer disinformation, and attacks on democracy.
- Greater awareness of life sciences may promote healthier habits, avoid preventable diseases and reduce health costs. Decisions to vaccinate, choose better nutrition, exercise, avoid drugs and sustain maternal health may be supported by better biology education and better awareness of statistical risks.
- Government can derive significant efficiency improvements by adopting digital services delivery. STEM education may modernise social norms to improve public acceptance of innovation in the roll-out of digital government services.

Answers to specific questions raised

Q1.4, Q1.5 – "21st century skills" are not necessarily new. These skills have been recognised by at least some employers for many decades. Some skills were not valued so highly by employers previously, and some have not been an assessable part of our school curricula. These skills are more difficult to teach in an assessment framework increasingly dependent on quantitative measures of success. (Q1.5) Assessment of 21st century skills requires a nuanced judgement, not just a tick in a box. Take "teamwork" for example. Everyone who has ever worked in a team or raised a family can recognise when children are collaborating effectively and working together as a team. Rather than constructing a rubric to objectively assess whether a

given standard of team work has been reached, individual skills can be improved by continuous reward and encouragement when they are observed in practice.

Q1.6, Q1.7 – The obsession with ATAR overshadows genuine learning if it encourages students to avoid undertaking challenging maths and science subjects for fear of spoiling a perfect academic career. Students do not learn by avoiding participation in senior secondary STEM subjects. Recent peer reviewed research on NSW students demonstrates how low levels of participation and attainment in senior secondary mathematics yielded students who were under-prepared for early university mathematics courses.[3] Follow up research published in 2018 shows that poor performance cascades forward from first semester difficulties to poor second semester performance in university physics and engineering courses.[4] Although universities have provided "bridging" courses to support students with poor secondary preparation, we are told by direct engagement with a lecturer of a summer bridging course that it provides only 50% of the required maths to commence a first year university STEM subject. University drop out / failure rates also potentially indicate inadequate STEM preparation in secondary school. This may be particularly evident in applied science studies with a lower ATAR that still require the same first year common science subjects as higher ATAR disciplines.

Q2.2, Q2.3 There are numerous Australian, US and UK examples cited in Appendix 1. (See for example, endnotes 6 and 9. Additional examples are in the parent documents on the Warren Centre website.) The best programs support teachers to understand economic trends and employment skills requirements. Ultimately, STEM programs are most effective when the provide context and empower students to undertake self-led extracurricular inquiry and learning.

The Warren Centre itself has sought to support teachers and parents through various efforts. Appendix 2 describes the Australian Kookaberry card, an initiative of industrialists within the broader Warren Centre network. Appendix 3 describes the Warren Centre's Inclusion[2] program and engaging videos aimed at girls and teachers.

A key problem with some industry partnership programs is that teachers do not know where to start to engage with highly technical volunteers from industry. Industry personnel who are very active in current business are busy and also do not have the curricula framework to shape their contribution. School schedules are fixed and cyclical. Discretionary service time from the industry partner can be difficult to match. Failure after the first or second meeting can lead to a fizzle of unsustained impact.

Q3.1, 3.2 Industry and tertiary supporters can create a sense of community and provide a scientist-on-call / technologist-on-call. Australia's community rugby clubs, cricket clubs and surf lifesaving clubs provide an example of how senior enthusiasts can instil a sense of encouragement and achievement in young STEM students. In the

US, the International Science and Engineering Fair (ISEF) is attended by volunteer industry professionals and delivers the same kind of local athletic club atmosphere as Australian community sports. The University of Sydney has supported a STEM Teacher Enrichment Academy for three or four years. A cluster of STEM teachers from one school enters the program as a cohort and jointly learns new skills and builds confidence. An industry philanthropist initiated the program, and it has delivered a number of successful training sessions. Teachers should not be in the position of quasi industry liaison officers. The burden would be high, and the results would be ad hoc and frustrating to teachers and industry.

The Warren Centre undertook a detailed analysis of 764 teacher survey responses from a study designed and administered by the Design and Technology Teachers' Association of Australia (DATTA) in collaboration with the Institute of Industrial Arts Technology Education (IIATE). Quantitative and qualitative results were reported to the Office of the Chief Scientist in a May 2016 report titled, "Technology and Engineering Teachers Survey Analysis" (wc3362-21). The original data set had information regarding industry partnerships and teacher feedback on those programs. Many of the comments in this 2018 discussion paper substantially repeats themes in the 2016 survey analysis.

Q3.4, Q3.5 Teacher qualifications, competence and confidence need to be surveyed/measured and analysed. Professional educators teaching off-discipline is a problem that needs education sector leadership and response. Entry pathways cannot be singular at the point of entry, and pathways must exist to change and adapt to new disciplines. In the observations and provisional recommendations section, the discussion paper suggests "to make subjects so compelling, so stimulating and so exciting that the student cannot help but be inspired". Schools need to be supported to "introduce" students to STEM rather than focussing on the performance of the school as a collective of the performance of the individual students. Teachers need technical knowledge and confidence to deliver it, but that is only part of the issue. Teachers need to be resourced, have time, and be able to facilitate a process that helps students discover a passion for STEM. The current pace of curriculum delivery fails to provide this atmosphere, and the singular focus on ATAR creates a conflict.

Q4.2, Q4.3, Q4.5 The Warren Centre undertakes each year to produce an Innovation Lecture that showcases an Australian innovator who has developed a new technology and taken it to market for real world impact. In 2014, Enrico Pallermo, and Australian engineer from The Spaceship Company in Mojave, California returned to Australia to tell his personal story of working in the burgeoning US private space industry with Virgin Galactic and rivals at SpaceX and Blue Origin. A special session was hosted during school hours to accommodate students and to open questions for a younger audience. In evening sessions, the lecture was repeated, with many parents and children attending. The Sydney lecture was repeated in Canberra, Perth and Adelaide where the Warren Centre built connections with local hosts. In February

2018, Elon Musk launched a remarkable demonstration rocket that was foreshadowed in the 2014 lecture. These programs provide real inspiration to young people. In 2015, Prof Salah Sukkarieh from the Australian Centre for Field Robotics described his work to build robots that can help Australian farmers. His work was showcased on ABC Catalyst in February 2018. In 2016, Marita Cheng told her story of multiple, serial social entrepreneurship ventures to build robots that help people. In 2017, Prof Andrew Harris of Laing O'Rourke Engineering described a vision of modern engineering from digital modelling to embedded sensors and smart actuators. His company's work to commercialise an Australian 3D printer described as the largest in the world for tiles on London's train upgrade project is a stellar example of Australian innovation on the global stage. We need more showcase examples of Australian stories in innovation.

The Warren Centre assembles a weekly review of science, technology and innovation. The Prototype newsletter aims to translate across boundaries of academia and business. It tells stories of Australian innovation mixed with trends in America, Europe and Asia that affect Australia. In annual surveys, STEM teachers indicate that they read The Prototype and use content to inform themselves and to make teaching more relatable to students. A typical story of 200 words might be followed with links to high academic journals like Nature or Science, but also with more approachable secondary sources like ABC, BBC and NPR. University press releases and YouTube videos accompany stories when they are available. Feedback is regularly in this form. "Subject: feedback on the Prototype. I LOVE IT!!! It is so great to receive a brief, accurate, unbiased, informative outline of some of the big issues around technology each week. I am a high school teacher and have found much of the material, links and ideas invaluable. I share much of what I read with my students and it is wonderful for them to have a teacher who is informed. Please keep it going!!!"

Summary

The Warren Centre appreciates the opportunity to provide answers to specific questions raised in the discussion paper. Please do not hesitate to contact us for further inquiry regarding the information in this submission.

Contacts

Ashley Brinson, Executive Director, The Warren Centre for Advanced Engineering
ashley.brinson@sydney.edu.au, (02) 9351 3752

About the Warren Centre for Advanced Engineering

The Warren Centre constantly challenges the economic, legal, environmental, social and political issues raised by innovation. We collaborate with industry, government and academia to achieve globally significant outcomes.
https://thewarrencentre.org.au/

Appendix 1: Three decades of Warren Centre STEM advocacy

The Warren Centre led early in public discussions on STEM education and has produced numerous recent papers on topics raised in this current discussion paper. In the 1988 *Preparing Australians for a future with technology* report, the Warren Center advised, "Australians must become more effective creators, producers and users of new technology if Australia is to have a real chance of becoming a freer, fairer and more prosperous society in the future. In the recent past, there has been a persistent divergence between industry and education. This report recommends a substantially increased focus on technology in our primary and secondary schools." That divergence persists. The report identified the importance of future ready citizens and advocated for each school to have a technology centre.

In 2007 the Warren Centre established the Education Project bringing together a roundtable of industry leaders including Macquarie Bank, Cisco, Resmed and Appen in conjunction with a broad cross section of the education sector including teachers and principals associations, primary, secondary and tertiary institutions, Parents & Citizens associations, Boards of Studies and related entities. The roundtable developed a strategy to: Review the challenges facing society, including business and industry in living and competing in this global and digital future; Consider the skills and attributes that our children will need to assist in meeting these challenges; Consider how the education system, in particular the K – 12 sector, might best equip our children to meet this future, and; Consider how ICT might be most effectively deployed across the K-12 sector to support our teachers in their task.

Recent submissions below highlight issues in this 2018 paper.

- Warren Centre study, *Who are Australia's Future Teachers?,* 2011, described the professional needs, motivations, expectations, dispositions, characteristics, skill sets, capacities, and demographic details of new teacher cohorts of education students in NSW. Over 900 starting teachers were surveyed using a Teacher Education Questionnaire. Longitudinal studies were recommended.
- Warren Centre submission to the APH Senate *Education, Employment and Workplace Relations References Committee Inquiry into the shortage of engineering and related employment skills*, May 2012. The submission reiterated the extensive long-term programs by the UK and US to address national skills issues by supporting STEM subject study and STEM teachers across all school years. Adaptation of international efforts was recommended.
- Submission to *Great Teaching, Inspired Learning* Discussion Paper, October 2012. Submission recommended re-establishment and support of specialist technology education degree courses, defined STEM specialisations, enhanced status for STEM, and updated perceptions for Design & Technology and Digital Technology to account for rising economic importance. A shortage of qualified

STEM teachers was noted, and programs were recommended to recognise and share outstanding practice among STEM teachers.

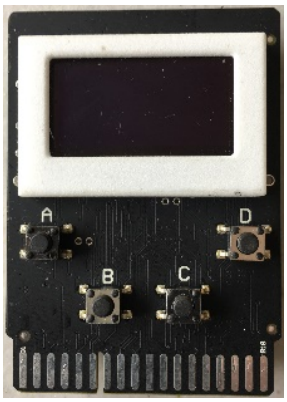
- *National STEM Strategy*, 2013. The Warren Centre called for: more emphasis on Technology & Engineering education; industry consultation in developing the strategy; recognition that technology and engineering education yields design solutions to meet human needs; education is key enabler of innovation; investment in STEM-qualified teachers; and the alarming lack of STEM qualifications in the teacher trainees who will educate future generations.
- Australian Federal Senate *Economics References Committee Inquiry into Australia's Innovation System*, June 2014.[5]
  - Technology literacy: Gap in widespread technology literacy in Australia. The problem arises in primary schools and is entrenched through the secondary system. Absence of nationally coordinated strategy for STEM subjects. Creates a lack of school leavers with a passion for technology. Australia needs significantly deeper literacy across the whole community on Technology and Engineering subjects – not just for professionals and practitioners in these fields, but in all members of our community. STEM subjects constitute the basic building blocks of addressing many technology related issues in society.
  - STEM education gaps: Extensive research by The Warren Centre and our colleagues has shown that a reliable grounding in the full breadth of STEM subjects – not just the maths and science, but also the technology and introductory engineering principles – is vital from primary school years and especially through late primary and early secondary schooling to provide children with the exposure to, enthusiasm for technology and innovation. This applies NOT just in traditional "technology" careers, but equally in all commercial and economic activity across all our industries.
  - Motivation gap: To enhance and support a vibrant Australian innovation culture, we need our education systems to deliver a rich pipeline of technology literate graduates (secondary and tertiary) enthusiastic to apply their knowledge and skills to address the issues they see around them.
  - Lack of strategy: Our national school education system lacks a coordinated strategy for the STEM subjects. Generally, Australian school education focuses on science and maths and deprioritises the technology and engineering subjects. In essence we teach kids the basic sciences, maths and knowledge only (the inventions), but not how to apply them and how to use them to address issues (the innovation processes).

- Vision for a STEM Nation, July 2015.
  - STEM: "Science" is not "STEM"; science is necessary, but not sufficient to capture the innovation opportunity of adding other dimensions.
  - Public-private partnerships: European and American exemplar programs can be adapted for Australia.[6] Public-private partnerships can motivate students towards careers in STEM, particularly engineering.
  - Teacher industry internships: Programs for internships help teachers understand how domestic businesses actually engage with the global STEM economy. Both European and US experiences show that contextualising teacher experience builds successful national STEM strategies.
  - Metrics needed: Broad metrics (parameters and targets) should be set to reflect international best practice indicators and international benchmarks.
  - Participation: The teaching of Science, Technology, Engineering and Mathematics in Primary and Secondary schools must be reformed to increase participation in the study of higher level STEM subjects in high school.[7] Overseas STEM education strategies are advanced, and Australia must catch up to international and regional peers.[8, 9, 10]
  - Disincentives: The current NAPLAN and ATAR ranking systems yield unintended consequences by creating perverse incentives for students to discontinue challenging STEM subjects. Avoiding challenging high school courses can yield higher ATAR scores but leaves students without exposure needed to excel at university STEM degrees, especially engineering.
  - Teacher capacity: Incentives are needed to encourage and support the entry of well-qualified STEM tertiary graduates or high-performing STEM students leaving high school into the teaching profession. The shortage of such specialist teachers is a problem, particularly in Primary and junior High School. Increasing the capacity of STEM teachers and increasing participation of students in STEM subjects is urgent. This is especially true for females[11] (both teachers and students) and for all students and teachers in disadvantaged socioeconomic areas.
  - Career changers can add capacity: Accreditation entry barriers for STEM professionals (e.g., those with an engineering degree) to retrain as High School STEM teachers should be streamlined. Career changers could provide a rapid increase of industry-aware specialists to education.
- Disruption Inquiry, February 2016
  - "Prioritise digital literacy and STEM education across primary, secondary and tertiary sectors. Allocate resources to STEM training for teachers and leverage digital learning models such as massively open online courses (MOOCs) to enhance the learning experience and gain further analytics."[12]
- Digital Economy Strategy, November 2017
  - "STEM education, diversity and inclusivity: For many years, the Warren Centre has advocated for strong STEM education to prepare students for the future. We are currently launching a new program called Inclusion2

focussing on encouraging greater gender diversity and inclusivity for the STEM professions and the entrepreneurship community. As digital transformation unfolds, it is obvious that Australia's efforts to improve diversity and inclusivity must accelerate. Otherwise, the undesirable effects of disruption are likely to be worsened. When the Warren Centre Innovation Advisory Committee met, there was strong praise from our industry advisors for an effort called The Australian Computing Academy. We are not affiliated with the initiative, but this is the sort of effort that the Warren Centre has recommended in the past. The Academy provides primary and secondary educators with the resources and skills required to fulfil the ambitious goals of the Australian Curriculum: Digital Technologies." The Academy is delivering a series of free National Digital Technologies Challenges…. The challenges are mapped against the Australian Curriculum: Digital Technologies and come with support materials, such as lesson plans, notes, hints and videos with further online support and a telephone hotline for teachers. The challenges are engaging and authentic, often reflecting on real-world problems. They are designed to be interactive, providing real-time feedback to the learners, helping them to tackle curriculum concepts and improving their code. The Academy also provides support for teachers in several ways, including teacher professional development workshops delivered throughout the country; an online virtual community for teachers; and a messaging and phone help desk to ask for content, technical or pedagogical support and discuss how teachers are using the activities in the classroom. In 2016, the Warren Centre undertook support for technology teachers to analyse a professional survey. There were consistent messages from the teachers that this was exactly the type of ongoing professional development support they needed. We applaud the efforts of the Australian Computing Academy and look forward to reports on their program outcomes. Australia needs more efforts like this." [13]

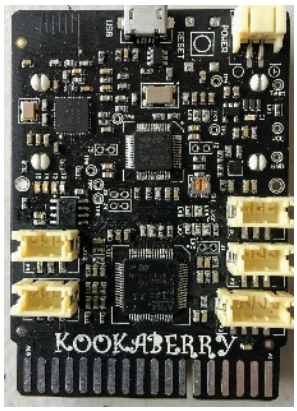
Appendix 2: Case Study: Australia's Kookaberry

The AustSTEM Foundation, a not-for-profit charity, has collaborated with Australian industry to develop a late primary classroom tool, the Kookaberry, to engage students directly with the science, technology and maths in the world around them.



Kookaberry is a credit card-sized, microcontroller-based, plug-and-play, technology platform targeted at Primary teachers who have no software or coding experience.

Kookaberry is compatible with both the Arduino and the micro:bit. It is capable of supporting the Digital Technologies Curriculum through High School.



To be made available nationally to all Year 5 children, Kookaberry will foster equity in STEM and technology-enabled learning, putting real experience into experiential learning across the curriculum and providing feedback required for individual student-paced learning across all subjects. Features:

- **Hands on**: Allowing children to react creatively with their local environment
- **Inclusive**: Providing access to real hardware for all children irrespective of their families' socio-economic status
- **Empowering**: Sparking curiosity in boys and girls who may never have previously considered using technology
- **Independent of the Internet**: Allowing uninterrupted operation in the absence of internet access
- **Easy to use**: Pre-programmed applications with minimal setup time (<5 mins)
- **Cheap to manufacture**: Designed to a budget of less than $20 when manufactured in large quantities
- **Open Source**: Allowing for completely free sharing and modification of both hardware and software
- **A Complete System**: Up to 400 on-board applications, accompanied by video tutorials, lesson plans, and logistics and support systems.

AustSTEM is currently finalising arrangements with NSW Universities, software experts, educators, and selected schools for a trial of the first 100 Kookaberry production boards during March. Once funding is in place, trials of around 1000 boards are scheduled for Primary schools across the nation, with Kookaberries planned to be made freely available to all Year 5 school children during 2019.

Appendix 3: Inclusion²

The Warren Centre's Inclusion² program is supported under the Women in STEM and Entrepreneurship Program, an initiative of the National Innovation and Science Agenda. Inclusion² is the first whole-of-career approach to support women in STEM. The program empowers women in STEM and entrepreneurship at critical career stages from school to mid-career entrepreneurship and on to senior executive.

The first tier aims to inspire young women to pursue STEM careers through engaging videos distributed via social media. The videos aim to improve the participation rate of women in STEM fields by building role models intended for 12- to 14-year-old girls.

Lights! Camera! Action! We recruited five undergraduate women to tell their stories to late primary and early secondary girls. Professional film crews recorded and edited compelling stories to share among girls and young women on social media.

A frame from one of the finished videos is below:

Later tiers of the program encourage mid-career entrepreneurship and late-career executive leadership. Our first Inclusion2 Entrepreneurship 101 Master Class is scheduled for 23 February 2018.

Notes

[1] Office of the Chief Scientist, Transforming STEM teaching in Australian primary schools: everybody's business, December 2015, p. 5.
[2] Rachel Wilson and John Mack, "Declines in High School Mathematics and Science Participation: Evidence of Students' and Future Teachers' Disengagement with Maths", International Journal of Innovation in Science and Mathematics Education, 22(7), 35-48, 2014.
[3] Jackie Nicholas, Leon Poladian, John Mack, Rachel Wilson. "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, 23(1), 37-31, 2015.
[4] Yoshitaka Nakakoji and Rachel Wilson. "First-Year Mathematics and Its Application to Science: Evidence of Transfer of Learning to Physics and Engineering", Education Sciences, 2018, 8, 8.
[5] Australian Federal Senate Economics References Committee Inquiry into Australia's Innovation System, June 2014, at http://thewarrencentre.org.au/wp-content/uploads/2011/11/wc2662-1-SenateInnovationSystemInquiry.pdf .
[6] For example, the Sally Ride ExxonMobil Academy at <https://sallyridescience.com/programs>.
[7] Russell Tytler et al, "Opening up pathways: Engagement in STEM across the Primary-Secondary school transition – Final Report", Australian Department of Education, Employment and Workplace Relations, June 2008.
[8] The Warren Centre, "Submission by The Warren Centre to the Senate's Inquiry into the Shortage of Engineering and Related Employment Skills", 2012, at <http://thewarrencentre.org.au/engineering-skills-education/ensk-resources/> along with many other papers on STEM subjects.
[9] Caroline Kearney, "Efforts to Increase Students' Interest in Pursuing Science, Technology, Engineering and Mathematics Studies and Careers – National Measures taken by 21 of European Schoolnet's Member Countries – 2011 Report", at <http://www.fisme.science.uu.nl/publicaties/literatuur/2011_european_schoolnet.pdf>.
[10] Sue Thomson, Lisa De Bortoli, Sarah Buckley, "PISA 2012: How Australia measures up", Australian Council for Educational Research, 2012.
[11] Australian Mathematical Sciences Institute, "Dealing with Australia's Mathematical Deficit", 2014.
[12] Disruption Inquiry for Productivity Commission consultation, February 2016, at https://thewarrencentre.org.au/wp-content/uploads/2016/02/wc3250-6-Productivity-Commission-Disruption-Inquiry.pdf
[13] Digital Economy Strategy, November 2017, at https://thewarrencentre.org.au/wp-content/uploads/2017/12/wc4188-0-Digital-Economy-Strategy.pdf