THE ENGINEERING COUNCIL

TECHNOLOGY IN THE NATIONAL CURRICULUM

Alan Smithers and Pamela Robinson

GETTING IT RIGHT

Acknowledgements

This document was originally prepared as a confidential briefing for The Engineering Council, but we are delighted that it has been decided to make it publicly available. We are very grateful to The Council for the commission and to its General Education Committee and Standing Committee on Education and Training for lively and penetrating discussion of the issues. Alan Smithers is currently on attachment to British Petroleum plc which kindly allowed him to use some of his time to share in the writing of the report.

Alan Smithers
Pamela Robinson
University of Manchester

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Foreword

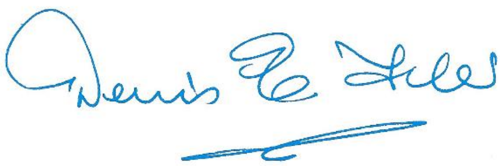
I have become increasingly alarmed at the level of concern about the development of school technology, expressed by teachers, students, parents and educationalists.

As a Member of the original National Curriculum Working Group under the Chairmanship of Lady Parkes I felt that I had an obligation to understand what had gone wrong and what should be done.

To produce an objective analysis of the problem I decided to seek advice from outside the engineering profession. Professor Alan Smithers and Dr Pamela Robinson, independent researchers from the University of Manchester School of Education, were invited to investigate the development of the subject. They were also asked to consider what should be done to put matters right.

What they have produced is a comprehensive report which I see as an important contribution to a national debate.

I very much hope that Government, the National Curriculum Council and the School Examinations and Assessment Council will take the report's findings into account in the future development of the subject. Action needs to be taken now if technology is to be a valuable part of the education of our children and if it is to be given credibility and respect among the community at large and in industry.



Denis E Filer CBE TD FEng
Director General, The Engineering Council

Preface

Like many technology based companies, BP welcomed the emergence of 'Technology as one of the Foundation subjects of the National Curriculum. It is our belief that, if we can get it right, this may prove to be one of the most important and far reaching educational reforms of recent years.

But in the struggle to define the subject, and to achieve parity of esteem with the well-established subjects of the curriculum, there are risks. Over ambitious claims or layers of complicated and elaborate theory may not only fail to convey the essence of this new subject to parents, children and employers, they may actually mask a larger failure.

If National Curriculum Technology is to achieve all that we hope for; it is very important that we are clear in our thinking about the nature and purposes of the subject. BP has made various contributions to this cause over the years, including funding for some of the initiatives reviewed in this Report. We are therefore pleased that Alan Smithers, during his year on attachment to BR was able to give time to this independent study with Pamela Robinson, for The Engineering Council.

Chris Marsden
Head of Educational Affairs, BP

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Introduction

1. Technology in the national curriculum is a mess. What has emerged seems to be very different from what was intended. Her Majesty's Inspectors are reporting that the standard of work in secondary schools, where national curriculum technology has been running for five terms, is actually declining (in contrast to the other subject areas where improvements have been noted). It is proving extremely difficult to devise the required standard assessment tasks. Those for age 14 have already been scrapped and put out to new contract (along with the other SATs for that age group), and there are grave doubts about those for seven year olds due for trialling this summer.

2. How is it that this important attempt to raise the profile of technology in schools and give making and doing their proper place in education seems to be foundering; and what can be done about it? In this paper we trace - through the documentary evidence, visits to schools, and interviews with policymakers, inspectors, advisers, employers, teachers, teacher trainers, curriculum developers and parents[1] - how technology comes to be as it is, and attempt to provide some pointers as to what might be done. Many of the difficulties seem to be associated with a progressively generalised and abstract notion of 'technology'.

The Invention of National Curriculum Technology

3. Technology as a national curriculum subject came into being through the various steps envisaged in the Education Reform Act of 1988. A Design and Technology Working Group was set up in April 1988 "to advise on attainment targets, programmes of study and associated assessment arrangements". An Interim Report was submitted in November 1988, the Secretary of State responded the same month, the Final Report was delivered in June 1989, the National Curriculum Council Consultation Report appeared in November 1989, and this became the basis of the Order laid before Parliament in March 1990.

4. At each stage, from the terms of reference to the Consultation Report, 'technology' became more diffuse. In its remit, the Working Group was asked to view technology as:

   > "that area of the curriculum in which pupils design and make useful objects or systems, thus developing their ability to solve practical problems."

   Information technology was to be included:

   > "Technological education should equip pupils with basic IT skills and develop an awareness of the potential use of IT and computer technology whether in the business office, or manufacturing or commerce."

   In Supplementary Guidance to the Chairman, the Group was also asked to:

   > "take account of the possibilities of links with other relevant subjects such as art, home economics and business studies."

5. The Working Group responded to this broad brief by deciding to treat 'design and technology' as a unitary concept concerned with "capability to operate effectively and creatively in the made world". At this stage it was seen as being based mainly, though not solely, on craft, design and technology.

6. This approach was endorsed by the Secretary of State for Education and Science but, in addition, he asked the Group:

> "to show how real world contexts for technological problem-solving can help to develop economic and careers awareness and business understanding, and personal qualities (such as imagination, persistence, the disposition to see a job through to the end, and the ability to judge worthwhile risks)."

7. Faced with a seemingly ever-extending remit the Working Group in its Final Report settled on four very general attainment targets for design and technology - identifying needs and opportunities, generating a design proposal, planning and making, and appraising - plus a further one for information technology. The looseness of the objectives was tempered, to some extent, by a detailed programme of study for each of the ten levels of attainment of the national curriculum. The specification made it clear that the four attainment targets for design and technology were to be treated as a whole. At level 5, for example, it stated that pupils should develop design and technological capability through, among other things, activities which "develop confidence in designing and making and allow them to take increasing responsibility for the form and nature of their work". This was to be achieved by teaching 'materials and components' (for example, a working knowledge of characteristics such as hardness, flexibility, reaction to heat and strain), 'energy', 'business and economics', 'tools and equipment', and twelve other specified areas.

8. The National Curriculum Council Consultation Report accepted the general drift of the Working Group's recommendations for attainment targets though with the fourth one re-titled 'evaluating'. But it rejected the proposed programmes of study on the grounds that they were over-prescriptive and too many of the examples came from craft, design and technology. Accordingly, the programmes of study were re-drafted losing much of the detail and bringing in more illustrative material from art and design, home economics and business studies. This had the effect of undermining the continuity of the attainment targets which were now left to stand alone. It was in this form that technology became law. 'Identifying needs and opportunities', 'generating a design proposal', 'planning and making' and 'evaluating' had been given separate and equal weight.

9. Over the two years of the consultation process the character of 'technology' as a subject in the national curriculum had thus changed considerably. As well as craft, design and technology it had come to include art and design, home economics, business studies and information technology. From being essentially about designing and making it had become generalised problem solving without a specified knowledge base.

Curriculum and Examinations

10. We can see what this is coming to mean in practice by looking at the resulting curriculum initiatives and new GCSE syllabuses. There is no doubt that many teachers, pupils and parents are unsure of what is involved:

> "I get asked time and time again 'What is technology, Sir?'. We had an open night the other week and we are now in the second year of the national curriculum so our first year are doing technology. I had some third and fourth formers in working on furniture and some of the parents came to me and said, 'When will

our Johnny make one of these?' I had to say, 'I'm sorry he won't, he's doing the national curriculum'."

(Teacher, Lancashire)

11. Prominent among the curriculum initiatives has been that of the National Design and Technology Education Foundation (NDTEF) which claims links with about a quarter of all secondary schools. It offers an approach based on themes, for example, 'fit for what?' (eg keeping fit), 'home sweet home?' (eg surviving on a deserted island), and 'who will buy?' (eg preparing a charity fair)[2]. But NDTEF is not prescriptive; its trainers work with technology co-ordinators and offer practical guidance on the management and assessment of national curriculum technology. From then on, it is left to the teachers themselves to devise their own projects.

12. In one school we visited in London, for example, there were four themes in Year 7 (the first year of secondary schooling), 'fast food', 'fun fair/ garden fete', 'entertaining a pre-school child', and 'developing a product'; in Year 8 there were another four, 'shopping', 'flight', 'disability in our school', and 'developing a product'. Each project lasted from five to eight weeks for three sessions per week of 140 minutes each. The 90 pupils per year were split into five groups of 18, each of which had a 'homebase'. The homebase teacher acted as consultant, mentor and guide, and was responsible for reporting on progress. The group of 18 was further split into four teams, each of which worked on a project of their choice within one of the four themes (with all four themes being represented in the one homebase group). Each member of the four or five person team contributed to the project by going to one of five workbase areas - materials technology (CDT), design studio (art), food technology, textile technology and business/ IT. At each workbase the teacher could therefore expect from 10 to 20 pupils each requiring help towards a different project. As this is Key Stage 3, the pupils could be working at attainment levels anywhere between 3 and 7.

13. The complexities of organisation almost defy description and one wonders how systematic the teaching can be, but from the point of view of understanding what technology is becoming it is important to note the wide range of themes available.

14. Not all schools were using the NDTEF approach; many were putting together their own schemes of work. But all were having to work out a new conception of the subject:

> "We're called technology, and we consist of CDT, art and design, home economics, business studies and information technology. It is not just about design, it's not just about all this Blue Peter technology that we hear about. We actually get children to use pieces of steel and wood and to develop some sort of craftsmanship. But as everybody's found there is a dilemma because of the amount of time. All the various areas are still discrete, and that's mainly because of the architecture. The home economics rooms are literally at the other end of the school, and it's a linear building, so that they really are a long way away. Textiles is next door, but the art room is in the middle of the school and it's on the second floor, so we really are broken up. To counteract that, to create some sort of bringing together of all these different technology experiences, we've got organised in May a suspended timetable for Year 7 pupils when they're going to work on manufacturing shoes – actually prototypes in card and paper. It is not something we've designed, it is something we've picked up from the education-industry liaison people".
>
> *(Teacher, Cheshire)*

15. The first students will not be coming up to GCSE examinations in national curriculum technology until 1995 and the Criteria have yet to be published. In an early version it was stated that the four attainment targets must be given equal weight, but there seem to have been second thoughts and it is likely now that they will be differentially weighted. However, it seems that construction materials (metal, wood, clay and plastics) are still only to be an option along with textiles, graphic media (such as paint, paper and photographs) and food.

16. Already the examination boards are offering new syllabuses as a bridging arrangement. NDTEF has developed a GCSE examination in design and technology in association with the University of London Examinations and Assessment Council, to be available in 1993, which depends on coursework (60% of marks) and a terminal examination (40% of marks). The terminal examination consists of an externally set 20-hour project and a written examination. The specimen project is on ‘markets’ - considering the people involved, brainstorming their needs, selecting areas for further investigation, and identifying possible outcomes. The example written paper includes questions on keeping food fresh, mass production, safety legislation, evaluating a kitchen product, and consumer legislation. Equal marks are to be awarded for: investigating, defining, devising, representing, managing, producing, reviewing and predicting.

17. The Southern Examining Group has introduced a new design and technology syllabus, available in 1993 and 1994. It consists of an externally assessed written paper (30% of marks) based on a case study given to candidates in advance. In the sample paper it is ‘a sports centre’ and the questions involve selecting an appropriate type of locker, for example. The other two elements are internally assessed course work - a special study and a portfolio - and were to have contributed up to 70 per cent of the total marks though this may have to be amended following the government’s limit of 60 per cent.

18. If we can regard these initiatives and examinations as making the nature of national curriculum technology explicit then it seems clear that it is more to do with ‘problem solving’ than ‘making’, and the problems are not delimited in any precise way. Technology in the national curriculum in these early days still seems to be seeking an identity. Whether this is because of its newness or because there is something fundamentally wrong we cannot be sure, but we can get some clues from its progenitor, craft, design and technology.

Craft, Design and Technology

19. As might be inferred from the composite title, craft, design and technology was itself a portmanteau subject with diverse origins.

Craft

20. Workshop skills were first introduced into schools just over a hundred years ago on the recommendation of the Samuelson Commission3 (1882-84) which was concerned to halt Britain’s declining industrial performance (plus ça change). Although at the outset intended to be the basis of a kind of apprenticeship, they soon acquired educational objectives:

> “the object of the instruction is not to create carpenters and joiners, but to familiarise the pupils with the properties of such common substances as wood and iron, to teach hand and eye to work in unison, to accustom the pupil to exact

> measurements, and to enable him by the use of tools to produce actual things from drawings that represent them."[4]

Woodwork, cheaper and easier to mount, predominated though there were recurring attempts to put metalwork on an equal footing. Technical drawing was made a separate subject in 1898 so that by the end of the century a pattern had been established which survived for more than fifty years.

21. But craft skills never enjoyed high status. English education was (and perhaps still is) steeped in a classical tradition which saw intelligence as distinct from the lower faculties used in practical activities, and something to be cultivated through the study of the pure and abstract. In fact, manual instruction at the time it was introduced into schools was mainly associated with workhouses and prisons. In schools, practical work was regarded as being mainly for the less able:

> "For boys, who are dull in all 'brain work', and whose only hope is in mechanical work - writing, drawing, colouring, measuring, in which alone they can be profitably instructed . . . woodwork would be a delight and a real benefit"[5]

The 1944 Education Act which should have given practical education a boost by establishing technical schools for those with the talent was never fully implemented - technical schools at their height took only about four per cent of the age group - and workshop teaching was mainly relegated to the secondary moderns, the schools for the 11+ failures.

22. Craft therefore tended to be the poor relation of English education, and those connected with it - particularly the teachers - were always striving to make it something more. When the breakthrough came it was by association, on the one hand, with 'design' and, on the other, with 'technology'.

Design

23. Design is, in some ways, the natural successor to the three orthogonal projections of technical drawing made possible by computer techniques, but in a movement lit by concerns with consumerism and creativity in the sixties and fanned by the Design Council it has taken on a much wider meaning and become a process involving identifying needs, thinking creatively and communicating ideas. It was seized upon by the Research and Development Project in Handicraft[6], under John Eggleston at Keele University, which was endeavouring to turn handicraft into a new and exciting subject:

> "Problem solving strategies became the order of the day. Teachers acquired a new vocabulary. Design methodologies using analytical and synthetical criteria moved logically from need identification to optimised solutions and their evaluation. Ways of extending the material boundaries of wood and metal were explored. The text encouraged teachers to look afresh at the home, leisure and community work as sources for design-based studies."[7]

Ideas about the subject were sustained and developed in the new journal of the Institute of Craft Education and College of Handicraft called significantly *Studies in Design Education and Craft*. In 1978 it was re-titled *Studies in Design Education Craft and Technology*.

Technology

24. The elevation of craft into technology was mainly associated with Project Technology launched by the Schools Council in the wake of Harold Wilson's 'white heat of the technological revolution' speech. Conceivably he had something else in mind than enhanced status for craft teachers, but Harrison, then head of the craft department at Loughborough College, appointed to run the project, successfully fended off the science lobby led by the Association for Science Education and Council of Engineering Institutions[8] and managed to establish craft as the route to technology in schools. Hence the curious hiatus between technology in schools and higher education to which we will turn later.

25. It is not clear just how many craft departments took to teaching technology, rather less than five per cent it is suggested[9], but from Project Technology came in 1970 the National Centre for School Technology at Trent Polytechnic which was:

> "soon pouring out new material . . . and developing a highly effective public relations operation which kept the teaching of technology high on the political agenda."[10]

CDT

26. Craft studies were now spreading out in all directions under a wide variety of labels from design to workshop technology and technical subjects. In an attempt to bring some order the Department of Education and Science began using the term craft, design and technology (CDT), for example in its document *The School Curriculum*[11] (1981), and so a new subject was born. Table 1 shows that from the mid-1980s CDT began to take over from woodwork, metalwork and technical drawing as the 16+ examination. It was as yet however without shape or rationale.

TABLE 1: Time Course of Technology Entries[1,2]

Year and Exam	Woodwork	Metalwork	Eng Stud Build Stud[3]	Tech Drawing	CDT	Other[4]	Total
1990 (GCSE)	5,137 (2.4)	2,484 (1.2)	12,556 (6.0)	-	173,110 (82.1)	17,475 (8.3)	210,762 (100)
1985 (GCE & CSE)	59,138 (16.8)	47,989 (13.7)	35,111 (10.0)	130,063 (37.0)	20,982 (6.0)	58,066 (16.5)	351,539 (100)
1980 (GCE & CSE)	76,395 (18.7)	72,717 (17.8)	43,063 (10.6)	151,302 (37.1)	9,208 (2.3)	55,062 (13.5)	407,757 (100)
1975 (GCE & CSE)	69,107 (22.0)	63,620 (20.2)	42,074 (13.4)	117,513 (37.3)	4,715 (1.5)	17,743 (5.6)	314,772 (100)
1970 (GCE & CSE)	43,858 (21.3)	39,923 (19.4)	8,611 (4.2)	95,938 (46.5)	-	17,926 (8.7)	206,256 (100)
1960 (GCE)	16,167 (29.6)	10,210 (18.7)	1,620 (3.0)	26,625 (48.7)	-	-	54,622 (100)
1955 (GCE)	Handicraft 14,804 (60.1)		1,122 (4.6)	8,723 (35.4)	-	-	24,649 (100)

1. Up to 1975 data for England and Wales, in 1980 and 1985 for England only, in 1990 for England, Wales and Northern Ireland.
2. Excludes absentees.
3. Including engineering workshop theory and practice and motor vehicle studies.
4. Up to 1985 includes other science and technology subjects, for 1990 includes graphics, control technology, sound recording, rural mechanics and technical studies.

Source: *School Leavers Survey*, DES, and *Inter-Board Statistics*, AEB.

27. An attempt to provide a theoretical underpinning was made by Black and Harrison (1985) in a discussion paper, *In Place of Confusion*[12]. They sought to integrate the

diverse elements of CDT by operating at a high level of abstraction and generality. The curriculum was represented as being made up of subjects each of which contributes 'resources' towards undertaking 'tasks' which lead to a range of 'outcomes' – including 'technological capability'. Learning was seen as taking place through the interaction of resources and tasks culminating in the development of capability. The Nuffield Design and Technology project[13] is attempting to implement these ideas to construct a course that meets the requirements of the national curriculum and leads to GCSE certification.

28. Technology was defined in *In Place of Confusion* as "a disciplined process using resources of materials, energy and natural phenomena to achieve human purposes" but in a subsequent project[14] devised to test out the ideas it had become even broader: "the exploitation of all knowledge (both scientific and non-scientific) for creative and productive activities in the interests of society . The original inspiration had become so attenuated that technology was no longer regarded as a subject but as a cross-curriculum theme.

29. In illustrating the applicability of their model, Black and Harrison give as an example of 'a task' that of devising a hybrid car. It involved:

> "a class of 15 year olds in an inner city school, which as a group, designed the complete system for a car propelled by a hybrid of petrol and electrical propulsion. The design process involved children in acquiring new intellectual resources, including detailed knowledge about high current electronic control circuitry, and about the mechanical, structural and dynamic principles essential in a road vehicle which has to conform to the Road Traffic Acts."

30. But while CDT undoubtedly led to some excellent work with students designing and making all kinds of things from boxes to store cassettes to automatic fish-feeding devices and infra-red controlled garage doors, it could become process for process' sake:

> "My son, Charles, is doing design and technology for his GCSE, and he was asked to design an artefact and he designed a desk-tidy, and he showed us the work he'd done for it, and it was absolutely beautiful. He had written why he was going to design a desk-tidy, he had written up another page with very nice drawings of why he had chosen the materials and how useful it was going to be for his mother to have on her desk at work, and I think the folder amounted to quite a large number of written pages. Anyway, we were all very pleased, although we felt that a desk-tidy was not stretching his abilities, he could have made something a bit more complex. When I enquired further how he was getting on with his desk-tidy we were told he hadn't actually made it, there was no need. That the project folder he'd done, which I think was a beautiful piece of work, was quite enough. He was never going to have to actually make it. All he was going to do was to write about it. That may have suited Charles very well because he's very literate, but I don't suppose it would have suited other people in the school so well."
>
> *(Parent, London)*

31. Thus over the period of a century the attempt to improve Britain's economic performance through skill training had mushroomed into an all-embracing methodology with ambitions so diverse that they could only be brought together at a high level of generality. But, in practice, the brave intentions could amount to no more than writing about how to make a desk-tidy.

Technology in Schools and Higher Education

32. One of the consequences of the heterogeneity of CDT in schools is the wide variety of GCSE examinations available. Table 2 shows that, in 1990, in CDT, itself, there were examinations in technology, design, design and communication, design and realisation, design and technology, building studies and other, and in the technology syllabus group there were also control technology, engineering studies, engineering workshop theory and practice, graphics, metalwork, motor vehicle studies, sound recording, woodwork, rural mechanics and technical studies.

TABLE 2: GCSE Entries in Technology, 1990

Subject	Entries[1]		Total[2]
	Boys	Girls	
CDT: Technology	40,151	4,466	44,618
CDT: Design	4,734	3,352	8,086
CDT: Design and Communication	40,978	9,464	50,443
CDT: Design and Realisation	73,951	10,266	84,231
CDT: Design and Technology	2,142	481	2,623
CDT: Building Studies	3,419	135	3,554
CDT: Other	161	22	183
Control Technology	962	79	1,041
Engineering Studies	976	48	1,024
EWTP[3]	1,089	32	1,121
Graphics	14,703	2,721	17,424
Metalwork	2,718	77	2,795
Motor Vehicle Studies	8,388	603	8,991
Sound Recording	20	2	22
Woodwork	5,406	319	5,725
Rural Mechanics	70	0	70
Technical Studies	266	106	372
Total	200,134	32,173	232,323

1. England, Wales and Northern Ireland. 2. Includes absentees. 3. Engineering Workshop Theory and Practice.
Source: *Inter-Board Statistics*, AEB.

33. This variety persists to A level where CDT, itself, comprises technology, design, design and realisation, design and technology, building studies and other (see Table 3). In spite of a common core there are wide differences between syllabuses and whereas Cambridge technology tends to be the applied side of maths and physics, Oxford design concentrates on product design and the broader aspects of technology, keeping maths

TABLE 3: A Level Entries in Technology, 1990

Subject	Syllabuses	Entries[1,2]
CDT: Technology	1	15
CDT: Design	3	1,773
CDT: Design and Realisation	1	177
CDT: Design and Technology	19	3,061
CDT: Building Studies	1	273
CDT: Other	1	367
Engineering Studies	2	54
GED[3]	7	629
Graphics	11	1,685
Metalwork	2	27
Woodwork	3	39
Total	51	8,100

1. England, Wales and Northern Ireland. 2. Includes absentees. 3. Geometric and Engineering Drawing.
Source: *Inter-Board Statistics*. AEB.

to a minimum. This duality is reflected in the career intentions of the students. In a sample[15] of 50 students taking A-levels in design and technology, of the 34 intending to go on to higher education about half (47.1%) were aiming for engineering and just over a third (35.3%) design-related courses, such as architecture, graphic design and interior design. Similarly for those choosing further education and employment, interests were polarised between engineering-based and design-based activities.

34. An A level in design and technology is rarely acceptable in place of maths or physics for entry to engineering higher education, and alongside these subjects may give little advantage over say an A level in French. This is all the more surprising since engineering and technology departments in higher education tend to be short of applicants. Admissions tutors seem reluctant to accept it as a major qualifying A level for a variety of reasons including unfamiliarity (there were only about 8,000 entries in all technology subjects in 1990 compared with 45,000 in physics), wide differences between syllabuses, and concerns about the standard of maths required.

35. It is significant that there should be no clear progression to higher education. Technology as it has emerged in schools - as the educational successor to craft – is different from technology as it is commonly understood, that is, inventing or improving things through the application of science and maths. Treating one as the other can lead to absurdities:

> "We have a good school here; we have a superb craft department, a superb science department. I do my job well and they do theirs well. They have now relinquished micro-electronics. They did it well. Now I don't do it well. I'm not an electronics expert; I'm a craftsman in wood, metal, call it what you want, but I'm literally only one jump ahead of the boys."
>
> *(Teacher, Lancashire)*

36. The problem with technology in the national curriculum can therefore be stated very simply: it lacks identity. The first step towards rescuing it would then seem to be to delimit it as a subject saying what technology is and, just as important, what it is not.

The Nature of Technology

37. Technology in essence is different from the other subjects of the national curriculum, most of which on Hirst's[16] (1974) useful definition are 'forms of knowledge' - that is, approaches to understanding distinguished by their means of establishing the truth. Science, for example, depends on continually re-checking pictures of the world against external reality; mathematics, on logical deduction from axioms; and history, on sifting evidence from the past. Not all subjects are like this, English literature, art and music illuminate through particular creations. English language is the basic communication tool, and geography is defined by its field of interest.

38. But technology differs from them all. So in inventing it as a subject there is little to go on. Perhaps the clearest analogy for the technologies in higher education is medicine which Hirst categorises as 'a practical organisation of knowledge' – that is, a class of problems that are informed by and are potentially solvable through the application of 'the forms of knowledge' and 'skills'. In medicine, the class of problems is to do with human health and it draws on subjects such as science and maths, and skills such as being able to listen carefully. Technology as a practical organisation of knowledge is implicit in the definition of an engineer adopted by The Engineering Council:

> "An engineer is one who acquires and uses scientific, technical and other pertinent knowledge and skills to create, operate or maintain safe, efficient systems, structures, machines, plant, processes or devices of practical and economic value."[17]

39. Categorising technology as a practical organisation of knowledge is helpful in at least two ways. First, it raises the question of what is the class of problems to be addressed and, second what is the appropriate balance between practical problem-solving and developing knowledge and skills?

40. The first exposes a crucial weakness in technology as it has emerged. It is not delimited so we do not know what counts as technology. Defined on problem-solving alone, most activities become technology - writing this report, conducting a scientific experiment, finding one's way to a railway station. What is needed is some statement of technology's domain. Because it has widespread application does not mean that it has to be left as a cross-curricular theme. Like the English language its products may appear everywhere, but it should be possible to organise it as a meaningful and recognisable subject.

41. The point about the appropriate mix between solving problems and knowledge/skills is an important one since, say, an electronics solution cannot be applied unless electronics has been learned. The blend is likely to be different at the different stages of education. Engineering departments in higher education perhaps prefer to recruit students on performance in maths and physics rather than technology since they see themselves as teaching the class of problems associated with, for example, mechanical or electrical engineering, and they look to the schools to provide the knowledge base.

Content

42. The main reason why technology in schools seems so elusive is that it embodies the aspirations of a number of different interest groups which have been kept together only by pitching its objectives and content at such a high level of generality that it can include almost anything. If it is to be given shape and substance as a subject then agreement will have to be reached at the much more difficult level of detail.

43. We have seen how design and technology came to be added to craft. Design itself is a multiple concept embodying the aesthetic qualities of objects and the necessary three-dimensional planning and representation of what is being made, but it is also a process and a movement. Technology in CDT is more an extension of craft than the application of science and maths. Affinities were found with home economics and art in Keele's Project in Handicraft.

44. But there is one other source of confusion that we have not so far explored and that is the tendency, on occasions, to use the term 'technology' synonymously with 'vocational education'. The National Institute of Economic and Social Research in a series of papers[18] has made a powerful case for the closer integration of education and employment opportunities such as occurs in a number of European countries, notably Germany and The Netherlands. This not only brings benefits in terms of productivity, earning power, workmanship and service, but individuals reach much higher levels of attainment in general education, for example, in maths. It is clearly important that Britain should seek to improve its vocational education but this will involve the whole

of the upper secondary school curriculum of which technology is only part. The industrial context of technology[19] is important but it only adds to the confusion if 'technology' and 'vocational education' are used interchangeably.

45. Given the diverse array of interests and the wide variety of ways in which the term 'technology' is being used, what can be done to arrive at an acceptable content? Perhaps a first step would be to seek some agreement on what technology is not. We would suggest that two important areas of educational experience which overlap with technology but differ from it could usefully be treated separately: basic life skills and vocational education.

46. An important purpose of schooling is to give children practical skills. Among these there are a number which are affected by technology though not necessarily part of it, for example, being able to cook, use a computer and word processor, and fill in forms. These are all important and they should be on the timetable, but to treat them as technology runs the risk of their not being valued in their own right but becoming intellectualised and part of some grand theory. It would be better if they had their own slot. Then much of the difficulty currently being experienced in trying to weave home economics, information technology and business studies into technology would disappear.

47. What would further help to delimit technology as a subject would be to distinguish it from vocational education. We would take the view that technology should be as other subjects in the national curriculum and like them feed into A-levels, and the general and occupationally specific vocational qualifications that are now being recognised and created under the aegis of the National Council for Vocational Qualifications. The work of that body has implications for upper secondary schooling, certainly post l6, perhaps from age l4. We ourselves favour the Swedish approach where around a common core of general education there is a range of options - academic, technical and vocational - organised into 'lines' (22 at present) based on an analysis of the labour market to which representatives of industry, business, the professions and public sector employment contribute. But this is a wider issue than just technology.

48. If we distinguish 'technology' from 'basic life skills' and 'vocational education', then of what is it to consist? Applying Hirst's categorisation of 'a practical organisation of knowledge' would suggest that we need to settle on the class of problems which it is to address and the associated knowledge and skills. It is probably not possible to define these by drawing a circle and saying everything within it is to be regarded as technology and everything outside is not. But we can attempt to identify 'a centre of gravity', as it were, and say that those things close to it are at the heart of technology and everything is connected but at varying degrees of remoteness.

49. We would suggest that technology as a school subject should centre on technology as it is commonly understood and is represented in higher education and employment. This would, in essence, be to return to the view of technology first offered to the Working Group in its terms of reference:

> "that area of the curriculum in which pupils design and make useful objects or systems, thus developing their ability to solve practical problems . . . drawing on knowledge and skills from a range of subject areas, but always involving science or mathematics."[20]

50. The question is then can ‘technology’ conceived in this way be turned into a subject which adds to the lives of people who want to leave school at age 16 or 18, or who want to continue in education but studying something else, just as much as those wanting to pursue technology further. That is, can technology be created as a subject with a number of different stopping off points which provides a general education as well as specific mastery?

51. We believe it could, but it would be for those with the necessary expertise to settle the details. Again an analogy with English is helpful since it directs attention to both language and literature. The ‘language’ of technology is essentially the knowledge areas (including materials, electronics, instrumentation, fluids, structures) and skills (including control, measurement, assembly, construction, project management)[21] applied to a particular class of practical problems, improving or inventing products or systems.

52. But we should not forget the ‘literature’, the art of creating. Here, however, as in English, the expectation should *not* be that everyone will invent new and marvellous things, as it were writing like Dickens, Shakespeare, or even Alan Ayckbourn. The important point is that everyone should have quality experience in making and designing, the equivalent of composing in prose and verse. An important part of that experience would be to study the creations of others. Among younger pupils, this could involve, for example, the study of toys:

> “The pupils brought in from home a range of moving toys some of which were from the 1940s and 1950s and others which were more contemporary. They investigated the movements, linkages, materials of the toys and the energy sources that made them move. The pupils researched some of the history behind the developments of material and toy design and then designed and made a range of moving toys from jumping jacks, push-along animal toys using cams and followers, to other more complex moving toys using syringes for simple pneumatic and hydraulic mechanisms.”
>
> *(School Inspector, Essex)*

In secondary schools, machines such as the Kenwood Food Mixer could be considered. This represents an example of good engineering which held the market lead for a very long time. It is particularly interesting because of the orbital track of the mixing implement, the arrangements of the gear train to take a blender at the top of the machine and further attachments on the front, and the elegance of a design suitable for mass production. The mixer makes use of a number of different materials in the construction, and in consequence the various parts are manufactured by different techniques[22]. Other examples could be the electric hover mower, personal stereo and fork-lift truck.

53. Technology on this basis would be a practical organisation of knowledge and skills. It would be a subject capable of bringing a better balance to English education which has been criticised as overly academic and theoretical[23]. It must be emphasised though - since the criticism is sometimes levelled - that the aim is *not* to go back to woodwork and metalwork for the less brainy but to give all children a firm grounding in skills relevant to today’s and tomorrow’s world, experience in making and designing, and insight into how things work.

National Curriculum Framework

54. If this approach were adopted what would it look like in terms of the national curriculum framework of attainment targets, programmes of study and assessment arrangements?

55. Currently there are four attainment targets in design and technology (other than information technology which we argue belongs elsewhere) - identifying needs and opportunities, generating a design proposal, planning and making, and evaluating. Although essentially part of the same process they have become separated and been given equal weight. We believe this does not give sufficient priority to ‘planning and making’, which since technology is a practical subject should be pre-eminent. Its importance could be signalled by giving differential weights to the existing attainment targets, or reducing them to two, perhaps ‘planning and making’ and ‘the process of making’ or just one, as is being considered in Northern Ireland. Here the Ministerial Group is consulting on one attainment target, significantly ‘technology and design’, which would be concerned with capability developed “principally through the design and manufacture of products”.[24]

56. The programmes of study would need to be worked out in detail with a clear indication of what progression up through the four key stages would mean in practice. They should also show how the subject would be a stepping stone to A-levels and vocational qualifications, and beyond them higher education and employment. As we have argued, the fundamental weakness of technology in the national curriculum is that it has not faced up to these issues of detail. We believe the approach we have outlined based on the ‘class of practical problems’ and associated knowledge and skills could be the organising principle needed for deciding what should be included.

57. With clear objectives (attainment targets) and detailed and graduated content (programmes of study), it should be feasible to devise satisfactory tests at 7, 11, 14 and 16, and GCSE examinations. The tests (standard assessment tasks as they were called) for seven year olds due to be trialled in the summer, which include interviews using technology, controlling robots and shelters for plants and animals look over-elaborate and time consuming, and one wonders how much useful information they will yield.

Other Issues

58. With the objectives, content and testing settled some other seemingly intractable problems would fall into place. For example, who should teach the subject? At the moment, teams are drawn from CDT, art and design, home economics and business studies, and led by ‘a technology co-ordinator’ who could come from any one of those fields or elsewhere. The success of technology as re-defined will depend crucially on a supply of appropriately qualified teachers drawing on good curriculum materials and supported by relevant in-service education.

59. Pinning down technology in the way described would also make the case for appropriate capitation, resources, curriculum time, workshop facilities and support staff, the lack of which have contributed to its failure so far to achieve quality outcomes.

60. One other issue to be addressed is whether technology is to be for all children 5 to l6 - both sexes and across the ability range. Our view is that it should, but as a subject

intrinsically meaningful and worthwhile, and not with areas tossed in to bring in their supposed client groups as we suspect has happened with home economics and girls.

61. Beyond age 14 we can see the argument for more specialisation and progressive focusing - included in the terms of reference for the National Curriculum Working Group but not really developed - so that while all students would be studying technology this could be towards a range of GCSEs and perhaps vocational qualifications.

Recommendations

62. The logic of the analysis offers a number of pointers as to what might be done to rescue school technology:

- it should be clearly established as a practical/ technical subject concerned with the design and manufacture of products and systems;
- its content should be specified as a practical organisation of knowledge and skills;
- it should be distinguished from the overlapping but different areas of basic life skills and vocational education;
- there should be clear progression in content with the subject acting as a stepping stone to higher education and employment;
- curriculum materials should be devised to reflect this sharper focus;
- the tests and examinations should embody the objectives and content as more precisely specified;
- the success of technology as re-defined will depend on a supply of appropriately qualified teachers supported by good in-service education;
- the subject will also require appropriate capitation, resources, workshop facilities and ancillary staff.

63. These recommendations are consistent with existing legislation. The National Curriculum Council is charged with keeping the curriculum under review and it could be urged to think again about attainment targets and programmes of study. The revised National Criteria for GCSE Technology have yet to be published and the School Examinations and Assessment Council should be pressed to take into account the concerns expressed here.

64. It would be reasonable to ask for technology to be re-thought in the light of the widespread dissatisfaction, and the changes in policy and curriculum subsequent to the Education Reform Act. Developments in vocational education, such as the introduction of general national vocational qualifications, make it important that the relationship to the national curriculum including technology should be considered.

65. Britain is the first country to make technology part of the compulsory curriculum for all pupils aged 5 to 16. It is a pioneering venture and not everything can be expected to go smoothly. But it does seem badly off course at the moment, and corrective action is

urgently required. Getting technology right in schools would bring benefits to the education of individuals, the economy, and ultimately the quality of life of us all.

Notes

1. Perceptions of the current concerns regarding technology in the national curriculum were elicited through interviews and consultations with representatives of the various groups with an interest in technology in schools. Information was obtained from: policy makers drawn from NCC (1), SEAC (1); HMI (3); professional bodies and LEA advisers (4); teacher trainers (2); employers (2); curriculum development experts (4). In addition to these 17 interviews, visits were made to six schools - comprehensive 11-18 (4) and 11-16 (2) - to talk to staff involved with the organisation and teaching of technology at Key Stages 3 and 4. Information was available also from our current pilot project for The Engineering Council on Technology at Advanced Level, including interviews with a representative sample of admissions tutors in higher education, with sixth formers on A level courses and with staff involved in teaching technology at A level.
2. National Design and Technology Education Foundation, *Technology*, INSET Support Pack 1.
3. Report of the Royal Commission on Technical Instruction (The Samuelson Report), 1882-84. In Maclure, J.S. (1973). *Educational Documents England and Wales: 1816 to the Present Day*. London: Methuen, pp 121-127.
4. Magnus, P. (1886). 'On manual training'. *Report of the Fifty-Sixth Meeting of the British Association for the Advancement of Science*, 748-49.
5. School Board for London (1898). *Report of the joint Committee on Manual Training on the Development of Work in Connection with Manual Training*, 1-24.
6. Eggleston, S.J. (1976). *Developments in Design Education*. London: Open Books.
7. Penfold, I. (1988). *Craft, Design and Technology: Past, Present and Future*. Stoke: Trentham Books, p.127.
8. McCulloch, G., Jenkins, E. and Layton, D. (1985). *Technological Revolution? The Politics of School Science and Technology in England and Wales Since 1945*. Lewes: The Falmer Press, pp 159-60.
9. Penfold, *op. cit*. p. 121.
10. Penfold, *op. cit*. p. 121.
11. DES (1981). *The School Curriculum*, London: HMSO, p 17.
12. Black, P. and Harrison, G. (1985). *In Place of Confusion: Technology and Science in the School Curriculum*. London and Nottingham: Nuffield-Chelsea Curriculum Trust and National Centre for School Technology.
13. Barlex, D. (1991). *Nuffield Design and Technology*.
14. Black, P., Harrison, G., Hill, A. and Murray, R. (1988). *Technology Education Project, 1985-88*, Report.
15. Data from a study of A level technology and its acceptability to higher education being carried out at Manchester University for The Engineering Council.
16. Hirst, P. (1974). *Knowledge and the Curriculum: A Collection of Philosophical Papers*. London: Routledge and Kegan Paul, Chapter 3.
17. The Engineering Council (1990). *Policy Statement: Standards and Routes to Registration*, Second Edition. London: The Engineering Council, p. 10.
18. Most recently, Prais, S. J. and Beadle, E. (1991). *Pre-vocational Schooling in Europe Today*. London: National Institute of Economic and Social Research, Report Series, Number 1.
19. The 'Technology in Context' materials developed by the Standing Conference on Schools' Science and Technology are an example, but they are in danger of becoming eclectic to the point where it is no longer clear what is the technology and what is the context.
20. National Curriculum Design and Technology Working Group (1988). *Interim Report*. London: DES, pp 86-87.
21. Examples taken from the Skills and Knowledge Map of the Technology Enhancement Programme organised by The Engineering Council and sponsored by the Gatsby Charitable Foundation.
22. Suggested by Professor Keith Foster, Director - Engineering Profession, The Engineering Council.
23. Smithers, A. and Robinson, P. (1991). *Beyond Compulsory Schooling*. London: Council for Industry and Higher Education.
24. Northern Ireland Ministerial Working Group (1991).

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10 Maltravers Street, London WC2R 3ER
Telephone: 071 240 7891