Technology Across the Curriculum

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Raising questions about different courses of technology across the curriculum I first consider some reasons why such programmes are being promoted. This is followed by some general points about integrated studies and a brief analysis of technology, together with a consideration of the main aims of technological education. The paper concludes with a synthesis of the points constructed into seven claims for technology across the curriculum models, which are then examined.

Some Reasons for Technology Across the Curriculum

It is not surprising that there is an increased interest in teaching technology across the curriculum.[1] Technology has come to occupy the same status that Christianity occupied in medieval society. Just as religion may seem to offer the possibility of Heaven or Hell, so technology offers the potential for good or evil, liberating mankind from hunger, poverty, toil or misery or destroying the world slowly by wholesale pollution or quickly by nuclear devastation. Technological values seem to compete with religious values, with technology emphasising materialism, secularism and human power over the spiritual, the transcendental and the sense of the holy. Because it permeates our lives, although we may dislike aspects of it, we cannot wholly escape it. We are part of it almost as much as medieval man was part of religion. Just as it was once argued that all knowledge could be studied from a Christian view-point, so the arguments are now heard that all school subjects can be given a technological perspective. Everyone needs to understand technology, to operate with it if they choose and to judge its value in present-day society. In short as the recent DES consultation document on *The National Curriculum 5-16* recognises it must be studied as a foundation subject by all.[2]

That word 'subject' raises a problem. Ten years ago in the HMI Report on the *Curriculum 11-16* it was argued that technology may not be a separate discipline but it draws on a number of disciplines, particularly science, in its wide scope.[3] It is concerned with people, society, reason and decision-making processes in politics and in industry. It aids our creative faculty; in its products it is concerned with aesthetic outcomes; it requires mathematical skills, it involves the application of science to the world of work and to society in general. It raises moral and spiritual issues that are bound up with political issues. Concepts from other disciplines are found to be of value in studying it, such as ratio (mathematics), cost (economics) and sequence and causation (history). Technology, the paper says, is not a given body of facts, not a unique set of ideas — it is a process with definite applications and origins in time; it involves the principles of natural science and considerable moral and ethical problems — all these considerations contribute to the conceptual framework within which we perceive technology. The essential areas of technology content draw attention to this basic interdisciplinary nature of technology in more detail: the basic principles of mechanics, optics, electricity and magnetism, electronics, energy and its conversion; the main chemical process of modern industrial society, the structure of materials, medicine and physiology: the historical origins of modern science, technology and industrialism: the principal ethical, environmental and economic problems arising from technology: a familiarity with a range of processes and materials employed in craftwork and the arts, such as the handling of metals, wood, textiles, ceramics, plastics, paints and dyes.

In their discussion document *The Curriculum 5-16* (1985) the HMI include the technological as one of nine areas of learning and experience.[4] They declare that such areas are not to be equated with subjects. Thus we can see once again that technology is to be taught through a number of subjects. Technology is seen as having historical origins, and social and environmental consequences. It employs problem-solving in order to exercise control over the environment. Design is seen as related to technology and should be taught developmentally from problems in the immediate environment to more remote problems. The total process of designing, we are told, is characteristic of CDT and the physical sciences, but the problem, solution and the process itself can emanate from biology, chemistry and from work in the humanities or social studies.

If one justification for technology across the curriculum is our total immersion in technology, another is the interdisciplinary connections drawn by the area. The HMI enquiry *Technology and School Science* (1985) suggested that since technology is a multi-disciplinary study, employing skills and knowledge developed by many subjects, more attention needs to be given to inter-departmental cooperation.[5] However, a third reason for the interest in technology across the curriculum might be the relative newness and weakness of technology as a school subject. There are competing models of technology — some drawn from physics, others from CDT and yet others seeking a new form. Technology, as Black and Harrison, point out, implies a wider range of interests and activities than those taught in school.[6] Many CDT teachers were not trained in technology and may lack the background knowledge to cope authoritatively in this area. Similarly many physics teachers regard their subject as liberal and theoretical rather than an industry-linked applied and practical pursuit.[7] Both subjects, but particularly physics, are in short supply of teachers so it is not the easiest time for such a large-scale innovation. Given the relatively weak structure of the subject as it stands, inter-departmental links provide important ways of coming to terms with the subject, and of increasing its depth and breadth.

In *Technology and School Science*, the HMI report that in only three of their fourteen school samples was there a policy for the place of technology in the curriculum and almost all the technology observed in the relevant science departments was concerned with physics and engineering. There were almost no biological or chemical components and no study of the social and economic implications. Project reports are described as badly written, lacking detailed analysis and graphic representation of the possible solution. The best work was achieved when the science and CDT departments worked together and the pupils were free to use all the expertise and facilities.[8] One

must conclude that there is an obvious need to broaden the scope of technological study and thereby to draw on the specialised skills and knowledge of different staff as well as departmental resources.

The earlier HMI observations *Technology in schools: developments in craft, design and technology departments* (1982) was even more pessimistic about technological education. It stated that technology courses have little foothold in the curriculum before the age of 14 years and are not strongly represented at 16 plus.[9] A high proportion of schools restrict technology to the most able, particularly those pupils who achieve well in mathematics and science. The problem is that in CDT only a small proportion of largely self-trained enthusiasts have been teaching technology. 'CDT teachers argue that they have insufficient time to achieve CDT objectives in craft and design, let alone technology. If they do not achieve a great amount of curricular time, two main courses of action are open. They can renounce technology and concentrate upon craft skills and the development of broad-based designing activity. Alternatively, they can embrace technology as part of their responsibility and cut the content of craft to suit the curricular time available. If they take the first course of action, there would still have to be the creation of a subject called 'technology'.[10] The picture presented by these two documents on technological education is of a subject, impinging on both science and CDT, with neither subject itself able to furnish adequate resources and expertise to develop the area. The case seems strong for collaborative teaching, clear school policies on technology, and the development of resources and inservice training for teachers. On this basis, one way of regarding technology across the curriculum might be as a temporary measure for broadening and deepening the concerns of science and CDT teachers in particular. Certainly the report of enquiry on technology and CDT (1982), while remarking that the idea of technology across the curriculum is attractive, concluded that as yet good examples have to be identified.

There are of course other factors that support an integrated policy in technology. For example, it can be argued that children acquire new social skills and skills of communication as the result of working in group projects. Some technology projects have deliberately set out to bring in outside assistance and to create a business enterprise. This helps to give the pupils an insight into the world of industry and to see how the skills they have acquired are inter-related and can be applied to commercial ends.

The various causes and concerns that explicitly or unconsciously motivate groups to experiment with technology across the curriculum projects are to be judged by the particular focus and aims that shape such projects. Any innovation needs to be justified to those involved, and after a time it needs to be evaluated in order to discover how far those aims have been met.

2. Cross-Curricular Links

So far we have briefly considered the possible attraction of technology across the curriculum projects. At this point we need to probe a little further into the advantages and disadvantages of cross-curricular links, before going on to consider what is unique about technology and technological education.

Integration implies bringing something into a harmony or unity. The demand, for some type of curriculum integration implies that what exists is fragmented, compartmentalised, and limited in its scope and outline. Each area of the school curriculum tends to have its own skills, methods of thinking and working, as well as its own conceptual framework and concerns. Teachers who specialise in the different disciplines tend to be concerned with their distinct contents and interests. The closed nature of the classroom historically, and the grouping of teachers into departments have often signified that secondary and further education teachers are subject teachers, first, and the educators of pupils at a certain stage, second. It is true that it was once considered essential to study two subjects in teacher training, and teachers even change stages and subjects, but generally there was a tendency to specialise. After a time one becomes secure in the specialism, one can anticipate problems and one needs therefore less preparation. It is through subjects that most secondary teachers gain their authority and thus their promotion opportunities and it is subjects which set the pattern of time for teaching periods, and the organisation of resources.

The structure of many subjects also tend to receive support in society. There are subject examinations and the subjects are taught in further education, polytechnic and university. Futhermore there are learned societies and social groups that reflect subject interests such as historical societies, art clubs, scientific conferences, and all of these and other subjects have their journals and their experts. It is not surprising therefore that most school teaching throughout the world is done through subjects. It is easier to work out a logical simple-to-complex, concrete-to-abstract, known-to-unknown developmental programme or syllabus in the textbooks that children can read, and while there might be a spiral curriculum, there is no need to repeat whole sections, as often happens in a thematic programme. These social structures tend to reflect the division of knowledge. While knowledge may be said to fall into different forms, marked by their peculiar concepts, logical structure and objective tests of truth, some disciplines are more marked by their methodology or by their concern with a unique set of problems. The speciality and separateness of each discipline it supported by the interests and authority of the appropriate learned society.[11] Thus there is a whole set of traditions which justify education through subjects, and with this a sense that the central academic areas contain a rigour that is lacking in projects, topics or areas of enquire.

Yet there are problems with subject teaching. Ordinary experience is not divided up like subjects are; hence one cannot follow through a practical problem when that raises a number of distinct disciplinary issues. Subject organisations, furthermore, are not necessarily the best psychologically for learning, for subjects, being related to adult enquiry, tend to be detached from

pupil interests and experience. The restrictions of a subject curriculum can be overcome, when disciplines not normally studied are brought into a project. Those who support integration see it as motivationally superior, though it need not imply a more open or practical form of pedagogy than that employed in subject teaching. Subjects, for example, may be taught in many ways, child-centred or formal, by many different styles of teaching and with different inter-personal relationships and motivations within the learning group and between the teacher and the class. The demands of p.e. and games, maths, chemistry, history and CDT are so different with regard to pupil activity and formal requirements of learning that it is difficult to generalise about them. Take one difference. Mathematics tends to be an accumulative subject, so that one stage leads into another and absenteeism creates problems, whereas history or English literature can be studied in isolated stages or topics.

Subjects may be integrated or brought together by a variety of techniques or methods. In primary education the employment of projects or themes which explore or stimulate special interests may arise out of local, national or international events e.g. the monarch's visit to another country or a local finding of archaeological interest, or out of the enthusiasms of the teacher or motivational concerns of the pupils. With these cases, the primary teacher is seen to be primarily a general teacher, able to relate a number of different disciplines.

A second form of integration is called by the Americans the *broad fields* approach. This involves bringing together subjects already existing within a faculty or department, where they can be seen to overlap. We have seen in this country the integration of the sciences and of the social sciences with history and geography. Integrated science can be justified on a number of grounds. Girls have tended to drop physics and boys biology from their options at 14 years. Integrated science involves learning aspects of all the sciences, so that no such sexist bias occurs. It helps when a school is short of teachers of one discipline e.g. physics — though all teachers require assisting in the other disciplines with which they are not familiar. One of the problems here is that in practice teachers tend to be more at home with their own disciplines and to concentrate most on them. Yet the rationale of the integrated sciences is good. It is concerned to explore questions of general interest through whatever findings will illuminate them.

Some other areas have more difficulty in becoming integrated. Thus the humanities was described by the Newsom Report as a broad field, together with the practical subjects and maths and science. But it is not clear as to what exactly is the rationale of the humanities which includes history, geography, religious education and literature. Thus other studies give us knowledge of man. Why these particular disciplines are picked out and seen as integrated to the theme of man is not explained.

Another way of integrating areas is that of taking an open-ended, *problem-solving* approach to topics. This may be seen in the Dewey-type school, junior school integration and in some secondary approaches. Here the logic is that one needs to follow whatever leads will help solve the problem or whatever can be elicited from the topic educationally. In the type of problem posed within design and technology the outcome is very often a product, and the process has required a number of group or individual decisions made by the pupils. for the Dewey schools it is usually thought that the teachers require a general education as part of their training if they are to make the connections that are most valuable.

Some topics require an *inter-disciplinary* approach to them. Thus sex education would be narrowly regarded if it were only taught within biology. Many of the topics involved in personal, social and moral education are of this nature. Some subjects lend themselves naturally to this approach. Thus history can be taught in relation to other subjects such as the history of medicine or of science (the former is a Schools Council project). Religion can be studied sociologically or even geographically. Maths has to be brought into physics and geometry needs to be brought into engineering drawing. But these examples are narrower in conception than the approach of the Dewey schools, and can be taught without reference to another teacher.

A new integrated programme runs into the same problems found in any curriculum innovation. Staff attitudes and values may create a reluctance to move in the new direction. After all there may have to be major organisational changes. Student groups may require restructuring, timetables may need blocking and resources given up or shared. New teaching skills may have to be acquired and staff who have hitherto worked in isolation, may need to see themselves as members of a team or community. The planning group must be able to represent the views of the staff involved, and the innovation needs to be prepared carefully, with the aims clearly understood and accepted. In the case of technology across the curriculum, this means that the sense of technology must be agreed, the relationship of technology to other areas of knowledge worked out and the aims of the technological innovation accepted. It is to the analysis of technology and technological education that we now turn.

3. Technology

One of the crucial questions for a technology across the curriculum project is that of so defining technology that the various participants are agreed about what aspects of the activity or area of knowledge they are focusing on. Technology is a general term that historically covers a wide range of pre-scientific and scientifically-based a) processes, b) knowledge and c) hardware by which various forms of environmental control have been achieved. There is no single form of technology — there are a multitude of specialised and institutionalised types such as agricultural, clothing, communication, medical, military and transport.

a) Technology as a Process

To call technology a process is to argue that ultimately it is not about objects — things made and used — but about the processes of making and using. For engineers the process is basically one of invention and design; for the social scientist it is the production and

manufacturing processes and the public use of technological products that characterise this aspect. In the design sense technology uses human knowledge and physical resources to solve practical problems. Both technology and design are all-embracing terms. They both have meanings unrelated to each other as well as overlapping concerns. Design essentially implies the notions of intention and planning in contrast to the idea of accident. In a general sense it is often equated with decision-making; hence in so far as politics involves making decisions about the society you want, it implies design. Urban planning involves making decisions about the artificial or man-made world.

Like morality, design implies changing the world or some aspect of it in some way. It draws on a particular content of knowledge and set of traditions, so that a furniture designer, an electronic designer and a boiler designer has to know different things and needs to draw on what others have learned in order to create his design for a specific set of circumstances. It has aesthetic and technical elements. Design can be found in creative writing, painting and in engineering. We also talk of designing experiments. Thus strictly speaking there remains an ambiguity about what is implied by 'design'. Technological design involves an analysis of the practical problem in relation to particular human needs, the application or modification of existing traditions or theories to the particular situation, involving different levels of imagination and creativity and the testing of the particular outcome, often initially by models or under laboratory conditions and finally under the actual condition of its use.

b) Technology as Knowledge

To view technology as knowledge is to see it as a series of claims about the universe as well as something constitutive of human nature. Technological knowledge ranges from individual tacit knowledge — which is technically not knowledge at all — to major theories. It involves something like four levels.[12]

1. An unconscious sensorimotor skill — not strictly knowledge — employed in making or using artefacts.
2. Technical maxims or rules of thumb of pre-scientific work, prescriptive rules which articulate generalisation about successful making or using operations, of which the clearest examples are cookbook recipes.
3. Pre-scientific, empirical and descriptive laws, generalised on the basis of experience, and taking a more general form than the technical maxims; and
4. Technological theories which either systematise descriptive laws or provide a conceptual framework to explain them, including the application of scientific theories. In HMI writings the major concepts or themes or areas of school technology are said to be control, materials, energy and communication. These constitute some general but not exhaustive categories of technological concern. In a wider sense technological knowledge is knowledge about devices and products and their environmental and social impact, the knowledge of how to use known technological methods, theories and tools in a practical problem-solving or creative way as well as the specific theoretical structures, forms of control or tools and the products themselves. Knowledge thus involves awareness, capability as well as claims.

In the report *Technology in Schools* we read 'Teachers were sharply divided on the question of whether technology was a multi-disciplinary activity involving CDT, science, mathematics and other conventional subjects or a distinctive discipline to be compared and contrasted with, for example, science'.[13] The report claims that those who took the latter view saw technology as a process. It goes on to say that since most CDT teachers did not believe that it was essential to learn scientific principles before applying them to the solution of technological problems, they denied that technology was applied science. 'All CDT teachers agreed that technology in school must be defined in terms of an active involvement of pupils in making and designing artefacts or systems. An awareness of technology derived only from reading, listening or observation was not acceptable, however illuminating'.[14] Here the CDT teachers are seen as affirming that at the level for which they teach, given the pupils they have, the technology should be practical, and imaginative. Much design work in technology would appear, then, to have a strong trial-and-error element, the electronics work a black box approach. In short, the CDT approach to technology tends at best to be what I have described as level 3 of technological knowledge. This is not to deny that there are excellent self-taught or technology-trained teachers who have integrated scientific principles with the detailed grasp of various forms of structures or control in their teaching. The point apparently being made is that this kind of technology has as yet little place in CDT.

c) Technology as Hardware

Technology is commonly identified with various types of devices, tools, machines and consumer products. The notion of device covers cases from screwdrivers to computers. Such objects are commonly regarded as the extension of human attributes and capacities. The more developed the device or machine is the less demanding it is on our strength, skill and attention. Over a period of time devices may be radically altered so that they come to fulfil their functions more efficiently. Machines and tools are characterised by the functions or ends they serve. If we were to study the development of radios or television, we would note their radical change of means without their change of function. Central heating has become increasingly safe and easy to operate; its results are instantaneous and its effects can be felt everywhere in the house.[15] Such devices as these have re-shaped the modern world, impinging upon every aspect of our life. Our lives have come to be re-shaped by changes in communication, work, leisure and home-life brought about by them. Through technology a mass culture has been created by which music, art and objects of comfort have been made available, often at the push of a button for the general public of the developed world.

3. Technological Education

So far we have seen four views of technology as an area of study: 1) the *CDT view*, which tends to stress practical problem-solving rather than applied science; 2) *the science view* which in its purest form gives little attention to application and in its applied form tends to focus on problems arising out of physics; 3) *the engineering view* is supported by a few enthusiastic teachers qualified in technology who are concerned to get pupils to apply scientific principles to technological problems, 4) the *team-teaching view* in which cross-curricular links between physics, CDT and further areas of study. The historical account of the first three competing models has been well documented by McCulloch, Jenkins and Layton,[16] and can be seen in the various HMI and DES enquiries about technological education. The fourth move is one considered in further depth throughout this paper.

In an earlier paper I suggested three justifiable aims of technological education:[17] 1) the development of technological awareness i.e. the moral and political preparation of students towards an understanding and critical awareness of the social issues of technology; 2) the acquisition of skills related to technological devices, tools and equipment, and 3) the development of understanding and capability in related areas of technology. Black and Harrison in their seminal work *In Place of Confusion* (1985) suggest three main aims — awareness, capability and the acquisition of the resources of knowledge and intellectual and physical skills i.e. whatever skills, concepts or knowledge are required for acting technologically.[18] These different statements stress the need to grasp facts and theories which can help describe, explain and evaluate technological events and products, the need to be able to use technological equipment and the need to be able to design and make technological objects. All agree that technology is not just black-box making, theoretical understanding or applied physics or engineering. The scope of school technology is enormous and must take into account the interests of both male and female and the differing scientific biasses and humanistic concerns of all pupils. There is a sense in which that can only be realistically done in most schools by a cross-curricular policy.

5. Technology Across the Curriculum

a) Across the Curriculum

For technology across the curriculum to succeed as a policy there needs to be both an emphasis on cross-curricular links and a concern with an acceptable form of technology. We have long since heard that all teachers should be concerned with moral education or that language needs to be taught across the curriculum. In the area of political education there has been a discussion as to whether it should be taught as a subject or through a number of different disciplines and activities. Now all these cases are different, and whether the ideas work in practice or not depends upon the degree of coordination and planning through the school, the normal role of the individual teachers and a general willingness amongst staff to implement the policy. Where can the time be provided for moral discussions? Can the subject teacher pay attention to the four aspects of language when there may be more immediate problems of behaviour or subject understanding? Across the curriculum work can either involve using one's own subject to emphasise the common element or of allowing the common task or project to prevail over one's subject interests. Sponsored programmes would be expected to operate the latter policy. For this to work the difficulties encountered by any innovation must be overcome. The staff who are involved must believe in the worthwhileness of the enterprise: it cannot just be imposed upon them with little consultation. There needs to be a planning group with sufficient time and commonly held resources to consider different schemes and to prepare for the new situation. This group needs to be able to represent the expertise and attitude of the staff. In a curriculum project the staff must be either familiar with the basic new learning material or respectful of the unfamiliar areas of knowledge. In this case there must be those who are strong in technological expertise to advise, and the rest must either be trained in the necessary skills or be willing to research their own subject so that the technological project can be related to it. For all this to work there needs to be support from senior staff and, in some cases from parents.

Before suggesting alternative methods and policies of technology across the curriculum I want to suggest two general points: 1) while it is easier to involve more departments by using a very general theme, the likelihood is that each group will interpret the theme in their own way so that the endeavours will become less integrated; 2) the more departments and subjects that are involved, the looser the curricular links are likely to be, so that the logical technological links between physics and CDT become stretched to breaking point when extended to, say, p.e.

b) Models of technology across the curriculum

So far we have noted that integration may involve a) the exploration of a theme b) inter-disciplinary work and c) problem-solving. This may be done by one or more teachers, often depending at which level of schooling the work is being followed, secondary teachers being more specialist than primary teachers. Technology can be interpreted as process, knowledge and hardware, while technological education can be seen as sponsoring awareness, understanding and skills and capability.

If we bring these elements together we have something like the following interpretations of technology across the curriculum:

i) uncoordinated work on and about technology

ii) coordinated links between subjects involving the exploration of themes

iii) hardware skills involving a) the use of workshop tools and machines or b) the manipulation of general technological devices

iv) a multi-disciplinary coordinated policy of technology teaching

v) a multi-disciplinary coordinated effort of teaching for technological awareness

vi) a problem-solving activity involving designing without a product

vii) designing and making on the basis of technological knowledge.

Before commenting on these different models of technology across the curriculum I will briefly consider links between subjects and technology.

c) Technology and School Subjects
The link can be made to technology through many subjects, whether it is planned and coordinated or not. For example, history can involve the study of various types of technology (e.g. the history of medicine), developed in the West or East (e.g. China) and comparisons can be made between certain historical periods (the Industrial Revolution) and today's technological society. Through geography and sociology one can study the development of modern industry, communication technology etc., and its effects, as well as alternative forms of technology found in developing nations or in, say, research into new energy sources. These types of study may be described as related to technological awareness. A subject like home economics includes the study and use of technological devices in the home as well as the implications of external technological development and the employment of the design process (e.g. in designing bed-sitters or toys).[19]

There are other subjects which are more concerned with the teaching of skills related to hardware (e.g. computer studies or information technology). Some subjects assist in the development of skills required in technology. For example the technological student can learn the skills of representational drawing and modelling in art and graphics, and language skills are essential for research work and both oral and written reports.

Besides these examples, there are subjects through which even more essential skills, concepts and tools of analysis can be taught, and the process might be reversed so that these other subject concepts and skills are taught through technology. The human sciences may provide help for the analysis of particular human needs for some technological design work. Mathematical ideas, as Cockcroft pointed out should be applied to a variety of practical situations, and in turn the analysis of mechanisms and structures, for example, require the use of mathematical skills.[20]

Technology is often equated with applied science and the science inspectors argue that five predominantly science activities constitute technology:

a. The application of scientific ideas to the production of a useful device or system, e.g. a piece of laboratory equipment;
b. Improving the design and efficiency of a device or system in the light of data and evidence obtained in an investigation;
c. Using a device or system, or making one within specified constraints, to tackle a scientific problem;
d. Applying scientific principles in the modification of a product in order to tackle a new problem;
e. Using scientific knowledge and/or method to help make balanced and informed judgements about technological innovation.[21]

Many influential science educators would argue the need for students to experience science through some engineering or design technology examples. The HMI give examples of first year pupils studying the works of an electric iron and a sixth form project involving the construction of a rig to test the performance of cycle tyres. Science may be seen to provide a bridge across different technologies (e.g. material science), while it is arguable that modular technology may be seen to be limited to two aspects of physics — mechanics and electrics/electronics. There are major differences of approach between science and technology, technology tending to use workshops rather than laboratories, to aim at design and construction rather than the seeking of explanations, and the use of materials and the making of well-crafted products rather than aiming at outcomes which merely illustrate principles or demonstrate function.

d) The Models of Technology Across the Curriculum Considered

i) Uncoordinated work on and about technology
While uncoordinated work on technology with different subjects touching on aspects of it may help in creating interest both in the particular subject and in technology, too much is left to chance for it to be described as a *policy* of technology across the curriculum.

ii) coordinated links between subjects involving the exploration of themes.
The exploration of themes can often produce an arbitrary and unrelated programme. A theme like power can mean different things in a political, religious or physicist context. A theme like technology and work or leisure can run into similar difficulties, and if set for different subjects can lead to the creation of an artificial programme (as when the English teacher runs out of ideas for discovering good poems, plays or stories on the particular theme but has to continue the course). But carefully planned in detail it can offer a coherent programme.[22]

iii) Hardware skills involving a) the use of workshop tools and machines or b) the manipulation of general technological devices.
Most technological skills are those used in the laboratory/workshop (e.g. electronic skills) or those used more generally in classrooms and offices. practical skills of the former kind will tend to be taught in a school whether or not there is some form of integrated programme. It is the latter — especially the acquisition of computer skills with word processing, data retrieval and graphics — that many people identify with technology. Therefore a school in which staff are trained in the use of such equipment and who in their turn provide opportunities for students to develop their skills, is often regarded as highly technological. Such skills can be very useful but they are means to ends, and the nature of the basic skills change as the equipment becomes more user-friendly. This kind of activity need not involve either technological awareness and capability or an integrated programme in the way suggested here: the level being operational or technical.

iv) A multi-disciplinary coordinated policy of technology teaching.
The technology teacher often lacks both the time and expertise to teach the

supporting mathematics or physics. Team-teaching, in which staff deliberately cross-reference syllabi and provide logical links between areas is one way of overcoming these difficulties. Of course it is only a limited integrated programme, merely overcoming some problems of separate subjects, but it can be very useful for the pupils.

v) A multi-disciplinary coordinated policy of technology awareness

This is another aspect of iv. One example of organising this is to consider certain specific types of pollution, in which scientific, environmental and social/political issues are raised (such as in Siscon projects).[23] It is educationally and politically important that we create citizens who are rational in their attitudes to technology, and are able to weigh up the scientific/technological and social arguments. Such programmes are often left to chance in schools. Many science teachers may deal with it, but politicians like Sir Keith Joseph have shown their opposition to it arguing it is not part of science teaching. Some topics also if not dealt with in a balanced way may be illegal because they are controversial. However, technological awareness is a matter that benefits from multi-disciplinary considerations.

vi) A problem-solving activity involving designing without a product

This might involve a large project drawing on many departments in which the local town centre is replanned or a group-based business venture is planned without a final manufacturing and selling outcome. The former example is more design than technology. However, the latter example may involve models or even prototypes being produced. There may be a market research as well as a design competition, to provide a sense of the market place. The teaching in physics, maths, CDT etc., may be coordinated to this specific end. The focusing may help pupil motivation, but in the end the logical links between subjects may be restricted to this one project, and the sense of industrial realism (a kind of practical business studies) that it might be hoped would be engendered may be missing.

vii) Designing and making on the basis of technological knowledge

Many of the models considered here are either weak in technology or weak in integration between subjects. Whether this particular one turns out to be good on both counts depends upon how far the actual project is more than just an extension of a CDT design. Technology calls for a balance between knowledge and invention, and the knowledge should be built upon a scientific and empirical base. There should be an opportunity to apply mathematical skills and to produce models and drawings employing skills acquired in graphics and art. Whatever is designed should, if possible, be accompanied by an oral and written report, which could both analyse and sell the product in an acceptable technological and linguistic form. The technological problem should also take into account the interests of both girls and boys and provide opportunities for group as well as individual work.

Conclusion

The test of a good technological project is that it fulfils the criteria for developing technological awareness and capability and is able to provide opportunities for research, considerations from disciplines not normally taught in schools and for integrating the work tackled in areas logically related to technology. For a problem to be successfully tackled one needs preparation in the related knowledge and skills.[24] All of this needs careful planning by staff from several departments, with the time to prepare the work, the resources to draw upon and adequate timetable arrangements. The project ought not just to involve non-examination students. In the end the project is only successful as technology across the curriculum, if the pupils have acquired valuable knowledge, skills and attitudes that they would not otherwise have gained. There is a danger that staff come to value the projects for their own gains in cooperation and inservice training, or for the links they see between subjects, but that the real gains in the learning, motivation, and insights into inter-disciplinary links, may be missing for many pupils. The topic could as easily be tackled in CDT. The school's image may be enhanced by an exhibition of such cross-curricular work. However, ultimately there are two questions that need to be asked i) is there an improvement in learning technology and learning about technology for all students? ii) will the project change the way the school teaches technology in the future, without endlessly repeating the same themes?

References

1. I have based a number of my comments on observations I have made and discussions I have had with staff involved in technology across the curriculum. I am particularly grateful to those involved in BST project, especially the project director Mr Noel Brownlow.
2. DES *The National Curriculum 5-16 HMSO 1987*
3. HMI *Curriculum 11-16* HMSO 1977.
4. HMI *The Curriculum 5-16* HMSO 1985.
5. HMI *Technology and School Science* HMSO 1985.
6. P. Black and G. Harrison *In Place of Confusion — Technology and Science in the School Curriculum* The Nuffield-Chelsea Curriculum Trust and the National Centre for School Technology 1985.
7. R. Schofield 'Physics in Craft, Design and Technology' in P. Preece (ed) *Perspectives in Physics Teaching* University of Exeter 1981.
8. HMI *Technology and School Science* HMSO 1985 3.57.
9. HMI *Technology in Schools — developments in craft, design and technology departments* HMSO 1982 p.19.
10. It is significant that CDT is not named as one of the 10 foundation and core subjects or even as a related subject in the 1987 government policy statement *The National Curriculum 5-16?* What is named is design and technology.
11. D.G. Swift notes in 'Technologising School Science?' in Secondary Science Curriculum Review *Science and Technology Education: Issues from a Conference* SSCR Autumn 1984 pp.33-34, there are no learned societies for technologists as such, only for certain kinds of engineer.
12. P.T. Durbin (ed) *A Guide to the Culture of Science, Technology and Medicine* The Free Press 1980 chapter 5 cp B.K. Down 'Knowledge and CDT: Some Questions Posed' *Studies in Design Education, Craft and Technology* Vol.18 no.1 1985 pp.16-23.
13. *op. cit.* p.16.
14. *ibid.*
15. For a development of this sort of analysis v A. Borgmann *Technology and the character of Contemporary Life* University of Chicago Press 1984.
16. v G. McCulloch, E. Jenkins and D. Layton *Technological Revolution* Falmer Press 1984.
17. B.K. Down 'Educational Aims in the Technological Society' *Studies in Design Education, Craft and Technology* Vol.16 no.3 Spring 1984 pp.64-74.
18. *op.cit.* pp.3, 4.
19. v School Technology Forum *Technology through School Subjects* Standing

Conference on Schools' Science and Technology 1982.
20. v Brunel University Education Department *Maths Design and Technology Conference Report* Brunel University Education Department 1983.
21. HMI *Technology and School Science* HMSO 1985 1.2.
22. For carefully worked out integrated projects which, however, are not wholly technological v BTec/City and Guilds *Foundation Programmes of Pre-Vocational Studies for Pupils aged 14 to 16 Case Studies: Guidelines and Examples* BTec/City and Guilds 1986.
23. vSiscon (Science in Context) and SATIS (Science and Technology in Society) writings.
24. B.K. Down 'Problem-Solving, CDT and Child-Centredness' *Studies in Design Education, Craft and Technology* Vol.16 no.1 pp.38-43.

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having tackled the Access Course were then equipped to do a PGCE in CDT.

We have now taken the first cohort into our B.Ed. Course. They have proved to be outstanding students. Their attitudes to study and to the task of teaching are splendid. We were very gratified to discover that every Access entry student finished within the top half of the group at the end of the first year of the degree course.

The Access Course at The Dudley College of Technology was granted additional funds by the MSC in 1987 and has now acquired additional space and improved equipment including its own computer suite. The Access Course which is about to embark on its third intake is still recruiting most healthily. Indeed we had to offer a second course which admitted men and some women. We are sure however that the notion of keeping the women on their own during the initial year is for many crucial. Only in this way are they apparently able to build the confidence to tackle projects which for so long have been the exclusive preserve of men. At the end of that segregated year it's the men who have to watch out!

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extend much of the excellent curriculum development work which has emerged over the last five or ten years.

The physical resources again need to be enhanced. From Easter this year we will have two new workshops/studios and a new resource centre. Finance for this development has come from both the Polytechnic and from external funding.

The needs of the education service, including the demands which will be made by the National Curriculum, and possibly 'Licensed Teachers', will ensure that the future continues to be promising providing we are capable of meeting the requirements of our customers. This can only be achieved by offering a product which has quality but can also be provided in a quick, flexible and cost-effective manner.

Reference

1. Fred Adamson and George Shield 'Two Year trained — stigma or star?' *Studies in Design Education Craft and Technology* (Vol.19 No.2 Spring 1987).