Creating a Pipeline of STEM skills for the Digital Economy

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In partnership with:

The report draws heavily on the STEM Pipeline for the Digital Economy Round Table held in Melbourne on Wednesday 8th October at Swinburne University of Technology.

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Introduction

This paper arose from a round table discussion conducted at Swinburne University of Technology in October 2014. The round table was co-presented by Cisco, the Business/Higher Education Round Table and Swinburne to generate discussion and direction for future action. The discussion was led by expert speakers including:

- Dr Alan Finkel AO, Chancellor, Monash University
- Dr Pamela Gay, Center for STEM Research Education and Outreach, Southern Illinois University
- Dr Brian Fitzgerald, CEO, Business-Higher Education Forum, Washington
- Professor Ian Chubb AC, Chief Scientist of Australia.

This report considers:

- The problem of Australia’s poor performance in developing STEM skills
- Why Australia’s STEM performance is poor
- What’s required and potential ways forward

1.1. The problem of Australia’s poor performance in developing STEM skills

Australia’s economy, like that of many of its competitors, is described as being ‘in transition’. For example, while agriculture and manufacturing will continue to be major industry sectors and sources of employment, the nature of jobs in those industries is changing in fundamental ways. It is estimated that 47% of today’s jobs will be able to be automated over the next decade or two.1 What is less understood as the economy transforms is the specific nature of ‘reconfigured jobs’ that will be required as replacements, and the foundational skills required to do them. While the answer is not straightforward, there is overwhelming evidence to suggest that STEM competencies are and will continue to be in high demand in the future. It is estimated that 75% of the fastest growing occupations require STEM related skills and experience.

[There are] no occupations, careers or professions that are not reliant on understanding of STEM skills.

– Dr Alan Finkel AO, Chancellor Monash University

So how well placed is Australia to thrive in a STEM-dependent economy? While Australia has the raw ingredients to prosper, including a long history of excellence in scientific research, its historic advantages are under threat. Not only does skill supply not match demand but it is in steady decline. All signs suggest that this downward trend will continue without decisive and rapid intervention. Perhaps the best indicator of Australia’s shortcomings in STEM is the ‘pipeline’ of future STEM graduates in our primary and secondary schools. Consider that at a time when STEM competencies are in high demand around the world:

- Australia has experienced a decline in year 12 participation rates for STEM subjects across the board. Between 1992 and 2010, participation in Year 12 biology dropped from 35-24%, physics (21-14%), chemistry (23-17%) maths (77-72%). The statistics for maths are actually less positive than they appear on the surface given that of the 72%, only 10% of students were studying at an advanced maths level in 2010.2

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1 Frey, Carl B. and Osborne, Michael A., The future of employment: how susceptible are jobs to computerization?, 2013.
2 Finkel, Alan, Attracting and Retaining STEM Talent, The STEM Pipeline for the Digital Economy Round Table, 2014. www.bhert.com,
• The situation for women’s participation is even worse than the average, with just 6.6% of girls sitting advanced maths in 2013 - just half the rate for boys and a 23% decline since 2004.3

It’s not just Australia’s year on year performance that is attracting attention, Australia’s competitors are considered to be responding faster and more decisively than Australia. Australia is falling behind on some of the innovation indices, certainly on productivity relative to countries such as the US or Germany. Our universities are world class with six in the top 100, but rankings are based mostly on our research capability not on the adaptability and workplace readiness of our graduates. As a result, we are unprepared for the new era that we are entering.4 Australia’s major economic competitors and sources of wealth are responding to the global shift towards STEM skills in tangible ways. Consider for example that:

• China and Russia have mandated the study of mathematics as a compulsory subject until the end of secondary school.

• The UK now insists that all primary schools students be taught software ‘coding’.5

• China has prioritised ICT in its Five Year Plans for decades. The ICT industry is identified as one of 7 strategic and emerging industries.6

• The European Union (EU) has committed to doubling public investment in ICT to € 11 bn by 2020.7

• Singapore has demonstrated a commitment to ‘productive failure’: letting people struggle with a problem and later asking them how they managed, with the objective of helping people develop mental models that create long lasting capability.

• Teacher salaries, the status of the profession and the value attributed to education in countries such as Finland are significantly higher than in Australia, which contributes to positive educational outcomes.

At the same time, Australia’s IT competitiveness has slipped from 9th (2004) to 18th today without intervention, there is every likelihood the downward trajectory will continue.

Until September 2014, Australia was the only OECD country without a plan setting out its future in science.

“If you think education is expensive, try ignorance.”

- Derek Bok, Lawyer and educator

The mismatch between the forecast demand for, and supply of, STEM is now a significant policy priority. The major themes arising from the round table and potential next steps are echoed in the recent release of the Chief Scientist’s report, Science, Technology, Engineering and Mathematics: Australia’s Future.

While there is a clear objective to increase the number of graduates with STEM credentials (undergraduate, postgraduate and beyond), the challenge is broader. There is a need to ensure that all people have the capacity to engage with STEM in a

4 Finkel, Alan op cit.
fundamental way, even if they aren’t deep subject matter specialists. For example, the capacity to do basic mathematic computations is critical to participating in a wide range of professions. The nature of innovation is also changing within companies and what is emerging is a new model that has been described as ‘T shaped professionals’: people who can combine deep subject matter expertise in one or two areas with broad generic competencies around collaboration and problem solving. This shift is creating demand for a new type of worker that is capable of interacting with or managing STEM inputs without necessarily having a STEM degree.

1.2. Why Australia’s STEM performance is poor

More difficult secondary school subjects are penalised

A number of commentators at the forum suggested that students do not study STEM because those subjects are perceived to be difficult and may result in lower ranking (and a lower ATAR score affecting university entry options). Because fewer students are studying STEM subjects, universities have moved away from demanding prerequisite subjects. Instead a higher priority is placed on the ATAR score of students. The focus on ATAR scores feeds students’ fear of studying subjects perceived as difficult that may lower their ATAR score. The circular nature of the logic behind students not studying STEM subjects in the latter years of high school and consequently at university therefore continues to be perpetuated.

The career advantages associated with STEM competencies are not understood

Another related contributor to the problem of students abandoning STEM subjects in the latter years of secondary school is the limited understanding by teachers, careers counsellors and parents of the vital relationship between future career opportunities and STEM skills. Teachers, students and parents are not considered to be well informed and up-to-date about career opportunities and the realities of the job market that will unequivocally comprise a high proportion of STEM related skills. The lack of understanding prevents parents, teachers and students from connecting STEM study with real world opportunities (and therefore additional incentives to persevere with STEM subjects beyond the middle years of secondary school).

The way STEM is taught is not necessarily conducive to developing a love of STEM and a capacity to apply it

Pamela Gay’s message was very clear. Teaching STEM subjects to a broader student population requires a commitment to genuine inquiry-based learning, a method of learning that allows for the mastery of critical concepts and rules. This is different to skills training, technical mastery or the learning of facts. Gay argued that science, too often, involves demonstration to young people, not experimentation. By teaching science and maths in an ‘inquiry’ based style with its emphasis on learning and reflection is i) more fun and, importantly ii) the principles of STEM are more likely to be retained and pursued.

“The objective in STEM teaching needs to be about sparking curiosity and making kids brave enough to ask why.”

- Pamela Gay, Astronomer and educator

A shortage of qualified teachers exists in STEM disciplines

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Exacerbating both the disincentive for students to study STEM subjects, and the variable quality of learning received by those that do, is an under-supply of teacher professionals in maths, science and ICT. It is perceived as a problem that teachers are no longer required to be discipline specialists (for example, 23% of Australian secondary mathematics teachers have not studied a mathematics subject). Teacher salaries are relatively low and workplace practices are not optimised for productivity. Professor Chubb recommends that teachers need to be better prepared and better supported by:

- Strengthening their content knowledge;
- Maintaining it at contemporary levels;
- Instilling the confidence to deliver the curriculum in interesting and novel ways, with relevant pedagogical development.

The effect of the shortage of qualified teachers in STEM disciplines has created a range of downstream impacts on the economy. Not only are some schools unable to offer specialist STEM subjects in senior years, those that do often rely on teachers without requisite subject matter knowledge. The undersupply of highly qualified STEM teachers may also lead to a poorer student experience and may contribute to high attrition rates in STEM subjects. While some efforts have been made to address the shortage of STEM-trained teachers, the average ATAR for teachers coming into the profession is actually declining. In some institutions the prerequisite ATAR is as low as 40 which is considered to be a contributing factor to low quality teaching and science excellence.

**Low levels of engagement - and performance – remain from a significant segment of the Australia population**

The Chief Scientist reported that a significant proportion of Australia’s population is not engaged with technology and has limited capacity for engagement. Consider, for example, that more than two in five families in the lowest income bracket (representing more than 610,000 families and their children) are not connected to the internet. Or consider that the achievement gap between best and worst performing states in maths is the equivalent of two years of schooling. These are alarming signals which again demonstrate the need for a major rethink about national strategies to improve access to, and the quality of, STEM teaching and skills development.

**The notion of talent security is not a priority in Australia compared to elsewhere**

In a more competitive and globalised economy, the best way to think about Australia’s STEM challenges is through the prism of an increasingly fierce competition for talent. Growth, investment and improved export opportunities are all dependent on access to the right mix of skilled and qualified people to fuel the innovation, design, production and marketing capabilities of firms, especially those competing in the digital economy. That “talent war” has a particularly acute focus in the STEM disciplines and is ramping up the importance of “talent security” as a major national policy imperative. That sense of urgency that exists in other countries about talent security is not considered to be as intense in Australia. ICT enrolments are one example of the extent to which talent security is being undermined. While Australian industry dependence on ICT is increasing, ICT student numbers are only inching forward after halving more than a decade ago. The gap is being filled by imported talent with a 74% increase in the uptake of 457 visas by ICT professionals in the past two years.

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9 Finkel, Alan, *op cit.*
1.3. What’s required and potential ways forward

The round table facilitated a wide-ranging discussion about STEM. Of major interest to those in attendance was where the conversation might lead and how some of the issues raised might be resolved. While there is significant work remaining to prioritise and implement, the round table pointed towards four broad areas for further discussion / action:

1. Adopt a “long-term now” approach

One of the challenges associated with being an economy or society in ‘transition’ is that no one knows how long the transition will take or even when it started. Addressing major issues about the supply of STEM skills to the Australian economy requires long-term, strategic action. The overwhelming sentiment of those attending the round table was that action was required urgently even though results will not necessarily accrue immediately. It is also worth noting that many of the aspirations and priorities outlined as part of the round table were reflected in Industry Innovation and Competitiveness Agenda – the Australian Government’s action plan for a stronger Australia. This has the potential to create significant additional momentum for themes that were explored.

The presentation by Dr Brian Fitzgerald focused on BHEF’s track record of sustained action in the United States is illustrative. The US has been focused on building its STEM pipeline for decades and the task is far from complete. There are a number of activities required to promote a long term, sustained focus on STEM:

- Commitment to a national strategy for STEM as part of a wider economic discourse.
- Universities and industry take the lead and partner in the implementation of a national STEM strategy that links education, research and innovation.

There is an acknowledged disconnect between STEM disciplines and the creative disciplines (including arts). Some argue that instead of STEM, Australia should be focused on building capability in STEAM (with the A representing Arts as a headline covering arts, culture, design and creativity) thereby bridging the divide between humanities and science/engineering faculties in universities / industry. There are some programs underway that show promise. ATSE is leading a new program entitled ISME (inspirational science and maths education) which is a collaboration of ATSE and three universities. Funded through the government’s AMSPPP program, it will develop at least five authentic multi-disciplinary classroom modules that will be made available nationwide. Cosmos for Schools is a link to breaking news stories which is exciting for students and teachers alike. It promotes English literacy, science knowledge and understanding and future careers. There are other examples but not at the scale of that’s required to make a national difference.

2. Create high value ongoing partnerships between business and universities that enable action

A recurring theme of the round table was the cultural gap between business and universities that hampers more productive collaboration. Business often doesn’t have the patience for long, slow processes; companies need to see movement and outcomes quickly. However, universities are an under-utilised resource with skills, knowledge and expertise that are crucial if we are to lift productivity and innovation. Business success, nationally and internationally, is dependent on the talent and skills of their new graduate recruits for the next decade and beyond. These business/university partnerships are essential in addressing the development of a highly skilled 21st century workforce which must be innovative and world class.

Greater cross-fertilisation between academia and business is likely to lead to university expertise being more highly valued by industry. Less than 30% of Australian researchers work in industry compared to Germany and the US where the figure hovers around 70% of PhD graduates employed in industry. Anecdotally, it has also been suggested that there are low numbers of PhDs on Australian Boards. Poor collaboration and declining innovation has led to a culture of risk aversion and inward focus in Australia. An example of effective collaboration was announced at the round table event, with Cisco and Swinburne University agreeing to partner on new research initiatives related to the ‘Internet of Everything’. Under the agreement, Cisco and Swinburne will look to foster learning environments that integrate pedagogy, facilities and technology to boost student participation rates and focus on building a platform for innovation.

B/HERT is an organisation that not only understands these challenges and recognises the benefits of productive collaboration between business/industry and higher education, but also has the capacity to act. Specific initiatives that could be pursued include:

- Convene a CEO/VC “Australian STEM Leadership” forum with the specific purpose of developing an implementation plan to accelerate the Chief Scientist’s Agenda for Change in STEM learning and adoption.

- Ensure STEM skills are part of the national conversation through identification and publication of good examples of industry-led STEM projects.

- Connect global good practice in university/business collaboration overseas, and encourage adaptation of the international experience by the Australian representatives of those companies.

- Hold a STEM pipeline discussion at least once a year to review progress, showcase successes, highlight continuing blockages and broaden the debate to new participants.

- Monitor Australia’s international rankings to ensure the strategies are making a difference.

The demand for talent and STEM skills is the basis of the Higher Education Workforce Initiative (HEWI) being conducted by the Business-Higher Education Forum in America. CEO Dr Brian Fitzgerald outlined employers’ reliance on STEM skills is exploding beyond STEM jobs and increasingly there is a call for STEM enabled worker across a broad range of occupations. Through business/university partnerships, HEWI focuses on building up talent to feed into regional projects that include data science and analytics, financial services, water and materials sciences, energy and engineering. The initiative deploys a model of strategic business engagement in higher education to address employers’ high-skill, high-priority workforce needs. Initiatives like HEWI recognise that talent security is as critical as other dimensions of security for future economic and social development.

3. Understand the problem - fill information gaps

Australia urgently needs a better fact base for decisions around STEM policy. This should be an integral part of a plan of action, not instead of it. While much is known about the cause of Australia’s STEM challenges, some crucial questions remain:

- What’s fuelling the decline in ICT study?

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• What has been the impact of removing prerequisites from the study of STEM courses in universities?

• Where should the effort be focused in building the STEM pipeline? BHEF, for example, undertook a project in the US to model the success rate of STEM education in the schools system. The modelling showed how excellent teaching can stimulate STEM interest among students but not arrest the decline in later secondary school. The result is that BHEF’s HEWI program aims to minimize student attrition in the first two years of undergraduate study. The objective is to retain a significant proportion of the undergraduate students who are currently dropping STEM study and build the skilled workforce base needed. Australia would benefit from a sound understanding of the critical points in our educational system to capture and retain student interest in STEM study.

4. Take what’s working and do it scale

Australia has many examples of excellence but lacks a coordinated approach and the commitment to scale. One participant described Australia’s default position as ‘incrementalism’. The challenge, therefore, is not necessarily to invent new approaches and policies, but rather to take what’s working and scale them.

The John Monash Science School was held up as an example of leading practice. The school’s Principal, Peter Corkill, spoke of the school’s impressive results in bringing subjects such as nanotechnology, bioinformatics and astrophysics to secondary school students. The selective science school’s focus was on real world problem-solving and the application of science, not just the study of science. (This also reflects Pamela Gay’s emphasis.) The school recently began exporting its curriculum beyond the school boundaries to other parts of the Victoria using video technology. The philosophy adopted is that there is a finite number of great teachers and an infinite number of kids that want to learn good science.

Another example of excellence that could be scaled up is Cisco’s commitment to AusSTEM 2020. As part of the initiative Cisco has committed to having 20% of its workforce providing 20 hours of mentoring a year to students by 2020. The opportunity is for this approach to be adopted more broadly by industry, ensuring that students get opportunities to understand how STEM is applied by companies and the job opportunities that potentially exist. One potential opportunity is to sponsor a competition to find the best examples of STEM learning and skills development in industry and education.

This round table formed an excellent starting point for action. We look forward to presenting future reports on progress.