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AUSTRALIA'S CHIEF SCIENTIST

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******** CHECK AGAINST DELIVERY ********

Good morning, it is good to be with you and thank you for the invitation.

In the course of my work, I am invited to many events to talk about the importance of science.

But it is when I attend one like this, that I look around the room and sense a certain affinity with the responsibility that you bear.

I know it is teachers who work so hard on a daily basis to spark an interest in science among our students, one that we want to continue stoking for many years.

Science, technology, engineering and mathematics (STEM) skills serve students well.

But they also serve Australia. We cannot hope to remain an innovative, stable and prosperous nation without them.

Just about everything to do with the houses we live in, the food we eat, the cars we drive, the medicine we take, the communities and infrastructure we build, has required some or all of these skills.

And if you take a moment to think about the challenges confronting Australia, or the world, can you identify one that will not require a scientific solution?

So we need a steady supply of people with science, technology, engineering and mathematics (STEM) skills and that means continually developing them so we have them, when and where we need them most?

But we have an issue. Young people are not studying these disciplines in the numbers we need.

It was something we identified in two reports out of my office - *Mathematics, Engineering and Science In The National Interest* and *The Health of Australia Science, (MES & HAS).*

I have been talking about this problem a lot since May, but it bears repeating.

MES revealed a survey of Year 11 and 12 students, which indicated a fairly low understanding of how valuable science is.[1]

Of those actually studying science, 33% thought science was 'almost always' relevant to their future although 47% thought it 'almost always' relevant to Australia's future

Only 19% thought it 'almost always' useful in everyday life.

And when those students not studying science (roughly one-third the cohort) were surveyed it got even scarier.

[1] Australian Academy of Science, 2011. *The Status and Quality of Year 11 and 12 Science in Australian Schools*

Just 1% thought it relevant to their future ‘almost always’ and 42% thought never.

4% thought it ‘almost always’ useful in everyday life, 42% thought sometimes and 18% thought never.

I wonder how many of those surveyed, who questioned science’s relevance to their future or their everyday lives, pulled out their smartphone shortly afterwards without thinking about how science and innovation had provided it?

I’ll talk more about secondary schools in a moment, but is it possible that complacency about science starts much earlier?

Should we also be focusing on how to engage primary school students so that they’re naturally drawn to science and the joy of discovery?

I read with interest a recent article on *The Conversation* website by David Blair, Director of the Australian International Gravitational Research Centre at the University of Western Australia.

He questions the notion that you have to teach kids 300 year-old Newtonian physics, based on disproved 2300-year-old

Euclidean geometry, before you can teach them Einstein's theories.[2]

The logic of this traditional approach is apparently that kids can't learn the truth without first learning the old theories as a foundation.

So David and a colleague set out to teach 11 and 12-year-olds two of Einstein's theories (after an introductory whistle stop tour of the history of ideas that led him to them).

After a few sessions, these children learned Einstein's key prediction that time depends on your height above the ground.

They also learnt about how GPS navigators only work by correcting this time warp that Earth creates.

What amazed David Blair most about his outreach project was that the children showed none of the bewilderment or surprise he has noted in adult audiences.

They were interested. More importantly they didn't think they were too young to be learning this material.

Isolated examples like this one are interesting, but should we replicate them on a grander scale, and if so, how?

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[2] https://theconversation.edu.au/testing-the-theory-taking-einstein-to-primary-schools-9710

A review of primary school education a few years ago suggested some scientists believe the school curriculum held an out-dated and discipline-bound view of science.

They felt the focus should be on engaging young people, not on developing future scientists, but perhaps these don't need to be mutually exclusive.

Surely it is engaged young people who will continue on to become our future scientists.

Regardless of when the right time is and what measures we implement, the key message is that we have to do something.

The MES report revealed that the proportion of enrolments in mathematics and science in Year 12 has decreased over the years and that it continues to fall slowly.

Nationally, 51 per cent of students take a science subject or subjects (including psychology) which amounted to 110,328 students in 2010.[3]

Between 1992 (after which school retention rates were fairly stable) and 2009, the proportion of Year 12 students taking physics, chemistry and biology fell by 31 per cent, 23 per cent and 32 per cent respectively.[4]

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[3] MES in the National Interest – Pg 20
[4] MES – Pg 20

While there were 153,512 students studying mathematics in Year 12 in 2010, or 72 percent of the cohort, it was important to note the shift from `advanced' to `intermediate' or `elementary'

The consultation we undertook to try and understand the reasons behind the decrease, allowed us to hear some important messages.

One was that inspirational teaching is seen as the key - both to the quality of our science education system, but just as importantly to raising student interest to more acceptable levels.

Inspiring teachers will generally be those who are confident that they know their subject well, and can transmit that confidence, and their passion, into the classroom.

We have many teachers like that, but we need more. We require coherent in-service support for teachers, and quality pre-service education.

It is time to re-think how we prepare our teachers and how we support them: support to strengthen their content knowledge, to maintain it at contemporary levels and to instil the confidence to deliver the curriculum in interesting and novel ways.

The other key message was that the way we teach science, especially the techniques we use, needs to change.

That does not mean dumbing it down, but it is important to note that many students said they found the way science was being taught to them was too didactic, even boring.

They thought that the scientific facts were not related to what they saw around them, and practical classes were largely about recipes or watching teachers following recipes, with little time for reflection.

It was a theme we followed up on in the *Health of Australian Science Report.*

It cited a survey of students on how to improve science classes.

The most common suggestion they provided for improving science classes was to make those classes more interactive by including more investigations, excursions, practical lessons or class discussions.

Thirty per cent of students suggested this.

During our consultations (for *MES*), teachers themselves acknowledged the issues and thought that health and safety guidelines restricted their ability to offer ‘interesting’ practicals, and the lack of technical support meant that too much of the preparation was left to teachers with too little time.

The importance of technical support for science teachers was emphasised time and again.

The issue is that science is not taught as it is actually practised: hypothesis, experimentation, observation, interpretation and debate.

And interesting ways of getting the facts into context are not used often enough.

There are novel ways of enhancing the classroom experience of students while supporting teachers and bringing practitioners into the classroom.

The best of these draw on the expertise and enthusiasm of the mathematics, engineering and science community - the active practitioners.

For example, school principals and teachers spoke positively about some innovative pilot programs to bring mathematicians, scientists and engineers into schools involving the Australian Academy of Science, the Australian Academy of Technological Services and CSIRO.

There were also some helpful ideas in a submission from the Australian Council of Deans of Science.

The ACDS explained two notable reasons for teachers favoring dry theory over laboratory activities.

One was the enactment of much more stringent occupational health and safety requirements, which many teachers lack the expertise and resources to meet.

The other was teachers' lack of laboratory experience, which might result in them finding it hard to produce educationally sound activities and to adapt creatively to limited resources.

The ACDS suggested extending the ASELL project (Advancing Science Education by Learning in the Laboratory) to include not just tertiary science teachers, but those teaching Year 7-10 science as well.

So it was extremely pleasing to see the first ASELL Schools Workshop conducted just two months after the publication of our report.

Three experiments were submitted for evaluation at the first workshop in Sydney, so I think it is fair to say we have some way to go in establishing ASELL in schools on a larger scale.

My understanding is the next workshop will be in Adelaide next week and there will be one here in Victoria next year.

So I welcome this measure, just as I welcome changes to the Australian curriculum for secondary schools, to now include the strands - `*science as a human endeavour*' and `*science inquiry skills*'.[5]

We need more students experiencing the joy of scientific discovery through fieldwork and laboratory experiments.

Some of you might also be aware that following our MES Report, this year's federal budget allocated $54 million to begin to address issues related to training teachers and inspiring students to a greater interest in science and mathematics.[6]

The figure has been bandied about a fair bit since May, but I'm sure you would be interested in a little more detail about where some of this money will be directed.

The programs arising from this announcement will be run out of the Dept of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE) and the Dept of Education, Employment and Workplace Relations (DEEWR).

In order to drive inspirational and high quality teaching in high school maths and science there was a promise of: -

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[5] ACARA – The Australian Curriculum – Version 3.0

[6] http://ministers.deewr.gov.au/evans/budget-2012-13-investing-science-and-maths-smarter-future

$10.9 million to improve the quality of teacher training through innovative delivery of maths and science teaching programs for prospective teachers.

$3.0 million for national support and advice for teachers, including funding for a national advisory and linking service, online videos to illustrate new teaching standards, practical activities for school science laboratories and to provide advice for school science laboratory technicians and science teachers on safe practices.

$5 million for the Science Connections program to equip teachers with the ability and confidence to deliver inquiry-based science education and to provide a suite of high quality curriculum resources linked to the Australian Curriculum for Science (Foundation to Year 10) which I just mentioned.

And while we should all welcome measures such as this, I hasten to add that you can find similar statements of intent in other developed countries that we compete with, and collaborate with.

For example in the U.S., the National Science Education Standards emphasized that science education in primary and secondary schools must be something that students do, not something that is done for them.[7]

What does that tell you? Surely one thing is that the United States has identified some of the same impediments to attracting more of its young people to study STEM.

And they also are adjusting the way they teach science in order to address a potential blockage at the start of the supply line.

This means we cannot afford to complacent about the issues I have just outlined if we want to remain a competitive and innovative nation able to meet the demands of a global, knowledge-rich economy.

Moving from schools to higher education, the *Health of Australian Science* report looked at our universities and showed the extent to which the enabling sciences of mathematics, chemistry and physics all suffered declines in enrolments among undergraduate science students in the 1990s, especially at the continuing level.[8]

[7] Vision and Change in Undergraduate biology education: A Call To Action – Pg 57

[8] HAS – Pg 59

These losses have not been recovered and this looms as a potential problem.

An *Interests and Recruitment in Science* (IRIS) survey of 3500 first-year university science undergraduates at 30 Australian universities offers some potential insights in this regard.

Respondents indicated a generally positive response to their experiences, with 78% agreeing they had become more interested in their subject since starting their course, while 82% agreed that their universities offered good working conditions. [9]

Around 77% agreed that the course suited their personalities, while a similar proportion believed they saw the relevance of what they were learning.

However, respondents were less positive about their interactions with and support from teaching staff.

Only 56% agreed that their teachers cared about whether they learned or not while fewer than half (46%) believed they received personal feedback from lecturers and teachers when needed.

[9] *Starting Out in STEM: A study of young men and women in first year science, technology, engineering and mathematics courses – Pg 43 & 44*

It might be worthwhile for universities to note this, but the reason people move out of STEM courses is likely to be multi-faceted.

And it is important that STEM courses at universities continue to be seen as a vital gateway to a broad range of careers, not just in scientific research, but in many other sectors.

You should point your students to the Australian Council of Deans of Science commissioned report by Dr Kerri-Lee Harris, *A Background in Science: What Science Means for Australian Society.*

Dr Harris asked 805 science graduates in what ways their science degree was useful.

One in four respondents were working in scientific or medical research, and 12 per cent worked in scientific or engineering industries. [10]

But the rest had found jobs across sectors including law, government, health, education, food, agriculture, mining and construction.

[10] http://www.cshe.unimelb.edu.au/research/disciplines/docs/BackgroundInScience%20_web.pdf Pg VIII

97% of all respondents, regardless of where they were working, said their science knowledge or skills were useful in their work.

STEM graduates also said many social and personal issues are more easily navigated with the aid of scientific knowledge and skills.

Simple things like being able to understand your doctor more easily or establishing what is important or not in media reports.

88% of respondents reported drawing on their science knowledge or skills in understanding contemporary issues in society; 83% in providing advice to friends and family; and 87% in their personal interests and pursuits.

These are all important messages and it is up to all of us to communicate the breadth of a STEM background to students considering what university course to take.

The IRIS survey found the most common reason undergraduates gave for enrolling in STEM was their own interest in the subject.

We need to work out how to harness that interest, nurture it, keep it and grow it in others currently less interested.

In its report, *Vision and Change in Undergraduate Biology Education: A Call To Action,* the American Association for the Advancement of Science, tackles similar questions like ``how to induce students to enjoy science from the first day of their academic experience in a biology course?''

Suggestions given are: -

- Connecting the student to a community of scholars
- Personalizing the learning experience
- Placing science in context with events in students' lives
- Developing a curriculum sequence organized around widely agreed upon content themes
- Designing the curriculum so that it develops student competencies[11]

It also noted that making undergraduate course and teaching methods more student-centred and relevant, and providing authentic research experiences as part of an undergraduate education can also help achieve these ends.

And if we are successful at engaging our university students so that they complete their course, we then need to work out more pathways in order for them to find a job.

[11] *Vision and Change in Undergraduate Biology Education: A Call To Action – Pg 21*

And we have done some work in this area.

My office reported on employers' view of STEM skills in our Occasional Paper series - *STEM Education and the Workplace.*

Positives included research done for the UK's Department of Business, Innovation and Skills (BIS) which showed a diverse range of employers seeking to attract STEM graduates, citing numeracy, analysis, and problem solving as key skills of value.

As technology transforms developed economies, from manufacturing and retail to law and banking, STEM graduates will continue to be in demand in a range of sectors.

The paper suggested universities might need to ensure their degree programs are more responsive to the broad range of occupations that STEM graduates might enter, not just academic research positions.

That possibly means an adjustment to their curriculum settings or how we go about their education.

The former Australian Learning and Teaching Council recommended that universities map their science curricula against a set of 'threshold learning outcomes' which include many of the skills valued by employers.

And the Australian Government's Research Workforce Strategy argued for the development of both 'soft' or generic skills and innovation capabilities in university research training programs, which could then support students' productivity in a wide range of jobs.

It is important that Australian students interested in pursuing STEM degrees are not deterred by a false perception that their only option is a research career.

There are avenues at all stages of the student cycle to signal the possibilities that STEM capabilities unlock.

As part of recruitment efforts for prospective students, and careers services for current students, universities can highlight the applicability of STEM skills to a wide range of professions and sectors.

So if we can successfully engage more students, more broadly, some will pursue STEM careers (hopefully some will go on to become the STEM teachers of the future) and others will use their skills to add value in unforeseen ways in other sectors.

And just as importantly, we give ourselves a chance to lift our national scientific literacy.

As a developed, democratic, innovative country, we need all Australians to be able to take information presented to them and make decisions about what is important, what to discard and what to do.

The other day I was reading *The Best Australian Science Writing 2012.*

There is a contribution from Craig Cormick - ``*Why Clever People Believe Silly Things'*

Cormick credits British doctor and fellow author Ben Goldacre for coining the phrase, and uses the persistence of the anti-vaccination movement as an example.

Despite science discrediting a study which linked vaccination with autism, vaccination rates in Australia have been dropping to the point where only 83 per cent of four-year-olds nationally are covered, which is below the 90 per cent rate needed to assure community-wide disease protection and prevent outbreaks of fatal, but preventable diseases.

Cormick goes on to talk more broadly about how people react when complex information is rapidly fired at them.

He says: - ``*We are increasingly time-poor in a data-rich world; that forces us to make mental shortcuts more often, drawing* *upon whatever existing knowledge we have (all too often from the media than from formal education)''*[12]

Well we need to ensure that all Australians rely on formal science education rather than media outlets, even credible ones, when making important decisions.

So yours is a big responsibility.

Not only do you have to inspire, teach and retain the next generation of scientists, engineers and mathematicians, but you also have to assist in creating an entire generation of inquisitive, informed Australians.

It is not an easy job but I wish you well in your endeavours and offer what support I can.

Along the way, I hope you witness some short-term rewards that encourage you to keep going because Australia really needs you to be successful in the long term. Thank you.

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12 *The Best Australian Science Writing 2012, Why clever people believe silly things, Craig Cormick – pg 116*