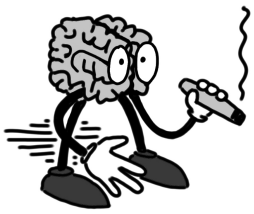

Math matters

Tony Dooley

The Editors of the *Gazette* have asked me to write a "somewhat provocative" column for its august pages. Having dismissed themes of sex, drugs[1], or rock 'n roll as *too* provocative, I found myself asking how research in our discipline could look in 50 years' time, if it survives that long.[2] Of course, this is highly dependent on policies adopted by various Governments, but under the assumption that current broad trends continue, I would like to suggest that it might be very different.

The traditional model Australian Mathematics Department had a large cohort of first and second year science and engineering students, who were all obliged to take mathematics, and who were taught as well and as efficiently as possible, in order to fund salaries of its staff to also teach relatively small, upper level courses, supervise students, and do research. The funding models do not, and never have, taken into account the real cost of doing research: we have been funded by student numbers.

Individual researchers did not, save for rare exceptions, have direct contact with users of mathematics in industry, relying on publication in refereed journals and talks at conferences as their major means of dissemination of results. The process by which a result on the geometry of Banach spaces or a paper on non-smooth optimisation (to pick two random examples) became a component in a computer game or a better option-pricing mechanism remained ineffable and mysterious and mostly did not happen. We have not cared whether precious opportunities were lost by this process, or whether our results never really found practical application. We have been too absorbed by the intellectual challenge of the discipline, and seduced by the argument that research is a continuum in which we are situated towards one end, to get closer to the real users. We have been secure that technology is marching forward – somewhere else!

Looking dispassionately at what is happening around us, I question whether this model is sustainable. Increasingly, other disciplines are lowering their mathematics teaching requirements: the Institute of Engineers now wants graduates who have taken Project Management rather than Complex Analysis. Driven by the EFTSU funding model, many faculties have appointed staff to teach basic mathematics to their own students, thus being able to subsidise their own research, instead of mathematical research. Students, unaware of, or unconvinced by, our rhetoric on employment prospects for mathematicians, are choosing other majors more clearly linked to career paths. Mathematicians are leaving the country in droves. Perhaps most disturbing for traditionalists, mathematical

[1] Although arguably, it is time to update Hardy's description in the *Apologia*, of the beneficial effects on mathematical research of just one Gin and Tonic, consumed mid-evening!

[2] See Peter Hall's article in the previous issue.

research continues to be done, but increasingly outside Mathematics Departments: in banks, in Computer Science Departments, in Schools of Finance, in CRC's in other applied areas.

This is, of itself, recognition of the fact that humanity in general, and the Australian populace in particular, continues to need mathematical research and large quantities of it. The reason for this is that, when it works, it is so efffective. One formula can replace millions of hours of computer simulation. [3]

It can be argued that the trend for mathematics teaching and research to be done closer to their applications is not a bad thing. After all, society at large does not appreciate funding what it cannot understand, and mathematics certainly falls into that category. Many end-users argue forcefully that it is they who really understand the applications to their discipline, particularly if that results in a net transfer of resources to their area! To some degree, it is a manifestation of the continuum between pure and technological research which we all fervently hope is happening.

But if the trend were to continue unchecked to the point where Mathematics Departments simply disappeared, I could see major problems for the discipline. Teaching done by non-specialists quickly becomes trivialised and out of date. Students do not experience the paradigm of a different discipline. Industry-based applied research is of necessity short-term focussed and outcome-based. It is often expressed in language specific to the application, rather than in generic and accessible terms. Much of the time, it is confidential and not published. There is a massive risk of duplication because of these factors. Research increasingly runs the risk of being done by people unfamiliar with the huge body of existing knowledge, and without the time or the mathematical culture to search through it[4]. In some cases, there is a tendency to pick up a 30-year old textbook instead of the phone! If the preponderance of research in our discipline were to be done in situations driven only by immediate outcomes, our discipline would be irrevocably changed: I believe for the worse.

As I said above, I believe that we have gone some distance down this path already, pushed by a mixture of economic rationalism and the requirement for research which is easily understood. What can we do to survive?

This much is clear: we must open the channels of communication wider. This is easier said than done, and requires a great deal of forbearance on both sides. Practitioners often struggle to formulate their problems clearly in language which professional mathematicians understand. Professional mathematicians in turn may simply not have the tools to solve the problem, or may have trouble making their solutions comprehensible. Usually, neither party wants to put in the rather massive investment of time needed to understand the insights and methods of the other. The best result, a simple and lucid solution, may be so quickly absorbed into the consciousness of the discipline that its origin is forgotten, unprotected by publication. Hardy's famous toast: "To Pure Mathematics, may it never be of use to anyone", lies like a ghost over the discussions[5].

Of course, steps are being taken. Over several decades, the annual MISG meeting has provided a forum for interactions; it was

[3] I have had it explained to me recently that the most-used formula in all of history is the Black-Scholes formula. Each day, it is used millions of times in millions of computer programs, making it more used than Pythagorus' theorem! Imagine if each use of it were replaced by a numerical simulation.

[4] A good example is the theory of wavelets, developed separately by practitioners of geophysics, vision science and financial mathematics. Fortunately, Yves Meyer and Raphy Coifman were able to see that a commonality existed, and formulate a powerful and deep mathematical theory to unify and explain these apparently diverse methods.

[5] In Hardy's defence, this toast was a pacifist plea made at the end of a long and bloody war, when mathematics had been used to build bombs, break codes and generally caused suffering. This has not stopped the misuse of the quotation!

run in New Zealand this year. AMSI is helping, and our Centre of Excellence MASCOS has as a goal to improve the theoretical/industry research interface. Many individual mathematicians have developed linkages with industry, involving consulting and other types of research interactions.

What I am arguing here is that the profession must try to take greater control of that mysterious process between theory and applications. If this is better done and understood, our work will be seen as more relevant, the benefits of a centralised profession of mathematical researchers will be manifest, and mathematicians will also be seen as the natural people for teaching of mathematics to other areas. If mathematics departments are still around in 2054, I think their members will be more aware of current applications and have better structures for sharing ideas and projects across the whole spectrum from the purest to the most highly applied research than we do today. On the other hand, outside users of the discipline will have a much clearer idea of how to find the right expertise inside mathematics departments, and how to use it when they find it. I believe that it is our duty to our subject to pursue actively the development of personal contacts, administrative arrangements, joint research grants and projects and whatever else it takes, to bring this about. In the words of Arnold Schwarzenegger (in his previous profession) "If you want to live, you will do this"[6].

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[6] *Terminator 2*