**To:** Committee Secretary
Standing Committee on Industry, Science and Innovation
PO Box 6021
House of Representatives
Parliament House
CANBERRA ACT 2600

**Submission:** *Inquiry into research training and research workforce issues in Australian universities*

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## Research training and the mathematical sciences

Mathematics and statistics are pervasive disciplines often essential to other research and higher degrees. The fragile nature of mathematical sciences is documented in the 2006 Review of Mathematical Sciences Research in Australia[1]. The Review, and the subsequent evaluation of its lack of impact so far[2], raise a serious question in regard to research and research training in Australian universities:

### *Except in exceptional circumstances, should a university that cannot offer a major in the mathematical sciences be involved in research training?*

The failure of universities to include some mathematics and statistics in the majority of undergraduate degrees means many students are inadequately prepared for research training and postgraduate studies. This situation is compounded when students undertake research training in universities that do not have an identifiable mathematical presence. This is particularly so in regard to statistics but it also applies to many areas of mathematics.

In terms of this review into research training and the mathematical sciences:

1. University mathematical sciences departments are contracting and the research base is narrowing.
2. While the number of PhDs is steady the number of Masters has fallen.
3. There is a declining level of statistical expertise across the sector, resulting in the potential to seriously impact on the quality of research and research supervision across many disciplines including social sciences and education.
4. The number of universities no longer offering a major in mathematics or statistics is increasing and therefore affecting the potential pipe-line for postgraduates.

The Review noted concerns in regard to research training[3] in the mathematical sciences and this submission builds on those concerns.

Australia's research training scheme has numerous problems. Many of these cross discipline boundaries but in the following there is a focus on the mathematical sciences.

### *Australian mathematical scientists are proud of their reputation for research training but that reputation is difficult to sustain*

As documented in the Review, there has been a substantial reduction in academic staff although the total number of research PhDs and masters students has remained steady. Combined with a narrowing research base that means that appropriate supervision is not available in some of the newer areas, it means that the quality of the past is difficult to sustain.

Appropriate mentoring of exceptional students is also at risk. Professor Terry Tao, Australia's only Fields medallist, received on-going mentoring and support until completing a research masters degree at age 16 and moving to the US for his PhD. At

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[1] http://www.review.ms.unimelb.edu.au/Report.html, subsequently referred to as 'the Review'.
[2] See http://www.amsi.org.au/pdfs/Questionnaire_summary.pdf for details
[3] The Review, p. 67

that time Flinders University had a mathematics and statistics staff of about 25. It now has fewer than five.

***Funding and completion times do not encourage best practice or necessarily the best students***

- Previously, student load was only counted for three and a half years. This obviously favoured narrow, safe projects in the mathematical sciences. Moreover interdisciplinary projects, where the students need to have a broad base of knowledge, are also at a disadvantage with such a short time period preferred. For example at the University of California at Berkeley, possibly the largest and most prestigious PhD program in the U.S, the average time for completion is around 5 years.
- The new system is even more draconian, with no income for load and only a completion payment. This means that unless students complete, university departments receive nothing. The income generated by departments has become ludicrous. It was recently computed that at the University of Melbourne, departments receive roughly $9000 per year, assuming students complete in three and a half years. Given some natural attrition, plus the fact that average completion times are around four years, the real amount is probably $6000 per year. Given the effort of training PhD students, with our very large student/staff ratios in Australian universities, this is ridiculous. Moreover, students require support for equipment and software, office supplies, money to attend conferences and workshops. So having PhD students has become uneconomic.
- The stipend for PhD students where there is high demand for mathematical or statistical expertise is unattractive compared with what they can earn by going into the workforce. This is a problem shared by some other skills shortage areas. Yet these are the areas that need to attract PhD students or there will be no-one to train the next generation of highly skilled people in these areas. Greatly improving the stipend for students who can attract large salary packages on completion of an honours degree should be a priority.

***There are serious gaps in providing the supervision and support needed for the next generation of mathematical scientists***

- The lack of appointments over the last decade has meant a narrowing and ageing of the research directions. Without an influx of new blood, which by necessity will have to come from overseas in many areas of mathematical sciences, the situation will not improve. Universities need to be held to account – the funding provided in last years federal budget for teaching in the mathematical sciences seems to have been mainly siphoned off by university administrations. The introduction of any research assessment exercise must take account of the potential to strengthen existing areas when there is an urgent need for encouraging newer areas of mathematics and statistics.
- Statistical and mathematical research training in other disciplines and in cross-disciplinary projects has other challenges. In particular this may place greater burdens on the statistics aspect. The mechanisms for recognising and rewarding the mathematical or statistical advice—either as a co-supervisor or on an ad hoc basis—are often non-existent. Without them being in place mathematical scientists, given their other work commitments, are unlikely to engage in providing much needed advice to other scholars and their PhD students.

- In regard to this, there is a lack of interaction between the various other granting schemes and the RTS. Lip service is paid to checking whether grants or fellowships produce RTS outcomes. Given the disastrous lack of appointments in the mathematical sciences over the last ten years, giving fellowships to leading researchers and then having them under no obligation to take on PhD students is clearly a problem. The welcome increase in ARC funding some years ago had the adverse effect of creating more positions seen as 'research only'. There needs to be a redefinition of 'research only' to encompass some PhD supervision, teaching or industry based work. There should be a component of this in the Future Fellowships program, not only because this is talent that must be used to the greatest advantage of the whole system but because this is part of an academic's job.
- The RTS should encourage research training at the highest international level. In most countries, advanced coursework and seminars is an integral part of the PhD in mathematical sciences. Rodney Brooks, the legendary head of the Artificial Intelligence Laboratory at MIT has been quoted as saying he would never employ an Australian PhD, as they do not have the broad training required in his area. Brooks' initial degree was honours in pure mathematics at Flinders University and he then did a US PhD. The PhD experience must be broadened so that more flexible and broadly trained mathematical scientists are produced by the tertiary sector. In this regard, the Australian Mathematical Sciences Institute (AMSI) has fledgling graduate courses and industry internship programs that could be expanded. AMSI member institutions have the potential to deliver postgraduate courses and an established Access Grid network means these can be offered widely.
- As already noted, Australia has a critical skills shortage in several important areas of mathematical sciences, especially statistics and operations research. Industry is hampered by a lack of graduates and for example, BHP Billiton now exports problems in the mathematical sciences to India and Russia for solution and offers scholarships to students in such countries to attract them for employment. However university mathematical sciences departments have been losing positions and so it is hard to find enough supervision in such areas. The RTS needs to take into account the actual situation in universities and where there are areas of critical need, action must be taken to rebuild departments as well as offering support to students.
- In mathematical statistics groups in Australian universities the average age of staff is increasing by almost one year ever year, largely due to the non-availability of young academic staff. The problem is chronic, and it feeds a massive national skills shortage in statistics. Indeed, there is a substantial shortfall of PhD graduates in mathematical statistics, for jobs in industry, business, government and universities.
- More generally, the average age of academic staff in Australian universities is increasing; this problem, and the long-term challenges that it is creating, have been noted in several reviews. Any program that restricts the training of first-rate PhD students serves only to make the problem worse.
- The government has just announced an innovative and much-needed "Future Fellowship" program, designed to enable relatively young scholars and scientists, mid-way through their careers, to be as productive as possible in research (and to keep them in Australia). However, unless the nation now expands the

supply of PhD graduates, the beneficial effects of the Future Fellowship program will be negated. Today's PhD students are tomorrow's mid-career Future Fellows. Without more potential supervisors, offering increased numbers of scholarships will only overload our current ageing academic staff.

***The PhD pipeline must be improved***

- That a significant number of universities no longer offer sufficient courses for students to qualify for a PhD is a serious concern. Universities tend to blame this on problems in schools but there is little justification for this. All universities should be able to generate sufficient income from service teaching to maintain smaller classes at second and third year so that students can major in the mathematical sciences. At the honours level various collaborative teaching arrangements are already in place including the AMSI Summer School and courses via the Access Grid network. There is no excuse other than reluctance on the part of university administrators to act.
- While advocating a broader PhD experience in the disciplines of mathematics and statistics, the situation in regard to school mathematics could be significantly improved by improving PhDs and the RTS in mathematics education. Currently PhDs in mathematics education in Australia seldom, if ever, include further study in mathematics or specific requirements for prior study of mathematics or statistics. This contrasts greatly with higher degrees in mathematics education in the US where there is a clear focus on ensuring that candidates have mathematical knowledge well above the level at which they will be teaching or advising schools and government concerning curriculum and teaching issues[4].

***Concluding comment***

The authors are generally supportive of the submission from the Federation of Australian Scientific and Technological Societies. We differ on the value of APA stipends. While a 30% increase in stipend would be generally attractive to many and should apply across the board, it is insufficient for some high demand areas such as financial mathematics, biostatistics and geophysics. A mechanism needs to be found to address this.

[4] See http://www.ams.org/notices/200710/tx071001283p.pdf for details