International Review of the Mathematical Sciences

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Town Meeting

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Background

Planning for the International Review of the Mathematical Sciences in the UK begin more than one year ago.

The review was commissioned and managed by EPSRC, and guided by a Steering Committee (listed in the report) chaired by Professor Tim Pedley (Cambridge).

The present review covers all areas of the mathematical sciences addressed by the 2004 International Review of Mathematics, as well as operational research (which received a separate review in 2004).

In concert with the chair, the Steering Committee selected fifteen other members, all based outside the UK, representing a balanced mix of international researchers with expertise spanning the mathematical sciences and relevant Research Council disciplines.

The sixteen members of the panel:

[Our names are given in the report]

The Panel's Busy Schedule

On 5 December 2010, the full panel met and received a preliminary briefing from EPSRC.

During 6–8 December, three sub-panels made site visits (in adverse weather conditions) attended by participants from 42 institutions.

Each site visit included a meeting with collaborators, both academic and industrial, and a lunch limited to early-career researchers (PhD students, postdocs, junior faculty). EPSRC agreed in advance that a 30-minute segment of each site visit could involve only panel members and participants.

The full panel spent the morning of 9 December (and lunch) with industrial 'users' of the mathematical sciences.

A preliminary version of the report was delivered to EPSRC and the Steering Committee late on 10 December.

The Panel's Charge

Broadly framed, the panel's charge was to assess UK mathematical sciences research in comparison with the rest of the world, and to address a list of related questions.

The Terms of Reference for the review are given in the report.

The Evidence Framework for the review, formulated by EPSRC and the Steering Committee, consists of eight questions, each with several sub-questions.

The Evidence Framework (1)

A. What is the standing on a global scale of the UK mathematical sciences research community both in terms of research quality and the profile of researchers?

B. What evidence is there to indicate the existence of creativity and adventure in UK mathematical sciences research?

C. To what extent are the best UK-based researchers in the mathematical sciences engaged in collaborations with world-leading researchers based in other countries?

D. Is the UK mathematical sciences community actively engaging in new research opportunities to address key technological/societal challenges?

The Evidence Framework (2)

E. Is the mathematical sciences research base interacting with other disciplines and participating in multidisciplinary research?

F. What is the level of interaction between the research base and industry?

G. How is the UK mathematical sciences research activity benefitting the UK economy and global competitiveness?

H. How successful is the UK in attracting and developing talented mathematical sciences researchers? How well are they nurtured and supported at each stage of their career?

A Key Point, to be Stressed Early and Often

Actions taken by EPSRC since the 2004 International Review of Mathematics and the 2004 Review of Operational Research have greatly contributed to invigoration of mathematical sciences research, including improved structures for PhD education.

About the Mathematical Sciences. . .

- The mathematical sciences provide a universal language for expressing abstractions in science, engineering, industry and medicine;
- Mathematical ideas, even the most theoretical, can be useful or enlightening in unexpected ways, sometimes several decades after their appearance;
- The mathematical sciences play a central role in solving problems from every imaginable application domain;
- Because of the unity of the mathematical sciences, advances in every subarea enrich the entire field.

More on Unity

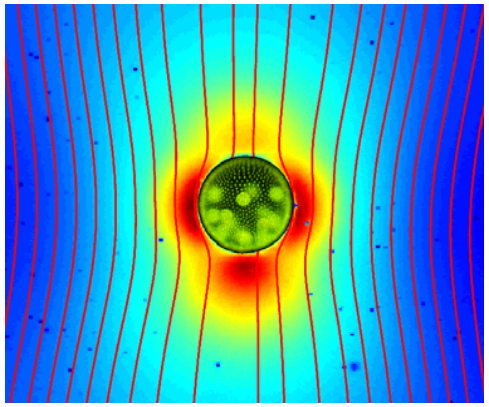
In the panel's view, standard divisions of the mathematical sciences into categories that are, by implication, close to disjoint can be useful to convey real differences in style, culture and methodology. However, a focus on these categories has had an increasingly negative effect when the mathematical sciences are considered in the overall context of science and engineering, by stressing divisions rather than unifying principles.

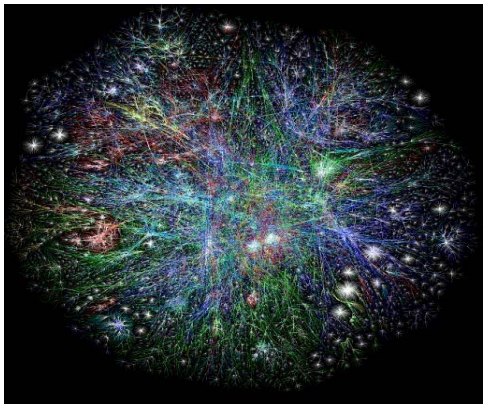
The panel urges the UK mathematical sciences community, relevant learned societies, and government funding bodies to adopt the view 'united we stand' in the context of this review.

More on Abstraction and Generality

The same (or closely related) abstractions from the mathematical sciences

- provide insights and intellectual tools for understanding and solving problems that seem disparate when represented in their 'natural' form and
- reveal underlying similarities as well as differences, and translate fundamental concepts from one field to another.





Integration, not Differentiation

The not-to-be-missed point is that the contributions of the mathematical sciences community should be considered as a whole.

Although some researchers focus some of the time on addressing real-world challenges, other researchers produce remarkable insights and results that advance and strengthen the entire discipline by pursuing self-directed adventurous research.

Special care is needed when placing the mathematical sciences within the broad context of research funding in science and engineering.

Diversity and Distributedness **of the Community**

Two major factors in the present excellence of the UK academic mathematical sciences enterprise are its diversity—in area, group size and size of institution—and its geographically distributed nature.

To preserve and increase the present level of quality, the panel believes that

- It is essential for research funding structures to honour diversity and distributedness, subject to the principle of funding only excellent research, and
- Flexible funding models are needed that will permit geographically distributed researchers working in a broad scientific area to receive adequate long-term funding.

Communication and Understanding

In this time of change and uncertainty about support for research, understanding and communication between the mathematical sciences community and EPSRC are especially important.

The panel recommends creation of a new structure, designed together by EPSRC and the mathematical sciences research community, that will allow frank and timely communication about crucial issues, such as the most effective structures for funding and the nature of initiatives.

Interactions and Collaborations

Connections among subfields of the mathematical sciences constitute an unending and enriching source of inspiration and new ideas.

Mathematical sciences researchers participate actively in multidisciplinary collaborations involving important and complex problems.

Mathematical scientists serve as valuable partners for industry in addressing its long-term challenges.

Structures exist for making these connections, but more are needed.

Evaluation of Multidisciplinary and Initiative Proposals

The review panels for multidisciplinary proposals whose topics include the mathematical sciences should include members with expertise in both multidisciplinary research and relevant areas of the mathematical sciences.

The mathematical sciences should play a much greater role in defining, and in the research of, multidisciplinary and 'grand challenge' projects.

[Excel story]

Connections with Industry

Based on the enthusiasm heard at the panel's stimulating meeting with industrial users, the panel urges that, in addition to existing programmes, long-term collaborations focussing on basic research driven by industrial challenges should be explicitly encouraged.

These collaborations should include multi-year, close relationships that involve academics and one or more financially committed industrial partners, as well as graduate education in the theory and methods needed to solve industrial problems.

Companies should explore establishing long-term strategic relationships with universities. Smaller companies should take full advantage of the Industrial Mathematics Knowledge Transfer Network.

Just To Be Clear. . .

Is the UK mathematical sciences community actively engaging in new research opportunities to address key technological/societal challenges?

Is the mathematical sciences research base interacting with other disciplines and participating in multidisciplinary research?

Is the mathematical sciences research base interacting with industry?

Is the UK mathematical sciences research activity benefitting the UK economy and global competitiveness?

YES, YES, YES and YES.

But of course more can be done, the community wants to do more, and the panel agrees that more should be done.

[See comments in the report.]

Institutes and Learned Societies

Activities of the institutes and learned societies make a significant contribution to the visibility and quality of UK mathematical sciences research.

And the panel would like them to do more, in collaboration with EPSRC if appropriate—for example, by arranging workshops that encourage and enhance connections (as already mentioned), and that include the mathematical sciences community in proposed or contemplated major research initiatives.

Big Concerns about PhD Education and Training

The most worrying factor in education and training by far is that, for the most part, UK PhDs appear to be uncompetitive for academic positions in today's global market.

Measures taken by EPSRC since 2004 (Taught Course Centres, Centres for Doctoral Training) have been very helpful, but it's too early to judge their long-term results.

Effective strategies are likely to require provision of PhD student funding during an adequate period.

An option suggested by the panel is a one-year 'Research Master's' followed by three years of PhD study.

Strong efforts should be continued to ensure that UK PhD training meets the highest international standards.

Looking to the Future: Early-Career Researchers

Very few of the postdocs and junior faculty met during the panel's site visits received their PhD education in the UK.

This shows the attractiveness of UK academic positions in an international context, but indicates a worrying trend if the UK cares about developing home-grown talent.

Depending on what other countries do, the situation is fragile and needs continuing attention.

Women in Mathematical Sciences Research

Based on data provided by EPSRC and attendance at the site visits, the proportion of women visible in UK mathematical sciences research is strikingly small compared to other countries.

As far as the panel could tell, this situation did not seem to be the subject of widespread concern for the UK community (although some people obviously do care).

Panel members unanimously believe that a lack of attention to this issue will be damaging to the future research excellence of UK mathematical sciences research, and that significant changes will happen only when the issue is taken seriously.

If it is decided that action is appropriate, there are potential roles for the institutes and learned societies.

Statistics: A Special Case

Despite areas of excellence and welcome measures taken to strengthen it, the UK statistics research enterprise is in a fragile and weakened condition.

Several forms of decisive action should be considered, including a more flexible grant structure and an in-depth study of the relevant structural issues.

Individual Subfields

UK mathematical sciences research is world-leading in some fields, outstanding in many others and strong overall, although there are, of course, aspects that could be strengthened. The report contains detailed comments about

algebra,	analysis,
combinatorics,	fluid mechanics,
geometry and topology,	mathematical physics,
number theory,	numerical analysis,
operational research,	probability,
statistics	computational science and engineering,
financial mathematics,	materials,
mathematical biology,	industrial mathematics.

Some final thoughts about support for the mathematical sciences

It seems absolutely clear that mathematical sciences research in the UK achieves a high standard of excellence on an international scale.

It seems absolutely clear that mathematical scientists interact productively with one another, with other disciplines, and with industry, helping to solve major problems in science, engineering, industry, and medicine.

But, despite the enormous importance of the mathematical sciences, their role is often invisible or disguised.

One possible reason. . .

Wow!

So cute!

?????

$$-\Delta u = f$$

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\Big(-\tfrac{1}{2}\big(\frac{x-\mu}{\sigma}\big)^2\Big)$$

minimize $c^T x$ subject to $Ax \geq b$

$$u(x) = f(x) + \int_0^x k(x-y)u(y)dy$$

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi\big(\frac{t-b}{a}\big)$$

On behalf of the panel, I urge those of you in powerful and influential positions, who surely understand the importance of research in the mathematical sciences, to argue on behalf of, and to make every possible effort to enhance, the outstanding UK mathematical sciences research enterprise.

Thank you.