Response to Royal Society paper:
Science Higher Education in 2015 and beyond – call for evidence

HE Academy Maths Stats & OR Network – Graduate Skills Working Group
(Michael Grove, MSOR Network Manager, University of Birmingham
Dr Stephen Hibberd, Chair of Group, University of Nottingham)

This submission addresses directly the identified issue:
"increasing employer and other requirements for subject specific knowledge, relevant experience in a workplace, and generic skill assimilation within first degree courses."

1. Graduate skills in mathematics

There is well-documented expectation from Government, employers and students that undergraduate and postgraduate courses should provide graduates with enhanced skills and attributes for future economic and other benefits. In particular, the Robert's report 'SET for Success' [1], highlights serious implications for UK Science and Engineering:

"graduates and postgraduates in these strongly numerical subjects are in increasing demand in the economy – to work in R&D, but also to work in other sectors (such as financial services or ICT) where there is a strong demand for their skills."

There is an increasing realisation within a digitally connected and enhanced world of the importance of enhanced specialist skills from mathematics graduates, and that mathematical training within Engineering and Science is needed for a shift to a higher level of innovation in R&D. The Smith Report [2] presented a number of difficulties faced by employers in recruiting appropriately qualified scientists. Within the report Smith concluded that the current (School) curriculum and qualifications framework *'fails to meet the mathematical requirements of learners, fails to meet the needs and expectations of higher education and employers and fails to motivate and encourage sufficient numbers of young people to continue with the study of mathematics post-16'*. A key requirement from any form of initiatives is to ensure that such comments cannot be aimed at the HE – MSOR provision. Clearly to attain this aim will require co-ordinated action from the Government, employers, universities and the HE mathematics community and professional organisations.

Recent Government led responses include the publication of a long-term strategy [3] that includes a proposal to increase in the number of young people taking A-levels in mathematics by about 10,000 entries per annum by 2014. Further, a community-wide mathematics proposal has been formulated to increase the supply of Mathematical Science Graduates [4]. These initiatives are tangible recognition that employment demand for mathematically capable graduates is perceived as widely applicable throughout industry, business, commerce and the public and private sectors [5]. In 2004, 61% of mathematics graduates had entered employment in over 18 work sectors [6]. The QAA Benchmarking statement [7] highlights that MSOR graduates posses knowledge and skills that will enable them to make a contribution beyond other subject areas particularly where a combination of analytic, numerical and communication skills is valued. Additionally many maths graduates can diversify further through postgraduate study, either into research in universities or advanced courses towards specialist employment opportunities within many industrial and commercial sectors. In 2004, 24% of all maths graduates went into further study and another 11% combined both employments with study [7]. Case studies of MSOR graduates entering a diverse range of jobs are readily available through websites [8] and [9] aimed at informing pre-university, undergraduate and graduate sectors; these confirm the good careers enhancements and personal satisfaction that can be obtained. The areas of work entered by graduates are identified within Table 1, with some 40%

entering traditional areas of Business, Finance and numerate areas such as Accountancy, but also a great diversity of other employment areas.

Marketing, Sales and Advertising Professionals	2.9%
Commercial, Industrial and Public Sector Managers	9.0%
Engineering Professionals	1.2%
Education Professionals	12.0%
Business and Financial Professionals and Associate Professionals	28.8%
Information Technology Professionals	5.4%
Other Professionals, Associate Professional and Technical Occupations	2.7%
Numerical Clerks and Cashiers	9.9%
Other Clerical and Secretarial Occupations	11.7%

Table 1 – Main careers undertaken by mathematics graduates 2004 (% of all work) – from [6]

2. A strategic case for graduate skills enhancement

Within a strategic review of STEM subjects [10], mathematics is recorded as having a substantial base of 17,000 FTEs in 2003-4 but identifying a prior period fall of 9.3%, which is of concern. An underlying vulnerability has been identified for mathematics and the reality of possible impact on other subjects would be significant. The report identified vulnerability as having possible mismatch between either of the two or more parts as illustrated in Figure 1.

Supply of potential students for HE
↓
HE provision (whether of skills, business and community activities or research) to the nation
↓
Employer, government or 'other' (e.g. cultural) demand, whether current or predicted

Figure 1 – Illustration of areas of vulnerability- see [10]

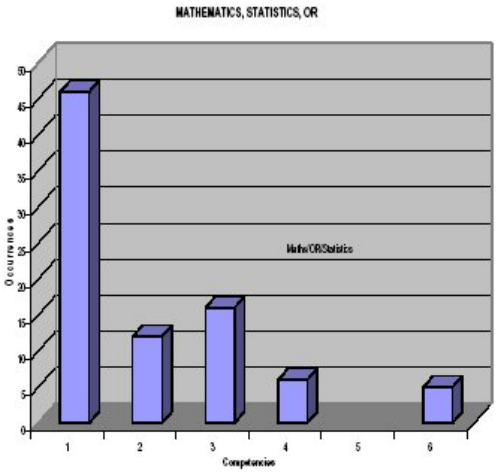
A welcome response is HEFCE funding for the proposal to increase the supply of students to the Mathematical Sciences [4], however to obtain full benefit, other downstream aspects will need to be implemented from within HE through greater attention to skills acquisition for graduates and greater interaction between HE and employers.

HE is coming under increasing pressure that graduates should possess enhanced skills alongside a strong tradition of provision in knowledge and understanding, indeed the Robert's report [1] notes:
"Furthermore, there are mismatches between the skills of graduates and postgraduates and the skills required by employers (for example, many have difficultly in applying their technical knowledge in a practical environment and are seen to lack strong transferable skills)".

Explicit recognition of the importance of skills development within undergraduate programmes is explicitly included in the latest QAA specifications [11] which proposes that specifications should be written to provide a source of information for, amongst others,
'Employers, particularly about the skills and other transferable intellectual abilities developed by the programme'.

Further, guidance suggests learning outcomes
'should be linked directly to the knowledge, understanding, skills capabilities and values that a student will have gained after completing a programme'.

The Benchmark Statement for MSOR is very upbeat on the topic of career opportunities for mathematics graduates however there remains a significant lack of detailed study and claims are not readily justifiable in all programmes. A recent project on enhancement of student employability skills is provided by ESECT and the HE Academy [12] that has been ongoing since 2002. One outcome was the creation of a 'Student Employability Profile' [13], based on a competencies analysis of the QAA Benchmark Statement. Such data was also reproduced in more graphic style, as shown in Figure 2, in a recent guide to employers [14].



1. Cognitive Skills: analysis, judgement, attention to detail
2. Generic Competencies: high level transferable skills
3. Personal Capabilities: life long learner, self-starter, finish the job
4. Technical Ability: ability to apply and exploit modern technology
5. Business and/or Organisational Awareness: appreciation of how business operates, work experience, organisational culture, basic financial and commercial principles
6. Practical and Professional Elements: critical evaluation of professional practice, reflecting and reviewing own practice on an ongoing basis

Figure 2 – Plot of competencies evaluated in Mathematics - see [14]

Even a cursory inspection will identify a traditional overwhelming emphasis on cognitive skills (with strong emphasis on knowledge and understanding) with more limited attention to other competencies. This imbalance is also highlighted by the availability, for the first time, of additional post-graduation data collected by HESA and displayed on the HERO website [15] to provide detailed information for prospective undergraduates and employers. For 2005 this identifies mathematics graduates as the least satisfied over all subjects in terms of personal development (based on responses to: helped me to present myself with confidence; my communications skills have improved; I feel confident in tackling unfamiliar problems). The overall satisfaction of graduates in mathematics, however, is high.

3. Integrative learning for the next decade

Mathematics should be well placed to articulate and provide information to employers and prospective students of the relevance, wide skills base and skills attainment that can be gained from within the wide range of the 1496 courses within 95 UK Universities [16]. Potential skills, intrinsically embedded within a Maths degree and relevant to an extensive range of employment areas include:

- Analytical, modelling and logical problem solving skills;
- Ability to evaluate, analyse and interpret numerate information;
- Apply transfer knowledge from one situation to another;
- Ability to learn for oneself; be a self-starter and a finisher;
- Highly developed skills of numeracy permitting accurate and informed manipulation of numerate concepts;
- Gained general and specialist ICT skills;
- Ability and readiness to address new and related problems.

Increasingly students are looking for high employability prospects upon graduation. The areas of employment (careers) and employability skills are not sufficiently recognised or acknowledged, partly perhaps as many MSOR graduates move seamlessly into multi-disciplinary teams. There is

an ongoing need for academic staff and employers to understand and integrate the skills that are, and could be, developed during the learning process for mathematics and statistics. This may involve more innovative individual or group based project activities, vocationally orientated experiences, interdisciplinary seminars and case studies. Personal attainment can be identified through peer-assessment, reflective logs and personal development portfolios. Such skills are also extremely beneficial and relevant to those going into advanced study or university-led research. A number of initiatives are underway and good practice does exist within the MSOR community in pedagogic development, innovation and implementation. The HE-Academy Working Group has been established to identify and help coordinate individual initiatives but also related activity is ongoing within the newly established CETLs (e.g. [17], [18]) and individual Institutions (e.g. [19]).

4. Conclusions

Graduate skills attainable within MSOR need to be evidenced by appropriate attention to the curriculum and structure of degree programmes. There is a compelling case to identify, articulate, develop and record the core general and subject-specific skills proficiencies, but also to include achievement outside of the traditional taught discipline aspects. Provision might include extensive and innovative project work, vocationally related experiences (e.g. UAS), Study Abroad experiences and also mechanisms for the inclusion of placement or voluntary work as credit bearing elements. A more integrative approach has the potential to enhance student's motivation, their academic performance, their employability in a global market and their confidence to engage successfully with the challenges and expectations of a rapidly changing world.

References:

1. Roberts Report: SET for Success, The supply of people with science, technology, engineering and mathematical skills – Report of Sir Gareth Robert's HM Review, HM Treasury 2002.
2. Making Mathematics Count - Report of Prof Adrian Smith's Inquiry into Post-14 Mathematics Education, HM Treasury 2004.
3. Science and innovation investment framework 2004-2014: next steps, HM Treasury, March 2006
4. Have you seen this…? Increasing the Supply of Mathematical Science Graduates. M Grove, MSOR Connections Vol 5, No. 3, August 2005.
5. What Do Graduates Do, Association of Graduate Careers Advisory Service - www.agcas.org.uk
6. Graduate Prospects – graduate career information / advisory service - see www.prospects.ac.uk.
7. Subject Benchmark – Mathematics, statistics and operational research, QAA 2002.
8. Maths Careers – Maths and Stats Work – website supported by the Council of Mathematical Sciences, www.mathscareers.org.uk.
9. Plus Magazine – Careers with maths Library – www.plus.maths.org.
10. Strategically important and vulnerable subjects – Final report of the advisory group. HEFCE Report, June 2005;
11. Guidelines for preparing programme specifications, QAA 115, June 2006; www.qaa.ac.uk/academicinfrastructure/programspec/guidelines06.pdf.
12. Enhancing Student Employability Co-ordination Team (Oct. 2002-2005) & HE-Academy, see URL:www.heacademy.ac.uk/employability, accessed March 2006.
13. Student Employability Profiles, HE-Academy, URL: www.heacademy.ac.uk/2174.htm, accessed March 2006.
14. Student Employability Profiles – A guide for Employers, compiled by Bianca Kubler and Peter Forbes, The Council for Industry and Higher Education, 2006.
15. Higher Education & Research Opportunities (HERO) website. URL:www.hero.ac.uk, accessed September 2005.
16. UCAS courses 2006-7, www.ucas.ac.uk.
17. SIGMA – Centre for Excellence in Maths. and Statistics, Loughborough and Coventry Univs.
18. Centre for Integrative Learning, University of Nottingham.
19. Centre for Education and Industry, University of Warwick.