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Submission to Review: Higher Education at the Crossroads

I am grateful for the opportunity to make a submission to the review.

As Chair of the National Committee for Mathematics of the Australian Academy of Science, I am particularly concerned by the rapid decline in Australia's ability to provide quality higher education in mathematics, and to conduct research in this vital field. In a related submission, the Australian Mathematical Society will supply data detailing this decline. The Society will provide information about the loss to Australia of many of its key mathematical scientists, on whom we would normally rely to build a base for the future. In this submission I shall give a broad view of the problems which Australia will encounter if we face the future with such severely depleted resources in the higher education sector.

Mathematics underpins just about all the new technologies of science and engineering. It is both the currency and the language of core research and development in information and communication technology, bioinformation science, the analysis of biocomplexity and the environment, and much of the socio-economic sciences. Many mathematicians, particularly those working in Australia, are highly multi-skilled. They develop new mathematical technologies and apply them to solve practical problems. Let me take myself as an example; I work on problems in signal processing (with the Commonwealth Department of Defence), stochastic control (with BAE Systems), and medical diagnosis; and at the same time I do basic research in probability theory, theoretical statistics and related fields. This direct and explicit linkage between theory and applications is critical to delivering quality higher education. Yet we are rapidly losing this facility, through dwindling resources and declining staff numbers.

In particular, my colleagues in key areas of mathematics are leaving for abroad, taking their skills with them. Their departure opens substantial gaps in Australia's strengths in, for example, sampling theory, theoretical methods of computer science, cryptography, statistical genetics, nonlinear mathematics, and a range of fields of applied mathematics. The mathematicians that remain in Australian universities face escalating teaching loads, low morale, and further budget cuts flowing from the upcoming enterprise bargaining round. It is ironic that as ARC funding starts to improve, teaching and administrative loads are soaring to such high levels that many mathematicians have no time left for research. One can hardly wonder, then, that a number of those that remain in Australia are currently exploring employment opportunities abroad.

Australia is almost the only developed country that seems unaware of the fundamental importance of mathematics to its future. In our region, the governments of both Singapore and New Zealand have recently established research institutes to retain and apply the skills of their mathematicians. In each of these institutes, and in the many others which have been established across Asia, North America, the UK and Europe, research, higher education and public outreach are closely linked. Australia still lacks a similar facility, despite many proposals, over more than a decade, for federal assistance.

Moreover, other nations have started increasing their skills in the mathematical sciences, appreciating that this is one of the keys to expanding their economies. For example, the US National

Science Foundation (NSF) has recently begun supporting mathematics at a level which is quite unprecedented in the Foundation's 51-year history. After many years of very flat funding, which did little more than keep up with inflation, in 2002 the NSF increased its support for mathematics from USD 120 million to USD 150 million per annum. A further increase, to USD 180 million, has been tentatively approved by Congress for 2003. And on 7 May 2002 the US House Appropriations Committee forecast an increase to USD 210 million in fiscal 2004. That's a 75% increase in just three years.

The NSF is not backward in highlighting the economic importance of this boost to funding for the mathematical sciences. Development of new technologies is essential to the growth of the US economy, and mathematics is critical to that development. Philippe Tondeur, the outgoing Director of the NSF's Division of Mathematical Sciences, and the architect of the new NSF policy, notes that the extra funding is motivated by:

> ... a vital need for mathematicians and statisticians to collaborate with engineers and scientists... Technology-based industries fuel the growth of the US economy, which, in turn, relies on large numbers of college graduates well versed in mathematics, science, and engineering. In our increasingly complex world, the need for broad mathematical and statistical literacy becomes ever more acute. [Philippe Tondeur, in "Notices", American Mathematical Society, March 2001.]

In particular, the linkage between quality higher education, and funding for university research, is vital and strong.

Where are the US, and other nations that are ramping up the levels of mathematics in their higher education sectors, getting the skills they need? They are drawing them largely from countries like Australia that are neglecting mathematics. There is already a shortage of mathematicians in US institutions, and today some of our best PhD graduates and postdocs in theoretical mathematics (for example) are going straight into tenure-track positions in the US. This is virtually unprecedented in the quarter-century during which I have been working in Australian universities. When new funding initiatives, such as those from the NSF, take hold, and the demand for mathematicians is magnified by the masses of retirements from US mathematics departments that will occur during the next decade, institutions abroad will draw ever larger numbers of first-rate mathematical scientists from Australia, unless we do something urgently to reverse the trend.

I should stress too that the crisis created by Australia's decline in mathematics has dimensions that go beyond ensuring our economic prosperity. For example, there is a significant security aspect. The intelligence services of all developed countries are major users of mathematics skills. In particular, the US analogue of Australia's Defence Signals Directorate (DSD), the National Security Agency (NSA), acknowledges that it is that nation's largest single employer of mathematicians. Any weakening of higher education, and of research skills in mathematics, is of serious strategic concern, and in fact the NSA is a strong supporter of the NSF's initiatives for boosting mathematics training in US universities. I would be surprised if the DSD was not worried by the crisis facing higher education in mathematics in Australia.

Let me make special mention of my own area of the mathematical sciences, statistics. In recent years the number of departments of statistics in Australian universities has fallen from eight to three, largely through resignations and budget cuts. Furthermore, unlike some (but by no means all) other fields of mathematics, there has been a sharp decline in the number of Australian graduate students in statistics, to such an extent that Australian statistics programs find it extremely difficult to recruit suitable staff. By way of contrast, the number of US doctoral programs in statistics is steadily climbing. There are now 86 such programs, turning out graduates for both university and non-university employment (in a ratio of about 1 to 2). Moreover, these data omit US programs in biostatistics, of which there are many.

The decline in Australian statistics graduate student numbers parallels that in related areas like IT. In both cases, highly attractive career paths exist in business, industry and government for non-doctoral as well as PhD graduates. And, unlike some other fields of mathematics, the majority of PhD students in statistics that graduate from Australian universities are not attracted to university posts. For example, of my last 10 PhD students, only two still work in Australian universities. The last five did not even consider the university sector; all have jobs in business and industry. When I asked one of these five if he would apply for a university post in statistics in Australia, he declined, noting that pay, working conditions and job security in universities are all lower than in his present area of employment. "The only thing that's higher in universities," he observed, "is the level of stress."

These problems make it extremely difficult to maintain Australia's university teaching and research programs in statistical science. Yet of all areas of mathematics, statistics is arguably of greatest direct economic and social benefit to our nation. Through an unprecedented decline in Australia's expertise in statistics, we are seriously compromising our ability to develop and apply new technologies in areas ranging from bioinformatics to social science. We all know that the global economy thrives upon the information revolution, yet Australia is systematically dismantling its once proud heritage and intellectual leadership in statistics, the first of the information sciences and one which is poised for even greater influence in science and commerce in the years ahead.

To put into its proper economic and cultural perspective the intrinsic importance of statistical science, and to demonstrate the strategic reliance that Australia should place upon this discipline, one can hardly do better than recall the words of the distinguished UCLA historian Theodore Porter:

> Statistics has become known in the twentieth century as the mathematical tool for analysing experimental and observational data. Enshrined by public policy as the only reliable basis for judgements such as the efficacy of medical procedures or the safety of chemicals, and adopted by business for such uses as industrial quality control, it is evidently among the products of science whose influence on public and private life has been most pervasive. [Theodore M. Porter, "The Rise of Statistical Thinking, 1820-1900," Princeton University Press, 1986.]

Note too the advice of the Fields Medallist David Mumford, reflecting on the demand for statistics, and university-trained statisticians, throughout the foreseeable the future:

> Stochastic methods will transform pure and applied mathematics in the beginning of the third millennium. Probability and statistics will come to be viewed as the natural tools to use in mathematical as well as scientific modeling. The intellectual world as a whole will come to view logic as a beautiful elegant idealization but to view statistics as the standard way in which we reason and think. [David B. Mumford, in "Mathematics: Frontiers and Perspectives," American Mathematical Society, 2000.]

How, then, is Australia to face the challenges of the new millennium, with its knowledge base in statistical science in such disarray, and its ability to offer higher education in the discipline in an advanced state of degeneration?

The issues I have raised, about the parlous condition of the mathematical sciences in Australia, are not drawn from one side of politics or the other. Rather, they relate apolitically to Australia's survival as a competitive trading nation with a high standard of living, enjoying real security in an increasingly dangerous world. Higher education is indeed at the crossroads, but the direction we should take is surely clear. We must rebuild that which has been brought down, in a way that ensures Australian mathematics is vibrant and internationally competitive. And, most imperatively, we must do it quickly, before it is too late. To this end, I urge the Review to adopt the following four recommendations:

* Reduce university teaching loads in mathematics (through higher levels of funding per student), and increase salary

flexibility, to make research-and-teaching careers in Australian universities more attractive;

* Increase the level of competitive, performance-based support for research in mathematics, including federal assistance for a mathematics research institute;

* Introduce targeted research grants for early-career mathematicians, to assist them in using their full potential right from the beginning of their careers;

* Cease the DEST practice of assessing university research performance merely on the basis of research funding earned, and in its place introduce a measure of of the quality of intellectual and scholarly work.  The present DEST approach heavily penalises the intellectual sciences.

Yours faithfully

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