AMSI
AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

National Collaboration in the Mathematical Sciences

Australian Mathematical Sciences Institute submission to the Senate Inquiry into Australia's Innovation System

Key Points

There are significant retention problems at various points on the study and research training pipeline in the mathematical sciences. These problems choke the supply of mathematically competent professionals in all the STEM disciplines and limit private sector access to a group which drive innovation in our competitor economies.

Improved private sector employment pathways for research trained graduates are desperately required in Australia to grow industry-university engagement, which by its very nature is focussed on innovation.

Australia must have a national STEM strategy in order to bring coherence to, and adoption of, state and federal government policies and incentives in areas critical to innovation and productivity growth.

Introduction

Individuals drive innovation. In this context Australia is increasingly struggling to get enough of the right people, let alone get them in the right place at the right time with access to the right money. This is particularly true in the mathematical sciences where we are experiencing significant retention problems, worst amongst women, at senior high school, undergraduate, honours and postgraduate levels. Our graduation rates are a fraction of the OECD average and, with 40% of year 7-10 maths classes being taught out of area, they won't be getting better anytime soon[1]. The impact of this on all STEM disciplines is acute. The security of supply of mathematically trained professionals in finance, engineering and biotechnology is under threat and this must be considered in any review of Australia's innovation system.

The often indispensable role of mathematics and statistics in innovation is well-known: optimisation, information security, internet searching, biotech, communications, Big Data, etc. It is not only the discipline's professionals who drive this innovation but mathematically competent professionals from the areas of application themselves. It is our working hypothesis that innovation in advanced

[1] Australian Mathematical Sciences Institute (2014), "Discipline Profile of the Mathematical Sciences 2014", www.amsi.org.au

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economies is proportional to the human mathematical capital of those economies. At the moment Australia has what might be called a mathematical deficit[4]. This is a structural impediment to innovation and productivity growth. On the plus side Australia has a very high quality mathematical and statistical resource in its universities, government agencies and finance sector[1]. With the right policy directions we should be able to leverage this resource to support innovation and reduce our retention vulnerabilities in the education pipeline.

AMSI has 35 members across the universities, government agencies and the learned societies. Our research internship program has placed more than 100 PhD students, *from all disciplines*, into projects with the private sector and the public agencies: see amsiintern.org.au. Our higher education programs have serviced more than 2000 undergraduate and postgraduate students in the mathematical sciences see www.amsi.org.au. On the basis of this experience we make the following observations concerning obstructions and drivers of innovation.

Obstructions to innovation

- Poor Industry-University engagement. Australia is one of the worst in the developed world[2].
- Lack of incentives for universities to engage. Individual researchers are generally interested in publication to the exclusion of engagement unless they are based in a CRC or similar.
- This is compounded by the dominance of schemes such as the ERA which create an inward facing research culture in universities.
- Low rates of employment of research trained staff in the private sector[2]. Again Australia is one of the worst and this has a direct and significant impact of the capacity of industry to engage with the universities.
- Lack of preparation of research trained staff for employment outside academia. In Canada more than 1700 higher degree students undertake research internships each year with around 40% direct retention into employment (see www.mitacs.ca). The contrast with the Australian situation could not be more stark.
- Low rates of female participation in key areas, especially maths & stats and engineering[1,2,3,4] This limits the size of our STEM workforce as well as the other well-known and undesirable impacts.
- Poor public perceptions of the STEM disciplines are compounded by the absence of a national STEM policy framework. This situation has created severe retention problems at various points in the study pathways in STEM, particularly in the mathematical sciences.
- Declining numbers of trained high school maths teachers and declining enrolments in maths STEM gateway subjects at Year 12 are choking the supply of graduates[1,4].

[2] Australian Council of Learned Academies (2014), "Securing Australia's Future: The role of science, research and technology in lifting Australian productivity". www.acola.org.au
[3] Australian Council of Learned Academies (2013), "Securing Australia's Future: STEM Country Comparisons". www.acola.org.au
[4] Australian Mathematical Sciences Institute (2014), "Dealing with Australia's Mathematical Deficit", www.amsi.org.au

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- By OECD standards Australia has very low graduation rates in maths and stats at undergraduate and postgraduate levels[1]. This threatens the supply of research trained professionals working in finance, biotechnology, commercial optimisation, etc. This has and will deter foreign investment in areas requiring this workforce.

- The absence of a national STEM strategy perpetuates these chronic retention problems[5]. The resulting lack of coherence compromises the impact of government programs intended to ameliorate the situation.

Drivers of innovation

- Various international studies indicate that increased employment of research trained staff by the private sector drives up university-industry collaboration which, by its very nature, is focussed on innovation[2,6]. Australia needs a clear state and federal government policy framework which will drive this.

- PhD research internship programs simultaneously drive up both private sector employment of PhD graduates and establish university-private sector engagement. Australia's universities and the Commonwealth Government need to remove obstacles to such internships by changing timely completion and enrolment status rules to accommodate them.

- Work Integrated Learning programs for undergraduates and coursework masters students in the mathematical sciences are proving popular with industry partners and an effective means of improving the work readiness of students. Government policy should encourage their proliferation. In time they will be an effective measure to improve retention in the mathematical sciences and STEM generally.

- State and Commonwealth Government policies which encourage universities to engage with the private sector such as the ARC Linkage and ITRP programs, the CRC program and Researchers in Business. But acknowledgement of the commercial impact of research alongside publication impact (ERA) needs to be put in place to offset the inward facing influence of ERA. Incentives for capital investment in joint industry-university ventures are also urgently needed.

- Exposure of university students, especially those in STEM disciplines, to entrepreneurial business behaviours and commercial research environments.

- High public value of STEM and STEM research and commercial outcomes. International studies indicate a high public value for STEM in economies with high levels of innovation[1]. Career awareness campaigns, such as AMSI's program based around Maths Ad(d)s[7], need to be encouraged through a national STEM policy.

[5] Office of the Chief Scientist (2013), "Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach", Australian Government, Canberra.
[6] Pettigrew, A. "Australia's position in the world of science & innovation". Office of the Chief Scientist (2012), Australian Government, Canberra. www.chiefscientist.gov.au
[7] Australian Mathematical Sciences Institute (2014), "Maths Ad(d)s: A guide for students to the job market", careers.amsi.org.au

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Final remarks

Australian private and public sectors operate in an international environment where sophisticated mathematical tools are used to analyse massive data sets and to optimise business operations, communication and transport networks. The quality and integrity of these tools is critical and relies on mathematical scientists. The impact of these tools depends on their early and effective adoption. Governments should have oversight of the quality and integrity issue and they should provide an environment which encourages this early and effective adoption.

Government mandated innovation practices should be considered as a driver, e.g. the mandating of "optimisation by design" for major public and private infrastructure such as hospitals, transport and manufacturing (as opposed to post-installation optimisation)[8]. Such practices would have a transformative effect on the productivity and sustainability of national infrastructure and would put in place commercial optimisation resources available to small to medium enterprise.

AMSI strongly supports the Chief Scientist's proposal for a national STEM strategy[5]. A key part of the strategy should focus on improving retention throughout the maths study and research training pipeline. A national innovation strategy should strongly link to this national STEM strategy.

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[8] Prince, G. "Optimising the future with mathematics" The Conversation, 11 March 2014.

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