Design and technology in schools: future prospects: a comparative view

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This year's Design and Technology Exhibition has an emphasis on quality of teaching and learning. The programme also provides an important European perspective on developments in design and technology.

Because they are both in various ways concerned with the quality of children's educational experiences in this field, I will begin by saying something about two large-scale projects with which I happen to be associated. They not only have a European dimension to them, but also a wider international one.

The first is a project of the Organisation for Economic Co- operation and development (OECD) — what its critics sometimes refer to as the 'rich countries' club'. The OECD headquarters are in Paris and the organisation has 24 member countries, 18 of them in Europe, but including also some significant economic players such as the USA, Canada, Australia, New Zealand and Japan. The project is concerned with innovation in science, mathematics and technology education in the schools of member countries and has involved the preparation of case studies which it is hoped will yield models and insights helpful to those trying to improve criteria in these fields. Work started in the spring of 1989 and the first phase of the project was completed last year, with the analysis of over 50 case studies chosen, conducted and submitted by the various countries. The second phase, starting now, involves a more limited but deeper set of investigations into carefully selected innovations, conducted with a more rigorous methodology and designed to permit cross-country analyses in ways likely to yield findings of interest to both policy makers in governments and those professionally involved in science, mathematics and technology education. It is perhaps worth adding that there is a very strong USA interest and involvement in the project, not least because of the Bush administration's intention that America should be number 1 in the international league tables of students' performance, in science and mathematics especially, by AD 2000 — a nicely rounded and safe date which guarantees that few politicians who gave the pledge will be around on redemption day.

It will come as no surprise that one of the most significant findings from the first phase concerned the emergence of technology as a component of general education in many of the OECD countries: Australia, Finland, France, Ireland, the Netherlands, New Zealand, Sweden and the UK all contributed accounts of development. Furthermore, these innovations were all proceeding in different ways and from different origins. I will pick up some of the issues emerging from the phase 1 case studies in a moment and it is good news that technology is to be a special focus of the phase 2 work, which is planned to run through to the end of 1995. Regrettably, the substantial USA input into the project does not include a single technology innovation, a reflection not so much of inactivity in this field as lack of articulation between the networks of technology educators and those of science and mathematics educators there. Perhaps there is a message here of significance to all concerned with the future of school technology.

The second project to which I wanted to refer is organised by UNESCO. It is called *2000+: scientific and technological literacy for all* and it is a follow-up to the World Conference on Education for All held at Jomtien in Thailand in March 1990. Some of you may recall the devastating statistics in the Declaration which issued from that conference: more than 100 million children, including at least 60 million girls, still have no access to primary schooling and a similar number fail to complete basic education programmes.

The question that project 2000+ addresses is: 'What kinds of educational provisions and teaching are needed to ensure scientific and technological literacy for all, which in one extreme set of circumstances may be a requirement for survival, and in another for national economic development which does not jeopardise environmental quality?' The project has identified six focus areas:

1. The nature of and the need for scientific and technological literacy.

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Science *and/with* Technology	Science *of* technology	STS (Science, Technology and Society)
technological applications are 'added on' to science teaching in order to assist understanding of science and increase motivation of pupils.	the work begins with a technological context, which is then explored to extract the scientific principles and knowledge. The prime aim is still the learning of science.	the courses involve consideration of the effects of science and technology on society, and of society on science and technology. Opportunities to 'design and make' are rare.

2. Scientific and technological literacy for development.
   - 2.1 Life-long scientific and technological literacy.
   - 2.2 Research into scientific and technological literacy.
   - 2.3 Case studies and examples of scientific and technological literacy in various settings.
3. The teaching and learning environment for scientific and technological literacy.
4. Teacher and leadership education for scientific and technological literacy.
5. Assessment and evaluation for scientific and technological literacy.
6. Non-formal development of scientific and technological literacy.

Phase 1 of the project, which is not yet completed, involved the collection and analysis of all materials which could assist in a better understanding of scientific and technological literacy. It is, in effect, a huge, collaborative world-wide data sharing exercise to which interested persons and organisations may still contribute.

Phase 2 involves an international forum of some 500 participants, for six days at UNESCO in July 1993, the aim of which is to increase the political visibility of 'science and technology education for all' as a requirement for national development, and to provide a framework and guidelines for major programmes of action in science and technology education in countries world-wide, involving governments, inter-governmental (like UNESCO) and non-governmental organisations.

Phase 3 will be concerned with specific scientific and technological literacy projects in particular countries, evaluating progress, disseminating information and providing technical and other kinds of support. It is clear that national subject teaching associations like DATA will have a major part to play here. As one small contribution to the resource bank for Phase 1 of the project I am currently editing a volume on technology education for UNESCO in its series on *Innovations in Science and Technology Education.* This includes, out of a total of eighteen chapters, a series of seven on regional surveys covering the Nordic countries, Eastern Europe, Western Europe, Latin America, Africa, Australia with S.E. Asia, and North America. Not all the chapters are yet in, but I have read enough to appreciate the nature of some common concerns underlying these diverse developments and of the influences which are shaping them. It is to these issues I want to turn now, because they arise from the international context in which technology education is developing and I believe they are significant for our own National Curriculum subject and its future.

There are, in fact, four issues which I will comment on briefly and they are:

i. The relationship of design and technology to science (and by implication to mathematics also);

ii. the economics of design and technology (I mean by this, questions to do with the capital and recurrent costs of implementation);

iii. the relationship of design and technology to vocational education (unlike the situation in England and Wales, development of technology as a component of general education elsewhere are often strongly rooted in vocational/technical education); and

iv. the politics of design and technology (I mean by this, what forces are competing to shape it and how these are likely to be resolved in the future and with what consequences).

The issues are not independent of each other, but it is helpful to examine them separately.

The relationship of design and technology to science

The OECD and UNESCO projects bring this issue into sharp focus with their persistent bracketing together of science and technology. Particularly amongst some science educators associated with the UNESCO project there is a concern that 'to put undue emphasis on technology as a subject, to promote its definition, is to stifle the wider role for science education, a direction slowly gaining pace around the world'. It is argued that: 'Technology is a direction of specialism depending on a foundation derived from earlier studies and thus only acceptable outside the years of compulsory schooling.' Within compulsory schooling, they argue for combined science and technology courses (Holbrook, 1992)

Courses which purport to link science and technology exist already and we can distinguish a number of types (see diagram 1).

What is so far still undeveloped is the kind of provision in which the science is *for* technology, ie. science as a resource, one among several, for the development of technological capability. Such provision would entail a role change of some magnitude for science in education, from a discipline in its own right, studied for its own sake, to a service subject,

Stakeholders	Economic functionalists	Professional technologists	Sustainable developers	Women	Liberal educators
eg.	National Institute of Economic and Social Research researchers	Engineering Council	Intermediate Technology Development Group	Feminist groups and writers	Many teachers(?)
school technology should	lay the foundations of knowledge and skills for future training, especially in relation to intermediate vocational qualifications.	be characterized by rigour, working to industrial standards of quality, and the acquisition of knowledge in mainstream engineering areas.	empower people with knowledge, skills and values to undertake and control technological developments which achieve an acceptable quality of life not only for us, but for succeeding generations, North and South.	enable girls to define technological challenges, and respond to them, on their own terms, so countering gender biases incorporated in present day representations of technology.	initiate children into the unique cognitive mode of technology, and help them to construct and control this symbolic world.

Table 1

ministering to the needs of technology education.

The inclusion of technology in the National Curriculum, and especially the prospect of a revised Order likely to give greater prominence to the relationship between science and technology, obliges us to explore this new and additional role for science education. I draw attention to two problems which arise and which will to be addressed if the relationship is to be productive.

The first of these has been well expressed in an Interim Evaluation Report on the development of a Technological Baccalaureate for Key Stage 5. In a discussion of attempts to co- ordinate the teaching of technology and science, the authors of the report write:

> The problem of curriculum design is that while in no circumstance can technology be reduced to the 'appliance of science', much modern technology makes extensive use of scientific knowledge. Moreover it makes quite promiscuous use of it, with no regard for the convenience of those concerned with designing coherence and progression into a programme of study for science. (Young and Barnett, 1992)

They go on to suggest that a science 'core' should be established (ie. a programme of science work which relates to the technological aspirations of the scheme). Clearly this could only be done by defining with some precision the directions and scope of the technological studies.

The second, and related problem is that science, as encountered in most school science lessons, is not always in a form immediately helpful to those undertaking technological tasks. It does not always map neatly onto the design parameters in terms of which the construction of an artefact or system has to take place. The level of abstraction may be too high, eg. electric current may be understood as a charge cloud of electrons migrating over atomic nuclei whereas a simpler, fluid flow model of electricity may suffice for the technological purpose in hand. Data may need to be collapsed to provide a practical measure, eg. the UK National Energy Foundation's National Home Energy Rating (on a scale of 1 to 10, with 10 as high energy efficiency) is intended as a ready means by which architects and builders can calculate the energy costs of a house. The scientific knowledge may need to be reorganised in some way to assist it articulation with practical action, eg. unlike chemists who classify substances in terms of functional groups of atoms, pharmacologists arrange them according to their effects on the human body — stimulants, depressants, vasodilators, analgesics, etc. At times, new concepts which do not feature in the standard science textbooks may need to be evoked, eg. those who design and install air conditioning systems use concepts such as effective sensible heat ratio, solar heat gain factor and ventilation cooling load.

There are, of course, ways in which science contributes directly and without change to technological activities: for example

(i) the 'law of nature' as formulated by science set the limits within which all technological activity has to take place;

(ii) the ability to conduct systematic empirical enquiries (eg. into the comparative working properties of materials) is frequently called upon;

(iii) specific techniques developed in science may be valuable in the development of technologies (eg. for quality control and assurance, as in the non-destructive testing of wear on ball bearings in aircraft engines or the no-fail bacterial counts designed into the manufacturing process for Marks and Spencer sandwiches); and

(iv) scientific concepts and theories may suggest new operational principles for artefacts (eg. hospital diagnosis

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by nuclear magnetic resonance imaging).

But in the actual design and construction of technological products, the concepts developed in science in the quest for understanding of the physical and biological worlds may need to be reworked and integrated with other kinds of knowledge if they are to relate usefully to the decisions being taken. School science, so far, has rarely been faced with this requirement. (A fuller discussion of these and related results in Layton, 1993.)

The economics of design and technology

Somewhat surprisingly, there was little reference to the financial cost of innovations in any of the OECD case studies. The finance is a critical factor has been underlined subsequently by evidence that in some countries, where the economy has gone into recession, there has been backtracking on technology developments, especially those 'high tech' versions involving computers, CNC lathes and milling machines, computer integrated manufacturing systems including industrial quality robots and CAD-CAM.

These are high cost developments in many dimensions. Rooms and services have to be adapted or new accommodation provided: equipment has to be purchased and maintained; technical support services are required; and, most critical of all, teachers need inservice training and continuing support. A particularly disturbing aspect, afflicting some of the Government's spearhead City Technology Colleges and secondary schools under the Technology Schools Initiative, is that 'state of the art' technology does not remain so for long. Its status and value depreciates rapidly and necessitates regular updating and renewal. The cost of this is considerable and raises issues such as whether technology can be regarded as just another school subject, to be incorporated, as best as possible, into an institutional framework designed for subjects of quite different order.

The dilemma for technolgy here is that if it draws back from these high tech options, there is a risk that school technology will soon lose any correspondence with technology in industrial and commercial settings outside. If it does go forward on these lines, there are financial problems to solve which will almost certainly drive schools into partnership arrangements with agencies external to education. This may be no bad thing. But it may yield another crop of problems. The complexity of technological solutions which becomes possible may be associated with science and mathematics at levels which it is difficult to achieve with many children.

However, my central point under this heading is an economic, not a pedagogical one. The capital outlay on equipment alone, to provide a secondary school with, for example, an industrial quality computer integrated manufacturing system could easily run up to £100 K, and beyond. If we are serious about moving technology education in this direction, it is clear that not only do we need industrial and other partners — and genuine partnership entails some sharing of control of the enterprise — but also the developments will have to be on a selective basis. There is no prospect of every one of our 4000 or so secondary schools in England and Wales establishing a high tech facility of this kind. What this underlines is the need for co- operation in developments — again DATA could have an important part to play — and also the potentially important relationship of a school's technology resources to opportunities for offering external services, ie. not to put too fine a point on it, earning cash.

The relationship of design and technology to vocational education

Partnership with industry leads directly into the third issue arising from the case studies and that is the relationship of school technology to vocational education. In many of the countries where technology is emerging as a component of general education, it is doing so with roots which are deep in previous and technical education.

In the USA, for example, many recent developments in technology education have grown out of the high school subject called 'industrial arts', itself an evolutionary product of 'manual training'. The American Industrial Arts Association, the professional association of teachers, changed its name some few years ago to the International Technology Education Association.

In Eastern bloc countries, technology has been closely related to methods of production in industry, including agriculture. The school has been expected to lay the foundations of future labour activity of its pupils, whose education includes practical work in industry and designing and making. The change from socialist to capitalist economies has, of course, immense implications for education generally and for vocational education particularly. In the new regime, qualities such as individualism, entrepreneurship and enterprise become highly valued, in contrast to the past, and are reshaping technology education.

In the Netherlands, from 1973 a subject called General Techniques has been taught in the vocational secondary schools, but not in the general secondary schools, the choice of school being made around age 12. In recent years when the general secondary schools have started to introduce technology into their curriculum, they have drawn upon the most readily available model — that in the vocational schools. However, this provides little opportunity for pupils to engage in design activities. Indeed, one of the most arresting statements — at least to English eyes — in the 1989 Report of the Netherlands' Attainment Targets Committee at 15+, was the assertion that: 'Not all pupils possess the capability of providing a solution to a problem (ie. designing) and transforming thought and ideas into concrete form.' Hence, a very restricted notion of design prevailed and the emphasis was upon the production of prescribed functional work-pieces.

In each of these cases — and examples could be multiplied — the development has been from a vocational context and the power of precedents has been strong. This contrasts with the situation in England and Wales where subjects existing in their own right as components of general education have been drawn together to construct the National

Curriculum subject technology. In so far as there has been vocational influence on the development, it pre-dates the National Curriculum and came through TVEI in the late 1980s.

However, the pressure today appears to be in the direction of 'vocationalising' National Curriculum technology and the White Paper, *Choice and Diversity,* makes it clear that technology has a critical mission to achieve in connection with the Government's objective of securing parity of esteem between academic and vocational courses. Paragraph 10.10 refers to technology as 'a central bridging agent of the curriculum of all pupils' which has a major role to play in breaking down 'the divide between academic and vocational studies' and equipping 'young people with the technological skill essential to a successful economy'. It is asserted that 'Technology must be taught as a subject with clear practical objectives, and its vocational application is therefore as important as its academic grounding' (para. 10.9). We are also told that 'No other western country has given such prominence to technology in the curriculum of all pupils of compulsory school age' (10.8).

This adds up to a heavy burden of responsibility and, although design and technology in England and Wales is often looked upon as being in the van of international developments, we may have much to learn from some of the practices in those countries where technology education is emerging from vocational education origins. It does seem that there is something of a convergence of interests here; the vocational is becoming more generalised (certainly it cannot continue today in the form of narrow occupationalism) whilst the academic/general is becoming more vocationalised. Indeed, 'vocational' is a term undergoing continuing re-definition as industrial contexts change; the requirements of much vocational education are often now expressed in terms which are very similar to those used to describe general education.

The politics of quality in design and technology

I turn now to my final issue, which is the social shaping of school technology and what influences we need to be sensitive to in the immediate years ahead.

In a talk at the IDATER 92 Conference earlier this year I attempted to identify a number of stakeholders in the development of National Curriculum technology. The constituencies, with examplars and their broad value orientations, are summarised in Table 1. Abbreviated though this is, it is not difficult to discern the potential for conflict between the value positions of the various stakeholders, each of whom has different expectations of school technology. My purpose here, however, is not to explore this conflict and its possible resolution, but to draw attention to likely performance indicators and tests of quality which reflect some of these diverse concerns and which may be applied to the development in the future. These will be over and above the performance of students in relation to attainment targets and statements of attainment.

Given the Government's expectations of technology as expressed in *Choice and Diversity* and given the priority being accorded to competitive economic performance, it is inevitable that indicators of quality which reflect these dispositions will come into play. A broad dominating concern for 'value for money', possibly expressed in terms of 'What added value to children's learning outcomes has resulted from this expensive subject?' could be the source of more specific measures.

In relation to 'parity of esteem between academic and vocational courses', it would be reasonable to expect a focus on the percentage of 16-year-olds electing for vocational qualifications, or, more tellingly perhaps, the percentage of high ability (in academic subjects) 16-year-olds, opting for vocational qualifications. Just what an acceptable percentage would be, at any time and in particular circumstances, remains a matter of judgement.

In relation to the acquisition of industrial skills and knowledge, we already have National Education and Training Targets which require 80 percent of young people to reach NVQ level II (or equivalent) by 1997 and 50 percent of young people to reach NVQ III (or equivalent) by 2000. Nested significantly within these goals, there will be a contribution from technology, both as a National Curriculum subject and possibly as those shorter courses at Key Stage 4 which 'permit extension into or combination with other — particularly vocationally-oriented — areas of work or study' (to quote the terms of reference of the National Curriculum Technology Review). Industrial opinion on the extent to which alleged skills shortages in the economy have been reduced could also inform performance measures, as might the percentage of students opting to continue the study of technology or a technology-related subject after the age of 16.

Apart from technical considerations and value judgements about the validity of such performance indicators, two points emerge as important, I believe. First, we must be alert to the danger that school technology will become overloaded with responsibilities that it cannot sustain. Instrumental claims for the subject need to be kept appropriately modest. Second, those who share my conviction that we must not let economic imperatives dominate the shaping of school technology exclusively should be turning their hands to the design of a more encompassing range of measures of quality than those sketched out above.

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