COUNCIL FOR THE MATHEMATICAL SCIENCES

The Institute of Mathematics and its Applications | The London Mathematical Society | The Royal Statistical Society

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From the Chair:
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Secretary to CMS:
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Dear Alice,

The Council for the Mathematical Sciences, a consortium comprising the Institute of Mathematics and its Applications, the London Mathematical Society and the Royal Statistical Society, is pleased to enclose its response to the Royal Society's call for evidence for *Science Higher Education 2015 and Beyond*. The CMS notes that HoDoMS (the Heads of Departments of Mathematical Sciences) has also replied to this call for evidence.

A shortage of data - particularly regarding areas of employment of mathematically-qualified graduates and postgraduates, and of identifying the skills and expertise sought by different employers of mathematical sciences graduates - has been repeatedly highlighted in official reports such as Adrian Smith's *Making Mathematics Count* in 2004. It is hard to see how good, evidence-based decisions can be made by Government on the management of the UK's STEM provision (a key element of its ten-year Science and Innovation Framework) without this data base.

The CMS is working with HoDoMS to put together some data; it would be happy to make such data as it has available to the Royal Society.

Yours sincerely

John Toland
Chair, Council for the Mathematical Sciences

COUNCIL FOR THE MATHEMATICAL SCIENCES

Response to the Royal Society call for evidence:
Science Higher Education in 2015 and Beyond

a. *The nature of the benefits to a student that accrue from studying an STM subject at HE level, whatever their future occupation.*
The Mathematics, Statistics and Operational Research Benchmark Statement [1] captures with some enthusiasm the widely-held view of the enhanced employability of those who study mathematical sciences: "...employers know that MSOR graduates possess knowledge and skills that will enable them to make a contribution that is beyond the capabilities of those without a background in MSOR." The following list, which is illustrative and not exhaustive, shows the diversity of employment opportunities for mathematical sciences graduates: actuary, computer games consultant, computer game developer, statistical consultant, computer systems administrator, avalanche researcher, medical statistician, aerodynamicist, meteorologist, audio software engineer [see http://www.mathscareers.org.uk/14to16/articles/171.aspx and also reference [3]]

b. *The demand for STM graduates from the economy and wider society, and how this demand is changing.*
A worthwhile and non-trivial question to ask! There is currently a demand for well-qualified schoolteachers; this will not change. The recent "new" employment opportunities for mathematics graduates include everything to do with the "digital revolution". To exploit these opportunities graduates would need to include studies in computer science / electronic engineering, both software and hardware. These opportunities will continue but will be presenting new scenarios and graduates would need to be prepared to adapt and to continue learning.

c. *The quantity of those graduating at all levels of the higher education system, and the quality, depth and breadth of their educational and training experiences*
Figures for Mathematical Sciences graduates are available from HESA, but recent experience suggests that some caution must be exercised here. Official figures suggested an increase in Mathematical Sciences graduates, but subsequent investigation through a Council for Mathematical Sciences (CMS) project revealed that changes in category definitions were distorting what was actually at best a standstill position [2]. There are very few unemployed mathematics graduates, and, if demand continues to increase, then it is an economic necessity that more school leavers be persuaded to study mathematics and its applications, and prepared to be entrepreneurial.

d. *The length of time HE studies should take, and how that time should be broken down (with reference to the Bologna proposals to standardise the structure of HE across Europe).*
Graduates with mathematical skills are in demand and able to contribute successfully in a variety of areas of further study and employment. A significant proportion of mathematical science graduates do indeed go on to advanced study. Given the aim in the Government's Science and Innovation investment framework [10] that there should be an additional 10 000 young people taking A Level Mathematics by 2014, and also given the ambitions of the significant HEFCE funded project "Increasing the Supply of Mathematical Science Graduates" (see f below), one might reasonably expect this number to increase. It is essential that all relevant study opportunities conform to the EU framework, and that graduates are adequately prepared so that they can compete world-wide.

The current standard and consensual UK pattern in first degree courses in Mathematical Sciences (outside Scotland) is to take 3 years for a BSc with Honours followed by a possible

1 year MSc, or 4 years for an integrated Masters (MMath). A PhD would take an additional 3.5 - 4 years. These patterns are consistent with the Bologna framework. However financial support for MSc students is patchy, and it remains to be seen how well 4 year integrated Masters courses will recruit under the new UK fees regime. The Council for Mathematical Sciences (CMS) is currently producing a report on the situation.

e. *The current discipline boundaries, and whether a general science first-degree option could be appropriate.*

There is considerable doubt that a general science first degree would be helpful for those interested in mathematical sciences. While mathematics is indeed the queen of the sciences, she is also much more than this. Many students entering mathematics degrees do not have a scientific background, and the most popular work sector entered by mathematics graduates is Business and Finance [3].

f. *The changes to the skills, knowledge and experience of those entering the HE system and how the HE system can accommodate such changes.*

There has been a succession of reports over the last 10 or so years (e.g. [4], [5]) outlining the actual decline in traditional mathematical skills, such as algebraic manipulation, of students arriving on UK degree courses, although this is accompanied by increasing IT literacy and technological awareness. In fact it may be that because of the wide range of demands upon mathematical skills, mathematics is at the forefront of recognition of difficulties at the School/HE transition. The most recent report is that of Professor Adrian Smith's Inquiry into Post 14 Mathematics Education [6]. This report identifies a series of issues at play in school mathematics, including the shortage of specialist mathematics teachers, the need for an enhanced CPD culture, and misgivings about the current qualifications framework. It has prompted and is informing various government responses, such as the creation of the National Centre for Excellence in Teaching Mathematics, and changes to the qualifications framework. Such efforts will clearly have an impact at the HE interface. The need is not so much for HE to accommodate the changes, which it can do, but for encouraging measures so that school leavers are enthusiastic about a career in mathematics.

From the other side of the interface, many universities have reacted to the skills mismatch by providing Mathematics Support Centres for drop-in help. This may be supported by diagnostic testing. In some cases additional courses are offered. Good practice was summarised in 2001 in a publication from the MSOR Network [7], and subsequently in the MathsTEAM project [8]. One excellent example of generic mathematical support is the "SIGMA" CETL based jointly at the Universities of Loughborough and Coventry, and there are many others.

Difficulties in the full cycle of mathematics education are being further addressed through the imminent and significant HEFCE-funded project "Increasing the Supply of Mathematical Science Graduates", with overarching aim as in its title. This project should provide to all involved a clearer indication of the longer term benefits of studying mathematics to an advanced level. Themes include careers, enrichment, and a review of the nature of the Higher Education curriculum in the mathematical sciences to ensure that it is suited to a wide range of students. Given this project's aims, one might expect a significant number of additional students entering HE with increased expectations and enhanced mathematical skills.

g. *The need to allow students to be flexible in their choices of occupation as they gain their qualification and afterwards.*
We note there has been a separate response to this call for evidence from the HE Academy Maths, Stats and OR Network Graduate Skills Working Group, which explores this aspect in some depth. A theme which emerges from various sources quoted there and others (e.g. [9]), is that mathematics graduates enter a wide range of occupations (see e.g. [3]), and are welcome for their analytical and logical thinking, but are particularly valuable if they are also accomplished at the so–called transferable, key or soft skills such as working productively in a team, and communicating effectively in writing or orally.

h. *The increasing number of students who choose to study later in their lives, and/or part-time, and/ or have geographic limitations on where they can study.*
A range of measures are taken by various universities to welcome mature mathematics students, who may enter via Access or in-house preparatory year courses as well as A Level routes. There is some demand from part time students, and the Open University is worth mentioning here, but in most universities the small numbers mean that such students must fit in with full time cohorts.

A more serious economic constraint concerns geographical coverage. In recent years there have been a number of closures of Mathematical Sciences degrees (for example Ulster, Bangor and Hull), which lead to the danger that there will be some areas of the country where a person with geographical restrictions will not be able to study mathematics to honours level. The CMS has commissioned a study of this effect which is current.

i. *The financial impact upon students who undertake HE study.*
Another worthwhile and non-trivial question. There are early indications emerging that the government initiative to encourage more young people from the lower socio-economic classes to apply for a university place may be stalling. While it is true that the full effects of some initiatives, such as Aimhigher, are still to work through, it is clear that financial impact of fees and bursaries is a major factor.

j. *The impact, on the UK, of international flows of students and STM professionals*
There is an increasing number of non-UK appointments to UK academic staff posts in mathematical sciences. It would be useful to understand the effect of this upon the whole cycle of mathematical education in the UK.

k. *The developments in HE and economic policy inside and outside the UK and how the HE system can accommodate these changes.*
Education should enable a person to accommodate change as they live through it in a rapidly changing world. But HE is terribly conservative. Change can only be implemented by charismatic leaders who lead by example and persuasion, and not by diktat or bullying.

References

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