Professor Russell Crawford
President, ACDS

Professor Nalini Joshi FAA
Chair, National Committee for Mathematical Sciences
nalini.joshi@sydney.edu.au

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Dear Professor Joshi

Thank you for inviting the Australian Council of Deans of Science (ACDS) to provide input towards the development of the Decadal Plan for Mathematical Sciences.

The ACDS has a proud history in supporting projects and developing initiatives to improve the status of science and mathematics research and education in Australia. It does so through various activities. In relation to education and the scholarship of teaching, we refer to the sponsoring of annual regular conferences of associate deans (teaching and learning), funding the ACDS Teaching and Learning Centre[1], and supporting networks of academics focusing on science and mathematics education. Research strategy and research training are agenda items regularly on the annual meeting of the Deans. The ACDS can also refer to a number of reports that it has commissioned externally on key matters of interest that overlap several of the important elements of the Decadal Plan[2].

The recommendations below, which we offer towards the Decadal Plan, stem directly from the richness of activities indicated above.

Threshold learning outcomes for mathematics graduates

Through the national Learning and Teaching Academic Standards (LTAS) project, several science (and mathematics) disciplines have developed their Threshold Learning Outcomes (TLOs)— these comprise the knowledge, skills and aptitudes students develop by the time of graduation. The development of the broad science (Bachelor of Science and Bachelor of Science (Hons)) TLOs is a success story – with nation wide input they are now an endorsed set of standards. Other disciplines serviced by mathematics have also developed their TLOs. The mathematics community has also put considerable effort in developing the TLOs for mathematics and statistics programs[3].

1 See http:// http://www.acds.edu.au/tlcentre/
2 See http://www.acds.edu.au/occasionalpapers.html
3 See http://amslat.edu.au/tlos/

The reality is that the TLOs are suspected to be far from reflecting the current achievements of our graduates. Mathematics teaching and assessment continue to have a strong focus on techniques and technical ability. The TLOs however address a far broader range of intellectual skills and perspectives than this. This is a particular problem for disciplines like mathematics (and statistics), physics, and chemistry, where the general idea is to show that you can calculate everything even if you can explain very little.

The last few years' emphasis on 'bigger pictures' and 'generic skills' continues to shift the focus in relation to the quality and standards discussion, relative to the technical emphasis— we need to better understand the real teaching and learning weaknesses and gaps.

The ACDS would like to see statements in the Decadal Plan that articulate the need to rethink the teaching and assessment processes to better align with the desirable outcomes for our graduates.

Mathematics Service teaching: threats and opportunities

Most Mathematics departments rely heavily on service teaching, to biology, engineering, chemistry, physics, etc students. They argue on the basis of *quality*: that the depth and flexibility in mathematical understanding, derived from their expertise, will translate into a superior mathematics and/or statistics education for students of all disciplines. They propose the general view that 'students learn mathematics (and statistics) best from discipline experts', although they acknowledge that optimal results for students are obtained if there is a meaningful partnership with the user groups so that there is an appropriate balance of 'core skills and knowledge development' and 'context'.

The challenges facing Mathematics departments across the country are consistent. Other disciplines (serviced areas) often argue that

i. They (serviced area) have sufficient mathematical and statistical expertise to deal with the needs of their students.
ii. They understand better the interests and motivations of their students, and how mathematics fits into these, and so can engage their students with mathematics and statistics better.
iii. Mathematicians are too abstract and don't contextualise the mathematics (and statistics) in a way that makes it relevant to their students.

These are not new issues, but the higher education landscape is changing rapidly, and arguably placing mathematics departments in even more vulnerable positions. In particular,

1. *The quality and standards debate around Australia, and indeed the rest of the world, is changing the basis/evidence on which this debate should occur.*

A key notion in arguments must be about evidence. To meaningfully assert that students learn mathematics (and statistics) better from mathematicians than from their own

disciplinary colleagues, evidence is required. It is also essential to define what outcomes are expected in a way that it is possible to collect evidence. Most important in the design of such testable outcomes is that evidence should be simple to obtain, and integral to any assessment procedures, so that they do not add to the administrative burden.

There has recently been an ALTC project, called Quantitative Skills, that sought to uncover the rational underpinning the mathematics and statistics that is taught to science students, mainly biologists, and how the proponents judged the success of their approach. The good news for mathematics departments is that biology departments have clearly given little or no thought to this, and there is no obvious basis or evidence for the merits of biologists teaching their own mathematics. The bad news is that mathematics departments could not provide evidence of the 'value-add'.

2. *The increased availability of software packages of the 'mathematics for biologists' type, not to mention MOOC's, opens up a whole new dimension to service teaching arguments.*

The problem with software packages is that they make a claim for quality, especially if mathematicians and/or statisticians have been involved in some way in their design and development. Mathematicians/statisticians have been happy to work in the context of specific text books, having a clear idea of what is their role in topic delivery and the relationship of the textbook to it. For more generic software packages and other allied teaching tools (such as MOOCs) it is not always clear what the role of the discipline expert will be.

This must be explored urgently. It may be that some software packages / MOOCs contain valuable ideas for the design and expectation of service teaching. We must understand the user requirements. We must also understand the (current) gaps, faults and opportunities. If current options have serious deficiencies, we need to be able to explain (evidence based) how we can value add as a Mathematics and Statistics community.

For example, there is an emerging effort by a collective of biologists in Australia to introduce MathBench, a product from the US. Some mathematicians appear to be supporting this. If the two discipline groups—Biology and Mathematics & Statistics – are positive about this, then the ACDS considers this to be an example of a constructive approach, and urges others to become involved.

The ACDS would like to see the Decadal Plan take up the issue of what should be the required standards for service teaching— in course design, delivery, and assessment—on an evidence basis. The ACDS would like to see Australian Mathematics Departments work with their user groups/departments to further refine these standards.

If this can be achieved, Mathematics & Statistics in Australia will be in a much stronger position to assert itself legitimately as the standards and evidence based agendas roll out over the coming years, and to influence the character of this roll out.

Yours sincerely,

Professor Russell Crawford
President, ACDS