CEG SEMINAR REPORT
on
Mathematics for Science Students

Thursday 22 October 1998

Sir Walter Bodmer, University of Oxford, Institute of Molecular Medicine
The Importance of a Good Mathematical Foundation

This was a stimulating introduction which set the tone for the rest of the day. A good mathematical foundation was essential to science and he included with this the importance of statistical approaches for example in ecology, behavioural science and cancer research. Manipulative skill, mathematical modelling, understanding experimental design are also key areas. Science produces the appropriate contexts which give to maths particular relevance. Sir Walter's own contributions to cancer research is dependent on his early mathematical training.

Rosemary Feasey, Durham University Department of Education
Mathematics in KS2 Science

The Mathematics in the National Curriculum does not dovetail naturally with the Science. The maths schemes of work offer contexts which are too limited but it is to be hoped that the present curriculum review will rectify this. Due to their own educational experiences primary teachers often lack confidence in both their science and maths teaching, nor do they realise the centrality in science of evidence which can be quantified. When teachers are conscious of cross-curricular transferability and draw their pupils' attention to the involvement of maths in their scientific work the standard of their investigations is greatly enhanced.

Michael Brimicombe, The Cedars Upper School, Leighton Buzzard
Mathematics in KS3/4 Science

Science is about predictions followed by quantitative measurements to verify those predictions. In recent years much has been removed from the science schemes of work on grounds of difficulty with the result that science has been made less demanding. Past evidence has shown that children are able to use formulae, both algebraic and chemical, and without their use scientific understanding is incomplete. If science teachers could assume that their students had greater mathematical competency they could spend more time on the social, economic and environmental issues of science.

John Dexter, The Trinity School, Nottingham
Mathematics and 16+ Chemistry

There is a mismatch between what maths teachers think their students can do and what science teachers believe can be achieved. Students often worry about whether their mathematical ability will allow them to cope in science. Science students struggle with indices, logarithms, the use of their calculators, proportions and manipulation and the ability to appreciate whether their final answer is realistic. They need support and encouragement and these can be provided by IT and individual learning. Mr Dexter doubted whether the new 'key skills' would alleviate these problems. Maths must be taught in a more interesting way - he suggested a 'Salters' A level Maths'.

Jack Abramsky, Principle Officer for Mathematics at QCA
Maintaining Standards and Increasing Effectiveness through Co-operation

Dr Abramsky reminded the seminar that this year the Nobel Prize for Chemistry had been awarded to a mathematician. For some students innate fear of mathematics is demotivating while for the able mathematician absence of mathematical rigour is boring. Higher Education complains that degree students cannot cope with multi-step problems or routine manipulation, and do not appreciate the power of mathematics. The QCA and OFSTED are aware of the problems and are at present piloting 'Free - standing Mathematics Units for 16+ students'. These are at three levels; foundation, intermediate and advanced, and each unit is assessed through a 50% external examination and 50% student's portfolio. Each unit is equivalent to either an A level or a GNVQ module. The units, which will involve considerable use of IT should be available from the year 2000. (A leaflet is available from QCA.)

Dr. Harrie Eijkelhof, The University of Utrecht
An International Perspective

Dr Eijkelhof outlined the Dutch education system, indicating how senior secondary school students studying science courses automatically followed a more detailed maths course because there is a much broader curriculum at this stage. They have similar problems about collaboration between maths and science; the language is different in each subject, they are mutually unfamiliar and there is no co-

operation in syllabus preparation. Dialogue is required on the role of mathematics as auxiliary to science and as a subject with its own identity. Possibilities for co-operation are seen in defining syllabuses and in developing and using integrative modules.

Nigel Bufton, Senior HMI for Mathematics

A Mathematical Reaction

Mr Bufton reassured the seminar that there **is** good maths teaching; there **is** co-operation with science teachers and this is probably at its best in the early years. He elaborated on the problems with which maths teachers have to contend. In maths primary teachers are very insecure not only in their knowledge but also in their pedagogy. They do not fully understand how the maths curriculum develops and cannot identify the landmarks. Too often teachers turn to commercial text books for support and rely on these as work books so that technique becomes all important and the ideas are not transferable. At KS3/4 there is a serious shortage of properly-qualified good teachers and too often the weakest teachers take Year 8 pupils so at this critical stage the excitement of maths can be lost. There is a need to share examples of good practice of collaboration between maths and science teachers.

Professor Peter Saunders, Kings College , London

Reflections of a Mathematician

Professor Saunders found it encouraging that everyone was seeing the same problems: poor manipulation, poor solving of multi-step problems and poor understanding of the concept of proof. He believes that the mathematicians, not the scientists, should teach maths because it

- is a skill
- has a logic of its own
- has needs of its own (it is a discipline in its own right)

Topics should not be taught twice, in maths and then in science. Maths must take account of the needs of science, and the best place for applications is in science. Science teachers must also pay attention to maths teachers and offer examples. All A-level science students need some maths teaching and the free-standing units may provide this. It is important that teachers, academics and others can influence the system but it is not easy to see exactly who is in charge; is it Government Departments, exam boards or the FE Funding Council?

Professor Alan Cornish, Imperial College, London

The Perspective of Higher Education and Industry

Engineering is the application of scientific principles which must be expressed clearly in mathematical terms. Professor Cornish enumerated the skills and knowledge essential to university students, but, most important, mathematical maturity, which involves using maths to comprehend science and for problems and modelling. Universities are now well used to making corrective provision for their students but most of all they appreciate enthusiasm.

Summary of Discussion From the Morning Groups

Why do you consider it essential that science teachers provide a proper mathematical explanation of their work?

There was universal agreement that science teachers should provide a mathematical explanation of their work. Science postulates patterns and makes predictions, and the need to describe these involves a precision which is based on numbers. Science is an appropriate context in which to use, contextualise, practise and gain fluency in maths. Although scientific ideas may be introduced qualitatively, these should be developed quantitatively, even with quite young pupils, and increase the level of sophistication as the students mature. Some felt that the least able could be taught **about** science without mathematics.

Identify two or three mathematical techniques or methods whose mastery by almost all pupils at Key Stages 2 and 3 could have the greatest effect on science teaching at this stage and beyond.

- Algebraic manipulation of formulae.
- Basic calculations, including the 'reasonableness' of answers.
- Abstraction by the regular inclusion of symbols and graphs.
- A feeling for 'number', particularly proportions.
- Concept of scale.
- Handling data.
- Recognising patterns.

What steps are necessary to ensure a more mathematical approach to science teaching?

- Reintroduce at an earlier stage some recently-removed mathematical techniques (e.g. algebraic manipulation).
- A better supply of good teachers with subject-specific knowledge.
- More dialogue between science and maths teachers.
- The use of science concepts in the numeracy hour.
- The curriculum review should involve more linkage between subjects rather than maintaining subjects in water-tight compartments.
- Mathematics to be seen as a service provider to other subjects, including science.
- Standardisation of language between maths and science.
- Increasing children's mathematical confidence (possibly in the numeracy hour).
- Changes in the nature of examinations.
- Maths for science should be taught by scientists because at present there is an incoherent progression and too much compartmentalisation. (This was a controversial issue and many members disagreed.)

Summary of Discussion From the Afternoon Groups

What specific changes should be made in working to improve collaboration between mathematics and science teaching? Please make one proposal under each heading.

In Schools
- Better communication between departments.
- Additional time is essential for collaboration. This could be gained if there were fewer exams; KS3 tests could be eliminated, and likewise GCSE for those students continuing their studies post 16, thus establishing the 14 - 19 continuum. INSET time could be allocated so that the aims of collaboration are established. It would help if exam boards gave official encouragement to collaboration.
- Better networking between schools, including the use of local teacher centres.
- Organisation of ASE or RSC regional meetings on maths/science collaboration.
- Coursework covering both maths and science.
- The production of a set of activities which could be used by either department.
- A reconsideration of the ASE cross-curricular work done in 1990.
- Maths/science collaboration in Beacon Schools.

In Higher Education
- More financial recognition to those lecturers who work across departments.
- There is too much inspection of teacher training institutions and this inhibits developments, takes up valuable time and diminishes confidence.
- The ITT science syllabus has a section which draws attention to mathematical misconceptions. These should be dealt with in the institution by the maths tutor, and should be more widely disseminated.

In the Professional Associations
- These associations are nor hampered by the restraints which apply in schools, so they could offer INSET for maths/science collaboration, perhaps offered jointly by maths and science associations.
- Positive promotion of collaboration so that it is perceived as important.
- The production of small units of material, not cohesive schemes, which could operate within the curriculum.

Through Government
- Government could facilitate the sharing of good practice and networking by direct funding of local projects, especially those involving engineers and scientists working in the community.
- Improved communications so that teachers and others are aware of where key decisions are taken. (DfEE, QCA, exam boards, funding council?)
- Funding for special maths/science co-ordinators similar to special needs co-ordinators in schools. It is important that career development should be seen within the area of classroom teaching as well as in senior management.
- The problem of recruitment of high-quality teachers with specific subject knowledge must be addressed.
- A mapping exercise to be undertaken by QCA between the maths and science curricula, in order to identify any mismatches or omissions.

- Reduction of the curriculum content to provide more time to cover mathematical aspects.