Beyond disciplines? – A non-mathematician's apology

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The pronoun 'we' has caused me problems for at least a decade. Right now I am getting used to the fact that, for the first time in 23 years, 'we' no longer means CSIRO. At present I am working in MASCOS [1] with a brief that includes doing the sort of linking to end-users that Tony Dooley [2] regards as essential for the survival of the discipline of mathematics (research?). This article aims to expand on Tony's "if you want to live you will do this", drawing on my own experience in CSIRO and from watching the physics community grapple with similar issues.

In professional terms, I am not sure who should constitute 'we'. My preferred self-description is 'mathematical scientist' [3] as being more comprehensible (and more comprehensive) than 'biogeochemical modeller', not to mention 'ex-physicist'. Some details of my various roles are scattered through the endnotes.

One comment is that engagement is hard [4] – Tony Dooley commented on the 'massive investment of time needed to understand the insights and methods' [of each other]. It is essential to avoid what Maurice Kendall identified as:
Hiawatha, who at college
majored in applied statistics
consequently felt entitled
to instruct his fellow man on
any subject whatsoever [5].

The best model that I have seen for real engagement was the CSIRO Division of Mathematics and Statistics under Joe Gani, with mathematicians seconded part-time into CSIRO divisions which were oriented to disciplines and/or application areas. The aim (presumably) was to be 'time-effective' in that the mathematicians/statisticians would gain some familiarity with a field so that each new problem did not involve a major new learning experience [6]. DMS in this form was a casualty of the 1987 McKinsey review of CSIRO. For much of my subsequent CSIRO career, the CSIRO mathematics that I might wish to engage with were split into two groups. I was forbidden to talk to group A; group B were forbidden to talk to me [7] – in each case the issue was intra-CSIRO budget allocation [8]. This is, of course, the CSIRO equivalent of the territorial take-overs in universities that have mathematics service courses increasingly taught by 'user' departments, not by mathematics departments [9]. In some areas – e.g. theoretical physics and dynamical meteorology, autonomous departments exist whose mathematical research is at sufficiently high level that researchers move between such departments and mathematics departments. This is, I believe, a 'good thing' [10] in its way, but it pre-supposes a large critical mass of research, and so has limited applicability as a model for engagement across the whole spectrum of areas of application of mathematics.

If I select four points on the mathematical research continuum, described by Tony Dooley as "the mysterious process between theory and applications", I can talk about four roles: (1) proving theorems (2) devising ways of calculating things (3) calculating things about the real world (4) 'marketing' the results of such calculations [11]. The 'research' component of role (4) is going to be mainly researching the real and perceived needs of the end-users [12].

My own career has spanned (2) to (4) [13]. I hang around with people who prove theorems [14] – in fact I hang around such people enough to have acquired an Erdös number of 2, but my only two papers published in mathematics journals were in 1979 and 1992 [15], hence my reluctance to describe myself as a mathematician. This raises the question of whether – putting

aside such special circumstances as MASCOS [16] – could/would/should your mathematics department employ me? [17]. Probably not, for a bunch of very good reasons, starting with the small number of courses that I would be equipped to teach, but this 'gap' illustrates one of the barriers to engagement.

Most of my working career has involved studying the carbon cycle. Apart from its considerable importance, the fun aspect of carbon cycle studies is that it is an excuse for getting involved in almost every field of science (with a need to forge cross-disciplinary partnerships, avoiding the Hiawatha syndrome). Mathematics is just one of the areas where I need to learn new things from time to time, and, to use Tony Dooley's example, often getting what I need from a 30-year-old textbook is easier than the phone (or e-mail or the internet).

Is this a bad thing? The nature of mathematics means that mathematics that was valid 30 years ago is valid today, computer algorithms being an important exception. Do mathematicians want their role to be as support for people who are too lazy to walk to the library?

An important professional support for cross-disciplinary carbon cycle study comes through being a member of the American Geophysical Union (AGU). The AGU includes sections on Atmospheric Sciences, Biogeosciences, Geodesy, Geomagnetism & Paleomagnetism, Hydrology, Ocean Sciences, Planetary Sciences, Seismology [18], Space Physics, Tectonophysics, and finally, Vulcanology, Geochemistry & Petrology. However, the AGU itself, along with the The American Physics Society, The Optical Society of America, The Acoustical Society of America, American Association of Physics Teachers, America Crystallographic Society, American Astronomical Society, American Association of Physicists in Medicine and AVS comes under the umbrella of the American Institute of Physics. What I lack is correspondingly comprehensive links across the mathematical sciences community.

Philip Broadbridge's 'brain drain' article [19] notes officers of Australian professional associations who: 'recommend old mates for medals [20]' and 'denigrate any activity of mathematical science that is more than two journal pages way from their own beloved paradigms'. This is a rather harsh description, but in comparison to the American situation, Australian professional societies really do seem excessively parochial and fragmented [21]. In contrast, a more plausible analysis of how one might operate effectively in a relatively small (and geographically-isolated) nation would suggest a need for less rather than more fragmentation.

Part of this fragmentation reflects a situation where professional scientific societies reflect the divisions enshrined in university departments and, are of less direct relevance to those whose science cuts across traditional discipline boundaries [22]. This is, of course, a self-sustaining condition. In this regard, a recent article in Physics Today [23] (of which more later) sees engagement with all their graduates as being essential for the long-term health of the (US) physics discipline.

Using Douglas Adams' "SEP" recipe for invisibility, much of this is 'Somebody Else's Problem' [24]. A better-linked arrangement of associations of natural scientists in Australia (a) won't happen any time soon; (b) won't do much for the corresponding problems for mathematics.

There is, however, one very important 'fragmentation' issue for mathematics: Probably the most commonly-applied field of mathematics is statistics [25]. (It is also, almost certainly, the most commonly mis-applied, but that is another story). In their names, both MASCOS and my department at The University of Melbourne (and formerly CSIRO) treat 'Mathematics'

and 'Statistics' as two, presumably different, things [26]. From my own work [27], and a wide range of studies that I encountered through the CSIRO complex systems science initiative, I can report that, for much of the real world, this nice division between (applied) mathematics vs. statistics is not particularly helpful.

Returning to the Rigden and Stith *Physics Today* article [23], the vast majority of their words about physics could apply as well, or better, to mathematics. Some of the issues to which they attribute a decline in student numbers is:

- the invisibility of physicists [read mathematicians] in the workplace, since their high-level problem-solving skills take them into jobs [e.g. biogeochemical modeller] with non-physicist titles.
- the academic attitude that the only real physicists [again read mathematicians] are those who leave the department with a Ph.D.

Rather than inadequately summarise their proposed solutions, my main take-home message is to read the article if your care about these issues.

Two provocative recommendations:

- Australia needs an ANZIAM++, i.e. a group that covers the full range of applicable mathematics, not just what currently goes under the name of applied mathematics.
- Membership of ANZIAM++ should be available as a low-cost add-on for members of **any** other appropriate professional society in Australia (and New Zealand?), not just the Australian Mathematical Society.

Acknowledgement and identification of potential conflict of interest

Fifty percent of my salary at MASCOS is paid by CSIRO [16].

Endnotes

(1) MASCOS is the ARC Centre of Excellence for Mathematics and Statistics of Complex Systems, http://www.complex.org.au.

(2) Tony Dooley, *Math matters*, AustMS Gazette **31** (2004), 76.

(3) In Physics Today **57(5)** (2004), p. 10, http://www.aip.org/pt/vol-57/iss-5/p10.html, David Mermin describes the difference between mathematical physics and theoretical physics as: Theoretical physics is done by physicists who lack the necessary skills to do real experiments; mathematical physics is done by mathematicians who lack the necessary skills to do real mathematics. All I can do is plead guilty on both counts.

(4) Remember that this has to happen along with what Philip Broadbridge [19] identifies as the roles of researchers in the present climate: entrepreneur, administrator, PR expert, project manager, performer, stenographer and innovative teacher. He appears to have left out editor, graphic artist and IT manager. Of course in the mathematical sciences we have it easy – our list doesn't normally include the OHS responsibility for laboratories and/or field work – in the normal course of our work, no-one risks death if we foul up.

(5) This is really a minor aside in Kendall's parody of Longfellow's poem which seems to be about bias vs. efficiency. It is more relevant to issues of 'engagement' if one interprets it more generally as being about elegance vs. practical applicability. The parody, *Hiawatha designs an experiment*, can be found at a number of locations including http://www.ed.uiuc.edu/csg/documents/hiawatha.html.

(6) The direct consequence for me was M.L. Thompson, I.G. Enting, G.I. Pearman and P. Hyson, *Interannual variation of atmospheric CO_2 concentration*, J. Atmos.

Chem. **4** (1985), 125–155. The indirect consequences shaped much of my subsequent career in atmospheric science [27].

(7) Group A was the re-directed DMS who were to interact with the 'wealth-producing' half of CSIRO and could only interact with the other CSIRO divisions if they paid money. Group B were the Biometrics Units who were created to interact with the rest of CSIRO, apart from those divisions (including my own) whose chiefs refused to relinquish a position to create the units. Fortunately, CSIRO people like Bob Anderssen often had joint university roles and we were allowed to talk while they were wearing their non-CSIRO hats.

(8) I will have to leave it to others, and the passage of time, to assess whether the current 'One-CSIRO' slogan reflects a real improvement. Although I am probably biased on this matter, the CSIRO complex systems initiative (http://www.dar.csiro.au/css) shows great promise if it can survive amidst the prevailing micro-accountability.

(9) It has also been put to me, from the 'client side', that another reason for this loss of service teaching was that mathematics departments assigned such courses to the newest, most junior, least experienced faculty, or even to less qualified sessional teaching assistants. For mathematics, I have only hearsay – for physics, I've been there, done that.

(10) My view is that what matters most is the survival of mathematical research, not the survival of the name 'Department of Mathematics'.

(11) The people who devise techniques for calculations will, of course, draw on theorems to prove that their techniques will work. The other links along the spectrum are even more obvious.

(12) One of my most direct end-use involvements was the study for the inelegantly-named Subsidiary Body for Scientific and Technical Advice (SBSTA) for the Framework Convention on Climate Change (FCCC). This involved looking at a proposal, put forward by Brazil in the negotiations leading to the Kyoto Protocol, that emission reduction targets should be set on the basis of nations' relative blame for the greenhouse effect (see http://ms.unimelb.edu.au/~enting/brazil.html). However the suspicion remains that referring the issue to a scientific panel was the diplomats' alternative to doing something undiplomatic like telling the Brazilians to piss off. It was also presumably cost effective – scientists are much more likely than diplomats to be expected to fly economy class.

(13) One indication of serious engagement with the real world is when people try to suppress your work. For me that happened when representatives of US/Middle East oil interests tried to prevent the IPCC Radiative Forcing Report from referencing the CSIRO Atmospheric Research Technical Paper 31 on carbon cycle modelling results (republished at http://www.dar.csiro.au/publications/enting_2001a0.htm).

(14) My engagement was facilitated by having some powerful computational techniques that were of considerable interest to the Statistical Mechanics group at Melbourne – for a review see I. Enting *Series expansions from the finite lattice method* Nucl. Phys. B (proc. suppl.) **47** (1996), 180–197. This was a special circumstance which limits the applicability of my own experience as a role model for engagement. From my side, the motivations for engagement were (a) it's fun (b) the CSIRO constraints noted above [7]. CSIRO tolerated this statistical physics activity for many years, praised it highly when complex systems became trendy and used it as a basis for getting me out of the organisation when the budget got squeezed.

(15) D. Kim and I. G. Enting, *The limit of chromatic polynomials*. J. Combinatorial Theory B., **26** (1979), 327–336, *and* I. Enting, A. Guttmann, L. Richmond and N. Wormald, *Enumeration of almost-convex polygons*, Random Structures and Algorithms **3** (1992), 445–461.

(16) For which I am exceedingly grateful.

(17) My full publication list can be found at http://ms.unimelb.edu.au/~enting/ige_pubs.pdf.

(18) The paper by Rayner, Enting and Trudinger: *Optimizing the CO_2 observing network for constraining sources and sinks*, Tellus, **48B** (1996), 433–444 (and follow-on papers and contract work for CSIRO) would not have happened if I hadn't seen the poster version of the Hardt and Scherbaum paper (Geophys. J. Int., **117** (1994), 716) at an AGU meeting.

(19) Philip Broadbridge, *Brain drain: looking back from across the big pond*, AustMS Gazette **31** (2004), 89.

(20) Of course mutual medal-awarding is alive and well in the USA. See N.D. Mermin, *What's wrong with these prizes?*, Physics Today (1989), 9, reprinted in N.D. Mermin, *Boojums all the way through: Communicating science in a prosaic age* (CUP 1990).

(21) One minor, but pernicious, consequence of this fragmentation is the local persistence of claims of the form 'the science of the greenhouse effect is invalid because atmospheric scientists have not listened to geologists'. In North America or Europe, away from Australian parochialism, such claims would be more commonly treated with derision, as being contrary to the way science operates, without having to revisit specific examples starting with Högbom's input to Arhennius' 1896 calculations of global warming. The greenhouse position statement of the American **Geophysical** Union can be found at http://www.agu.org/sci_soc/policy/climate_change_position.html.

(22) As well as the AGU, I am a member of the Australian Mathematical Society (and ANZIAM) and the Australian Meteorological and Oceanographic Society and the TeX Users Group but have resigned from the Australian Computer Society, the Australian Institute of Physics and the SIGSAM group of the ACM. I could not justify the cost of so many separate memberships, let alone have time to actively contribute to these associations.

(23) J. Rigden and J. Stith, *The business of academic physics*, Physics Today, November 2003. Their 'business model' has the two outputs, "new knowledge" and "new physicists", produced from respective inputs of "existing knowledge" and "trainee physicists". They explore reasons, and possible remedies, for shortfall in the second input. As an AGU member, I get online (and hard copy) access to Physics Today. Legally, or otherwise, it seems that the article is available at other web sites. I commend it to you.

(24) Douglas Adams, *Life, the universe and everything* (Pan Books London and Sydney 1982).

(25) Note that Hiawatha majored in 'applied statistics', not 'Banach spaces'.

(26) Treating statistics as a particular application-oriented sub-branch of mathematics in the same way as meteorology or theoretical physics exacerbates the disjunction.

(27) I. Enting, *Inverse Problems in Atmospheric Constituent Transport* (CUP 2002).

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