Dr. Randal Richards  
Director of Research and Innovation  
EPSRC  
Polaris House  
North Star Avenue  
Swindon SN2 1ET  

Dear Randal,

THE INTERNATIONAL REVIEW OF UK RESEARCH IN MATHEMATICS

As you are doubtless aware, the UK Computing Research Committee (UKCRC) aims to promote the vitality, quality and impact of Computing Research in the UK and its members are internationally leading computing researchers drawn from both academia and industry: see http://www.ukcrc.org.uk. It is an Expert Panel of the British Computer Society, the Institution of Electrical Engineers and the Council of Professors and Heads of Computing. By contributing to policy formation within these three key national bodies, UKCRC enables UK Computing Research to speak with a single voice. This letter contains the views of UKCRC as regards the recent International Review of Mathematics (IRM). As might be expected, we limit our views to those aspects of Mathematics of particular relevance to Computer Science.

Not only do Computer Science and Mathematics share, at least in part, a common history, there is increasing scope for interaction as technology advances. Indeed, if one looks at the list of recent substantial contributions of mathematical research to society as laid out in the IRM, one cannot fail to note that many of the underlying topics, including cryptography, security, game theory, numerical algorithms, compression and data mining, lie (to varying degrees) at the interface between Computer Science and Mathematics. Moreover, as noted in the IRM, there are tremendous opportunities for the application of both Mathematics and Computer Science within the Life Sciences and e-Science.

The IRM regularly refers to the substantial interface between Computer Science and Mathematics, most notably in the contexts of theoretical computer science and computational science (though not exclusively). The review is emphatic in its opinion that the two inter-disciplinary research areas governed by algorithms and computational complexity on the Computer Science side and combinatorics, probability and discrete mathematics on the Mathematics side, and by scientific and parallel computing on the Computer Science side and numerical analysis on the Mathematics side are significantly under-developed.

Whilst the IRM is concerned with a review of UK Mathematics research and, as such, could not reasonably be expected to examine in detail all inter-disciplinary aspects of the subject, it should be remarked upon that the interface between Computer Science and Mathematics does not just lie within the research domains described above. The boundary between the two subjects is rich, diverse and largely unexplored and includes interactions between Computer Science and each of Pure Mathematics, Applied Mathematics and Statistics. Examples of such inter-disciplinary research are: the use of computers to help solve and reason about mathematical problems; the role of dynamical systems in modelling and predicting performance of
computer networks; the mathematical aspects of data sampling and data compression; and the role of probability and statistics in areas such as bioinformatics, data mining, information retrieval, software engineering and performance analysis.

As regards algorithms and computational complexity, the recent International Review of Computer Science (IRCS) also remarked upon this research area as being under-represented within UK Computer Science. However, one should not confuse under-representation with lack of scientific quality. In the general area of algorithms and computational complexity, UK Computer Science has some outstanding individuals who are recognised as such not only within Computer Science but also within Mathematics (witness the recent Newton Institute programme in “Computation, Combinatorics and Probability” and the forthcoming programme in “Logic and Algorithms”). Nevertheless, it is true that the general algorithms and computational complexity research area is under-developed, both within Computer Science and as an inter-disciplinary research effort between Computer Science and Mathematics. Note that some initial efforts have been made in recent years, for example through the joint EPSRC and London Mathematical Society initiative MathFIT, Mathematics for IT, building upon the LogFIT, Logic for IT, initiative, to develop research at the interface of Mathematics and Computer Science, and Smith Institute and its roadmap for industrial mathematics.

As pointed out by both the IRM and the IRCS, there is tremendous potential for algorithms and computational complexity research as the world becomes ever more digital and data sets and computational resources become increasingly more massive. We fully endorse the views espoused in both the IRM and the IRCS, and feel that building upon the existing scientifically strong, though sparse, research base in algorithms and computational complexity, in a coherent manner and embracing the related mathematical communities, should perhaps be a priority for any developmental (inter-disciplinary) initiatives.

A neighbouring inter-disciplinary research area, that of semantics and logic for computing, which was noted as being internationally leading by both the IRM and the IRCS (and which has a significant interaction with the logical aspects of computational complexity), is also an area within which Mathematics can further develop its interactions with Computer Science. Whilst the IRM did not mention this area of research extensively, logic and semantics research on the boundary between Computer Science and Mathematics has transformed logic as a discipline, within both Mathematics and Computer Science. The world-leading status of UK logic and semantics research should be enhanced and enriched by further development pertinent to both the Computer Science and Mathematics communities.

The IRM observes that computing has had a profound impact on research across the sciences and that many countries have made a significant investment in inter-disciplinary research in scientific computing and computational science. Furthermore, the IRM remarks that (the lack of) connections between numerical analysis and computer science is a major issue and needs to be addressed. Slightly worryingly in this regard, the IRCS commented that UK high-performance scientific computing appeared to have diminished in recent years (from an historically strong position). We feel that the relationship between Computer Science and Mathematics in the area of computational science will become increasingly important (particularly as, for example, e-Science will increasingly provide real-world challenges to the subject) and that this relationship should be significantly developed.
In summary, it is clear that it is the view of the IRM that much more could and should be done to further develop the extensive interface between Computer Science and Mathematics (and not just in the areas highlighted in this commentary), and the UKCRC strongly shares this view. What is particularly noteworthy is the degree to which the IRM and, by extension, the modern Mathematics community, acknowledges the fundamental contributions Computer Science can make to Mathematics, and Science and Engineering in general, and how important it is for Mathematics to have a properly developed interface with Computer Science. UKCRC is keen to assist in any initiatives and strategic thinking which might go towards strengthening the research interactions between Computer Science and Mathematics and is happy to work with, for example, the mathematical learned societies in this regard.

Computer Science has for a long time been a subject in its own right, having drawn in the past primarily from Engineering and Mathematics but since having developed its own modus operandi, research culture and traditions. Whilst the interface with Mathematics is but one of many on the boundaries of Computer Science and does not by any means define the subject of Computer Science, it is pleasing to see that another scientific discipline clearly appreciates with high regard the achievements and potential of Computer Science.

Yours faithfully,

Professor Iain A. Stewart

(for UKCRC)