Britain Debates Science Education Reforms

School curricula are criticized for being excessively academic; all agree changes are needed, but reforms may prove elusive

London. If scientific literacy were the most important key to success in the international marketplace, then Great Britain, with more Nobel Prizes per head of the population than any other country, should be far ahead of the rest of the pack. The fact that Britain is not, and that the strength of its scientific community has not prevented its economy from behaving more sluggishly than competitors such as Japan, West Germany, and the United States is prompting a far-reaching reassessment of the way that science is taught in British schools.

In contrast to the debate over science education in the United States, there is little concern about the overall quality of the science education offered to British school children. The number of both boys and girls taking science courses has been rising steadily over the past two decades, and examination results have also been improving in virtually all science subjects.

The principal concern is over the extent to which the *content* of both courses and examinations provides children with skills and attitudes to science that are relevant to their needs in the modern world. "A chasm has opened up over the last century between the world of education and the world of work," says Dr. Eric Bates, head of a newly formed Industry Education Unit within Britain's Department of Trade and Industry (DTI). "An emphasis has been placed on academic achievement, often reflected in the way that examinations are set, which had led to a lack of relevance in much of what is taught in schools to a child's future needs."

This emphasis on the academic aspects of science is reflected in social attitudes. Academic research, for example, has a higher social status in Britain than practical engineering, and this bias is said to affect even the way concrete problems are tackled.

The argument is not new. It has, for example, been a consistent theme in proposals for the reform of the curriculum from the 16,000-member Association for Science Education, made up mainly of science teachers from state-funded schools. Under the slogan "science for all," the association has for several years been arguing that an excessive emphasis on academic aspects of science has made it difficult to develop interesting or appropriate courses for the 80 percent of children who are not likely to continue into higher education.

What is new, however, is the way that the same issue of relevant courses has been taken up by a Conservative government which, until only 2 or 3 years ago, was complaining that the major problem with the educational system was its failure to provide basic skills in literacy and numeracy. The Conservatives in the past have tended to leave the details of curriculum reform to the separate local education authorities and examination boards through which the British educational system is organized.

The argument now being embraced by Britain's Secretary of State for Education and Science, Sir Keith Joseph, is that teaching basic intellectual skills can be used in concrete situations.

Sir Keith Joseph

Government may keep an eye on curricula.

For different—and sometimes conflicting—reasons, the principle that the science curriculum should be more relevant to social needs is endorsed by virtually all groups with an interest in the way that science is taught in British schools. Teachers claim that it makes it easier to show how science forms part of a broad liberal education; scientists argue that it helps to stir interest in and support for their profession; and politicians are beginning to argue that education should be seen as an investment providing dividends for society as well as for the individual.

Despite their different starting points, it has therefore not proved too difficult to generate a broad consensus between these groups both on the fact that major reforms in science education are needed, and where these should focus. There is now general agreement, for example, that science should form an important component of the education of all children up to school-leaving age of 16, and wide acceptance that a reasonable target would be for science subjects to make up 20 percent of the timetable by this age.

There is also agreement on the need for a more balanced approach to science teaching. The British system of "O level" examinations, which students take at about age 16, tends to require specialization at a relatively early age—even between fields of science. Many of those studying biology, for example, do not take courses in physics, and vice versa. The revisions to the curriculum being discussed would, where necessary, substitute breadth for depth, at least up to the age of 16, on the grounds that even for the future scientist, it is unreasonable to expect students to make well-informed choices between fields of study before this.

Central to all proposed reforms is the idea that science has suffered in the past from being taught as an excessively abstract activity. "The ethos of the British educational system is one that has been built in for a very long time," says Peter Warren, deputy secretary of Britain's Royal Society. "We are still operating in a mode in which too much weight is given to the thinking man's approach to problems rather than the doing man's approach, and it is being done at too high a cost."

This bias in the content of school science courses has recently been highlighted by a number of independent studies. It was, for example, one of the main conclusions of a series of surveys of the scientific abilities of school children at different ages commissioned by the Assessment Performance Unit of the Department of Education and Science (DES), a group set up to identify weak spots in the British educational system (apart from Scotland, which has its own system).

A nationwide survey of 11-year-old children showed that although many had well-developed techniques of observation and measuring, less effort seemed to have been put into the development of "science-oriented skills" such as formulating elementary hypotheses and apply-

ing them to novel situations. A similar picture emerged among both 13- and 15-year-olds.

"It seems that in all age groups, the ability to apply scientific concepts is lower than the ability to understand scientific data," says Wynne Harlen of the Centre for Science and Mathematics Education at Chelsea College, London. "The teaching of science should be related to needs; but at present the type of science that is done in the classroom does not seem to have a relevance to everyday life."

Similar criticisms are often heard in Britain about examinations in science, namely that they tend to assess the mastery of knowledge that a pupil has obtained but not his or her ability to use it. Employers often compound this problem, suggests Dick West of the Secondary Science Curriculum Review, by using the levels of academic achievement obtained in examinations as a criterion for recruitment, rather than testing broader skills such as the application of concepts to practical problem-solving.

Exploring ways to encourage a change of emphasis within examinations is one of the goals of the DTI's Industry/Educa-

Congress Sidetracks Science Education

Despite broad public recognition that there is a problem with science and mathematics education in the schools and a fast start by Congress on legislation designed to give a major boost in funding to improve it, federal action on the matter is currently stalled.

House and Senate committees moved promptly early this year to fashion science and math education bills (*Science*, 11 March, p. 1198). The House passed its bill (H.R. 1310) in March; the Senate bill (S. 1285) was reported out of committee in May but still has not been scheduled for floor action. The two bills are similar in funding—$400 million plus—but differ significantly in content.

Even if the Senate bill achieves early passage, therefore, reconciliation of the House and Senate versions of the bill could be difficult. And there are other obstacles. The reception the Administration would give to a science and education measure several times more costly than the one it asked for is uncertain. And there is really still no consensus among the congressional sponsors of the proposals and the education lobby on the specific shape the reforms of science education should take.

At the same time, staff sources on Capitol Hill say that public pressure for passage of legislation to aid science and math education remains high. Helping to maintain the edge of interest has been the appearance of a series of widely publicized reports on the ills of American education, most recently those of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology, and the Carnegie Foundation for the Advancement of Teaching report on secondary education. Longer term prospects for passage of a substantial federal initiative look favorable to Hill observers, although the legislation is currently consigned to the parliamentary slow lane.

Science and math education, however, has not been completely shut out in this session of Congress. The National Science Foundation (NSF) appropriations bill passed in July contained $75 million for science education, an increase of $45 million over the amount allocated in the last fiscal year which ended on 1 October.

Just how these additional funds will be expended is not yet clear. NSF authorization legislation, which customarily specifies program spending, has been held up, mainly by a tussle for jurisdiction over NSF in the Senate between Senator Orrin G. Hatch (R–Utah), chairman of the Labor and Human Resources Committee and Senator Slade Gorton (R–Wash.), who chairs the Commerce committee's subcommittee on science, technology, and space.

The play of personality and congressional politics also contributed to the slowdown on the broader science and math education bills. The House version of the bill reflects an accommodation between the chairmen of the House Education and Labor and Science and Technology committees, Carl D. Perkins (D–Ky.) and Don Fuqua (D–Fla.). The Senate bill represents a balancing of the interests of Senate Labor and Human Resources Committee's chairman Hatch and its education subcommittee chairman and ranking majority member, Senators Robert T. Stafford (R–Vt.) and Claiborne Pell (D–R.I.).

As now constituted, neither bill delights the coalition of mainstream education organizations representing elementary and secondary schools and higher education. A major concern is that the bills' distribution formulas would diffuse funds too widely to achieve significant impact.

Unanimity within the coalition is also under stress since the amount of money designated for higher education strikes some of the elementary and secondary school partisans as disproportionately high. To help the legislation over the final hurdles, it will be important that the education community front remains united.

A principal reason that the science and education bills have been sidetracked is simply the turn of the congressional cycle. By late spring, the legislators' attention was preempted by such as the MX missile and U.S. policy in Central America. Since Congress returned in mid-September from its summer recess, appropriations measures have inevitably occupied center stage.

The Administration attitude toward the proposed science and math education measures has not yet been clearly expressed. Basic policy follows President Reagan's view that domestic spending should be controlled in order to restrain the deficit, and the federal role in education should be limited, leaving the main initiative for reform to state and local authorities and private groups. Education Secretary Terrel Bell, however, has indicated that Reagan might sign additional science education legislation if its funding dimensions are acceptable, a position that is regarded as reflecting the political potential of the issue.

Democrats in the House evidently view education reform as an issue with sufficient popular steam behind it to propel it through next year. The House by voice vote on 3 October passed a bill authorizing $500,000 for a national education summit conference to make specific recommendations to Congress, the federal government, and the states on how to implement the reports of the expert committees. The deadline for the conference report was set at 15 June of next year, just in time for the presidential nominating conventions and the '84 campaign.—**JOHN WALSH**

tion Unit, a group set up in 1980 to encourage a greater interest in manufacturing industry in schools. The unit's budget and responsibilities have been significantly increased by the Conservative government as part of its broader efforts to help British industry.

Earlier this year, the unit commissioned an analysis of the questions contained in several thousand "O level" examination papers in physics, chemistry, and mathematics. This revealed that less than 5 percent of the questions were intended to test a student's ability to apply knowledge and understanding of principles "to problems and situations relevant to the 1980's." The majority of questions either tested a knowledge of principles in themselves, or applications of a purely scientific or mathematical nature. It is now gathering proposals on real-world problems that might be used to test the same skills.

Perhaps the most influential document in the current debate over curriculum changes has been the report of a major inquiry into the teaching of mathematics in schools carried out by a committee chaired by W. H. Cockcroft, vice-chancellor of the New University of Ulster in Northern Ireland, and published last year by the DES under the title *Mathematics Counts*.

The report presents a hard-hitting critique of the traditional way in which mathematics is taught, with its heavy emphasis on the development of intellectual skills. Indeed, it suggests that the need often quoted by teachers to develop powers of logical thinking, accuracy, and spatial awareness "does not itself constitute a sufficient reason for studying mathematics rather than other subjects." It suggests that, in contrast, teachers should realize their principal goal is to enable each pupil to develop "the mathematical skills and understanding required for adult life, for employment, and for further study and training."

The conclusions of the Cockcroft report have been widely applauded, particularly in government circles, as pointing the way forward for the whole educational system. Indeed, Cockcroft himself was subsequently appointed chairman of a new council established last year with responsibilities for promoting improvements in school-based examinations and other systems of assessments.

Nevertheless, considerable controversy still surrounds the question of what is meant by "relevance" in science education, and whether a major change in emphasis is necessary, as the Cockcroft report suggests for mathematics. The Royal Society, for example, in a report produced by a study group of nine of its members last year, accepted that there should be more emphasis on the applications of science in school science courses, but warned that the pendulum should not be allowed to swing too far.

"We feel that you can still teach a lot about the applications of science through the pure science curriculum by using practical examples that carry through scientific ideas and principles," says R. J. Blin-Stoyle, professor of theoretical physics at the University of Sussex and a member of the study group.

Others, however, claim that producing a "relevant" curriculum could require radical changes in the way science is taught. While the Royal Society report, for example, argues in favor of keeping the separate identities of physics, chemistry, and biology, a discussion document produced by a subgroup of the Association for Science Education proposes various forms of restructuring. Some of its proposals would give the same prominence to other disciplines or perspectives, such as earth sciences or the history and philosophy of science, perhaps even making these the dominant themes for a single year of science studies.

Secretary of State Sir Keith Joseph has already indicated his own definition of relevance. Earlier this summer, he rejected a proposal that questions on the social applications of physics be included in a set of "national criteria" currently being drawn up for all subjects as guides for the 24 separate boards which currently set examinations used in schools in different parts of England and Wales. In contrast, Joseph has added microelectronics to the list of subjects that should be included in school physics courses, a move which directly reflects the government's educational priorities (Britain is the first country in the world to have installed personal computers in all its secondary schools, under a scheme jointly financed by the DTI and local education authorities) but has upset some physicists who feel that the scientific concepts involved are too advanced to be covered even to an elementary depth in a general physics curriculum.

The controversy raised by these two decisions has come not merely from their content, but also from their implication that the government intends to keep a much closer eye on what goes into the curriculum than it has done in the past, and that although it lacks statutory authority to *impose* changes directly on local authorities, it is prepared to exploit the powers it has to achieve what it considers to be desirable changes in the education system.

One illustration of the government's potential influence on school science courses is a $30-million-a-year initiative announced last year by Prime Minister Margaret Thatcher aimed at providing new opportunities for technical and vocational education for 14- to 18-year-olds as a response to the growing problem of youth unemployment. The major emphasis of the courses funded under this scheme will be on training in technical skills. Indeed, in many ways, they are intended to compensate for the lack of practical training in useful skills provided by the traditional school science curriculum.

A government that explicitly endorses Victorian social values now faces the task of undoing the damage these values may have had on the teaching of science.

The dangers that many school teachers see, however, is that by consciously or unconsciously diverting the less able students toward such courses at a relatively early stage in secondary school, the initiative could undermine efforts to give a common grounding to all school children in core science subjects, and also widen still further the split between "thinking" and "doing" that many claim is the fundamental flaw in the current system.

"The tragedy is that the scientific and teaching communities dug their own grave in the 19th century by pushing science as an alternative *culture*," says Warren of the Royal Society. "There probably was no other way that science was going to get into the educational traditions of the time; having got in, however, little effort has been made until now to modify how science is taught." The irony is that a government which explicitly endorses Victorian social values now faces the task of undoing the damage that these same values may have had on the teaching of science.

—DAVID DICKSON