Technology Education and its Bearing on English*

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Introduction

My main purpose is to draw attention to the significances of a widespread current innovation in school curricula: the inclusion of technology as a 'core' element for all students in the compulsory stage of schooling. The content of technology education can take many conceivable forms (with, incidentally, different implications for language experience and the teaching of English). The emerging dominant model, soon to be given a statutory basis in England, has many strengths. As a selection from the range of phenomena comprising technology in the modern world, however, it has serious limitations. If schools were to address technology more inclusively and adequately than is being proposed, and in particular were to give full weight to the social embeddedness of technological practices, a very different curriculum — and with it a different language curriculum — would be the result.

Technology as Design

There are moves in a number of countries to replace or supplement vocationally-oriented school technical courses with compulsory *technology* studies seen as an element of *general* education for all. The main reason is the perceived economic need for whole populations, rather than simply specialist cadres, who understand technology. There are many possible emphases within technology studies. Distinctions are made, for instance, between the learning *of* technology to acquire *capability*. learning *about* technology to acquire *awareness* or *understanding,* and learning *through* or with the *aid* of technology. The general field of technology from which technology education derives its agendas is clearly very broad and includes, at the least, *devices,* which may be both outcomes of the means towards technological activity (and it is these which are most prominent in particular conceptions of 'technology'), bodies of technical knowledge and expertise, and sociotechnical practices. In the emerging technology curriculum, however, a particular set of emphases is coming to be adopted through a definition of technology as a *purposeful process* resulting in the production of *artefacts, systems or environments.* This particular formulation comes from the report of the working group commissioned to write the specifications for the subject Technology within the national curriculum which is to be compulsory for all pupils in state schools in England and Wales between the ages of five and sixteen[1]. Because they see technology primarily as process the group make capability — the ability to engage in technological practice — and not knowledge the aim which is to be tested.

Two aspects of this approach are worth dwelling on. The first is that artefacts, systems and environments are seen very broadly, so that outcomes of technological activity would include not just coffee tables and hacksaws, or electronic burglar alarms and CD players, but a picnic for twenty people, a new track suit, a supermarket check-out system, a playground or a new variety of melon. In contrast with what 'technology' means in some other education systems, the term does not primarily refer to computers, nor will it in this paper. (In the national curriculum computers come under 'information technology', which is dealt with separately.)

The second aspect, which I intend to address at greater length, is the nature of the 'purposeful process' which technology is primarily seen as. In traditional craft lessons students working from a printed drawing would fabricate identical artefacts of wood or metal, an exercise purely in manual skill and accuracy. In more recent practice students have often been given, as before, the overall dimensions of, say, a metal hacksaw, together with specifications for its main parts, but have been required in addition to *design* certain parts, such as the grip and the spindles, for themselves. The continuing tendency to enhance this element has culminated in the placing of design at the heart of the technological process in the new national curriculum subject, which at one point was actually renamed Design and Technology, 'to be spoken in one breath', though it is now back to simple 'Technology'. The working group identify the components of 'design and technological capability' as 'Identifying needs and opportunities' for design and technological activities, 'Generating a design proposal', 'Planning and making' and 'Appraising'.

There is widespread relief that the working group have defined the subject in terms of processes with such broad educational value. We *could* have had students being tested in recalling stress formulae, assembling gear systems or fault-tracing in electronic circuits. There are felt to be a number of ways in which the group have got it right. First, their proposals reflect an understanding of the following features of technological activity as revealed by research:

1. Technological expertise is not a matter mainly of the application of knowledge, though knowledge is important. In placing *capability* at the centre of their aims, the group make it clear that the teaching of scientific and technical knowledge will not on its own produce technologists, though this will be an important part of their training. The role which knowledge plays in 'technogical activity is a particular one, in that there is no specific body of 'technological knowledge'. Rather, the knowledge by means of which a technological problem may be solved can be drawn from any discipline and a mixture of disciplines, eclectically and opportunistically. Much knowledge is not intrinsically 'technological' but becomes so by virtue of being used for technology. Even in school technology, students sometimes reject the body of knowledge they have been taught as relevant to a specific area of problem-solving in favour of quite different sources. To give his students the opportunity to apply their

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knowledge of the measurement of resistance in materials, a teacher set them the task of designing a device to test the tenderness of peas being boiled ready for freezing, but had to accept one student's solution based on measuring the *chemical* changes which occur in peas when cooked.

2. Another feature of the distinctive relationship between technological activity and the knowledge on which it draws is that that knowledge is typically inadequate or exists only in a form inappropriate to the context. Although the oil industry appears highly science-based. David Yeomans and I found in the UK lubricants plant of a multinational oil company that the knowledge does not exist for predicting the characteristics of the specialist greases which were blended there, even though the composition of the constituents was able to be analysed with great precision. Technology is not synonymous with applied science.
3. Since knowledge cannot be simply 'applied' in order to generate solutions to technological problems, technological capability involves other elements which are as essential as knowledge. The important ones are quite different from the routine-following, algorithmic procedures suggested by the idea of 'applications', and in fact involve judgement, tacit knowledge and 'feel'. Grease-making we were told, is actually more like cookery than science. Staudenmaier refers to 'the uniquely pragmatic character of technological cognition'[2].
4. The process is typically social not individualistic. The working group emphasise learning to collaborate in joint technological endeavour.

The group, then, have got it right about technology, at least in some respects. There is wide approval also for their overall curricular intent, which is to raise the status of the practical in relation to the academic. 'Rehabilitating the practical'[3] involves giving dignity to practical activity and acknowledging making and doing, equally with academic knowledge, as a valid manifestation of intelligence, and derives support from the study of the complex and sophisticated cognitive processes of practitioners such as architects, surgeons, doctors — and, of course, teachers — who typically deal with ill-defined problems and draw on knowledge in complex ways in solving them[4].

In the new national curriculum in England and Wales, technology will be the only remaining subject in which students act on the world. Although circumscribed within the confines of a subject, through it interpretation of 'the practical' it enacts what is potentially a radically alternative pedagogy. The learning sought is less *dicipline-driven*, following the sequential logic of a subject, than *situation*-driven through engagement with the problem and opportunities presented by specific contexts.

Design and the Language Curriculum

A technology education based on design and points of bearing on the learning of language and literacy. The first concerns experience of language. Students working in practical situations, and especially in collaborative activity (organising, co-ordinating action, reaching agreement on design and on the division of tasks, persuading, reporting and so on), but also in obtaining help, information and materials, use a language directly associated with action. In the English curriculum, on the other hand, language has few direct consequences in the world of action, beyond occasioning evaluative or appreciative responses from the teacher and an audience. Since English largely neglects that considerable proportion of the world's language which seeks to make a difference to states of affairs, the chance for students to experience it elsewhere, in design and technological activity, is to be welcomed.

Secondly, design and writing have much in common. Both, for instance, are processes the occurrence of which is not confined to those when their overt manifestations, such as drawing or writing on paper, are in evidence. What is encoded with pencil or typewriter is generated partly on the spot, at the 'point of utterance', and partly in earlier mental activities which the subject would probably characterise not as designing or writing but as 'just thinking'. (One of the students we studied thought of some of his best ideas when he woke up in the night). Again, both designers and writers experience 'blocks', and are visited by solutions which arrive seemingly from nowhere, though sometimes aided by heuristic procedures. Finally, the recursive and iterative nature of the processes is strikingly similar.

A pursuit of the parallels might be quite fruitful, not least for students. Seeing writing as a form of design would interestingly enhance a *rhetorical* approach emphasising texts as contrivances to induce effects in others. Conversely, we might think of designers as writing the environment we live in. (And we recall, with a shudder, that poets were for Stalin the 'engineers of the human soul'!) New technologies are in any case confronting us with the connections, not least in enabling us to store and transport both writing and graphical designs, along with music, in identical form in the same medium of the floppy disk.

Thirdly we might note that neither 'technology' nor 'literature' can be identified by clear criteria and that both terms are used selectively as honorifics. Thus what women do at home is less likely to be dignified with the label 'technology' than what men do at work.

My last point arises from the consideration that English has a repertoire of topics by talking and writing about which students are believed to develop their linguistic capabilities. The repertoire might be expanded beyond the biographical universals such as birth,

death, love and accidents, the detail of personal experience in the private domain and a handful of ready-defined public 'issues', to take in (and dignify through attention) the working lives of people as maintainers, manipulators and modifiers of the material and technological base of the society. One could imagine an English programme in which students interviewed engineers, food chemists, printers, cooks, medical technologists, clothes designers, traffic engineers and sound recording technicians and collected the culture's narratives of invention, construction, problem-solving, inspired adaptation and ingenious improvisation.

Technology as more than design

Design, however, does not exhaust technological activity, and in fact accounts for quite a small part of it. Much technological activity is getting things to work. Word processing, for example, is not normally seen as a technological activity, and indeed it is not when it consists simply of typing in text (even though schools may teach this in courses called 'information technology'). But as soon as you go beyond the basic procedures which the program offers you in a user-friendly way, and into areas where you have to make your own ways through (like, in my experience, writing a macro which will get an address out of an address file, put it top left after the date in a letter and then, later, onto an envelope) then you are engaging in technological activity, one characterisation of which might be 'making things do things for you'.

Other technological activities are the *maintenance* of machines and systems and *repair*, involving fault diagnosis, and their *modification* and customisation. Scriven[5] argues that even in the development of new machines, innumerable small modifications made by operatives may be as important as the conception of the original named designer. The steam engine as it first appeared was of little practical use: what made it step by step into an efficient machine offering worthwhile gains in productivity was 'the inspired tinkering of anonymous mine foremen': 'technologists are improvers, practical creators, fiddlers, perfectionists, analysts — and all those things can be found on the production line'.

Consider one student's experience of technological activity in the context of an assessed project, extending over many months, to develop a new device. Andrew, aged fifteen, had chosen to produce a radio-controlled shutter release for his camera, for use in wildlife photography[6]. At one point Andrew was considering using a solenoid motor to provide the force which would activate the shutter release directly on the receipt of a radio signal. (A solenoid is a motor which produces not a rotary motion but a single thrust in one direction: the iron core shoots out when current is applied to the surrounding coil.)

This is how Andrew explained to us the stage he had reached in developing his idea. As he spoke he pointed to features on sketches and a mock-up device.

> But I'm not going to use that idea now, or that one, I'm going to use some type of potential energy, like just using the solenoid to trigger something else off, because we can't find no solenoids. We're not really experienced enough to make one, to get one just right... So, me and my uncle who's helping me a bit, we're going to work out something in the Christmas holidays that's using potential energy. Because he was quite a good engineer.
>
> [How does that work, Andrew? I don't know what potential energy is.]
>
> Where, like a mousetrap, where the mouse only has to touch the cheese very lightly and then it comes down to chop its head off... so just using a little bit of energy to trigger off the lock. With a relay you can use just a little bit of power to let through a big 240 volts or something...
>
> ...I went down to my uncle's one weekend and we didn't have any solenoids and stuff and so we had a look at what we'd got and we'd got some motors and things, so we thought we'd better do something that day, so we just made this up *[indicating a device]* which is made up with what we'd got. We'd just got a pinion [?] on the motor which drives onto this which has got a rubber grommet for a pulley, which is coming round here with an elastic band, then we grooved that out on an electric drill and put a bush in it, then this has got this cam on it which pushes that up like that... so with this, when we use this on the camera, see, the camera release is mounted there and that held it secure with a washer in there. And so on this it was actually the rubber band that was firing the camera, and not the pressure from the motor.

[The reason you had to go for this spring mechanism is simply because you can't get the appropriate solenoid. That's amazing that you can't actually. It is possible to make a solenoid?]

> Yes, it is possible to make them, but there's a lot of things to consider, like each turn of the wire has to be touching the one next to it and then you've got to take into consideration the thickness of the wire, how many turns you've got, how long each turn is, how long the barrel of the solenoid is, all different things and you have to read books and books about them before you can even start making them. Because me and my uncle did try making some... We set a drill up with a screwdriver thing on it which gears it down so the drill goes round slower, then we put it in a vice so it was going slow, then we put a shaft on it and then we held a pen barrel in the chuck of the drill as well and then we put a cork on it and then cut it in half and spaced it and then we had it turning, with the wire feeding on the floor to make a solenoid, but... and then we tried them, but they soon get

too hot if you don't know what you're doing. Because we couldn't do one that didn't get hot. Mind you, we were using them on car batteries.

What this exemplifies is technological work as *situated* cognition, conducted not in abstraction at a drawing board but within a highly specific material and social context which provides agendas, resources, cues and clues, and constraints. (Typical of *real* technological work are such considerations as 'we thought we'd better do something that day'.) Adapting a point by Brown, Collins and Duguid[7], what is going on here is not a deployment of knowledge within a situation which is essentially separable or neutral or can be seen as just 'context', but an engagement with knowledge in a way that is shaped by the situation: 'situations might be said to co-produce knowledge through activity.'

Andrew's situation-embedded mode of operating is typical of much technological activity outside design departments and is not adequately encompassed by the characterisation of technology as essentially *design,* with the implications that carries of a rationalistic goal-seeking trajectory followed in detachment from contextual mess. The mess in which the technologists works is not only that of the original ill-defined situation but may also be that of the production environment, with its finite material resources and specific social relations.

The important underlying question is whether privileging design over other aspects of technological activity negates the intention to rehabilitate the practical, and denies recognition to those who innovate in more immediate improvisatory and responsive ways and who 'think with their hands'. It tends to reduce the latter to the status of *para*technologists who are seen, like paramedics, as performing only the more routine procedures of the discipline without calling on intelligent creativity or deep knowledge. Might it be that behind the conception of the designer there lurks the image of the romantic poet, in contrast with whom the opportunistic bricoleurs and potterers, acting from shared social knowledge, appear as cloddish and dull? As science education in the nineteenth century moved from a 'science of common things' — practical, related to agricultural and other trades, locally specific — to an abstract mental discipline functioning as a means of exclusion[8], is there perhaps a similar anti-democratic risk that technology might be defined according to an idealistic conception of design identified with a small specialist elite who do not get their hands dirty?

Technology as Social Practice

My criticism of the design emphasis in technology education has been in terms of its lack of fit with the majority of technological practice. Referring again to the reality of technology in the contemporary world, I now want to indicate phenomena which suggest an educational agenda of a different kind. These phenomena are the changes which *information* technology facilitates in production and organisation and in the nature of work, including technological work. Here I rely entirely on the accounts of other researchers, and in particular those of Larry Hirschhorn, Tessa Morris-Suzuki, David Lyon, and Robin Murray[9].

The first phase of mechanisation produced machines which would do the same job endlessly. Those in Henry Ford's Model T Factory could each do one job only. Adjusting the machines for a new process was a long and costly business: hence the importance in the Fordist factory of long runs of standardised products for a market which presented, or had to be persuaded to present, a uniform demand. A lot of expensive design went into the product and had to last a long time; but as the production run went on into thousands and millions of units the proportion of design cost to materials cost fell and fell. In contemporary jargon, the information content declined in relation to the materials content. Redesigning and re-tooling for a new product were forbiddingly expensive; the River Rouge plant was closed for nine months when production switched from the Model T. When the new run was short-lived, as with the Ford Edsel, the costs were immense. *Innovation* was thus a desperate last resort when all else had failed. The machines were rigid and inflexible because what they were to do was built into the very structure of cogs and cams which determined the direction and speed of movement.

In more recent machines, however, the parts may be individually controlled by separate power sources — electrical, hydraulic, pneumatic or whatever — which can be independently varied. 'What the machine does', therefore, is determined only within limits by its structure. The detail of its operation is governed by controlling the power sources, which may in turn be controlled by a computer program. Thus the information formerly built into the structure is now held separately from the machine, in easily modified computer software. General Motors, with the most up-to-date versions of the pre-computer machine tools, could, we are told, re-set a body pressing machine in eight hours. Nissan and Toyota, with CNC (computer numerically controlled) machines take one and a half minutes.

The post-Fordist factory (of which the best examples are not in car manufacturing but in other sectors, including clothing) is therefore able to switch production rapidly and without the necessity to follow up with a long run. Diversity of production lines and small batch production become possible. These also become necessary as the individualisation of needs and tastes, and the generating of new ones, are promoted in the consumer not only by advertising but by developments in the culture as a whole (including incidentally, English teaching, which from the 1960s encouraged students to identify, reflect on, and amplify whatever was unique and

different in their personalities and 'needs'.) Rapid change is the order of the day: four fashions each season instead of the former one. Firms keep ahead by constant innovation.

Technology, particularly information technology, both enables firms to innovate and helps them decide in what *direction* to innovate. The Italian clothing firm Benetton is linked by computer to its thousands of outlets so that trends in sales may be instantly translated into production specifications; goods are produced 'just in time' by hundreds of subcontracted small firms, and no money is tied up in stocks.

The firms which survive produce organisational structures and cultures to maximise the possibilities of fruitful innovation and rapid adaptive response. Features are: flattened hierarchies, lateral rather than vertical communications, networks rather than fixed structures and the instilling of a few simple corporate aims and ethics rather than long job descriptions and tight discipline. Ideas are sought from everyone, no matter what their status in the organisation. The post-Fordist firm learns from community groups, the Greens, and small cooperatives and guerrilla groups, and cares for its people more carefully than for its machines. Seek out 'the gold in the workers' heads' is the Japanese slogan.

Product development comes not only from the protracted design process of a separate R and D team, but also from constant small changes in the course of production: Scriven's inspired tinkerers have full scope again in the *adaptable* machines of the computer age. And whereas a snarl-up in the Ford factory was a disaster by causing costly delay, Japanese post-Fordist culture welcomes perturbations in the system as making possible the learning which will produce the next advance and a new competitive edge. The firm has become a learning organisation.

The emergence of the post-Fordist model is certainly uneven (food retailing is just, with Macdonalds, entering the Fordist stage) and there is no reason to believe that it will determine the shape of most work in the future. The account which I have just given is moreover undoubtedly an idealisation; the post-Fordist firm may simply have found new ways of exploiting its workers[10]. But whereas the phenomenon is not necessarily a cause for celebration it undoubtedly needs to be noted for the *different* opportunities and constraints it offers for people's working lives. Not the least of its significance is the suggestions it evokes by analogy for developments in sectors other than production, including education. It invites speculation, for instance, about the characteristics of a post-Fordist school and curriculum which, instead of depending on standardisation, fixed groupings and timetables, inflexible plant, rules and tests, prespecified knowledge, departments and hierarchies, would be responsive to individual needs, would shift groupings of both students and teachers opportunistically, would blur the distinctions between teachers and students and between both and others outside, would bring knowledge to bear at point of need in the context of specific tasks and would dissolve the barrier between productive work and learning. Learning styles like Andrew's would be with, not against, the grain of such a school.

There is more to be said about the worker and technology in the latest manifestations of the factory. Note that what we had in my description was not the dream of automation: the workers are still there. The dream has in fact never been realised, although it goes back a long way. Mechanisation aimed at machines which would work together without human intervention by natural laws, like the solar system; but machines go out of adjustment through wear and through changes in vibration, heat and so on, so that constant supervision and adjustment are needed.

Cybernation appeared to hold out the promise of a solution: the so-called 'error' from varying conditions was imported into the feedback loop and activated continually compensating movements. But removal of the workers again proved unattainable and is likely to remain so: the complexity of the systems led to new sources of error and unanticipated interactions. Misplaced trust in the autonomy of the system leads to Three Mile Island — and to a possible nuclear exchange.

In some of the most advanced factories, therefore, the place of human agency is accepted and the goal becomes to maximise its effectiveness. According to Hirschhorn[11], the 'post-industrial concept of work and technology' is that the machine is constantly *developed* by workers, through adjustments to the software, in response to mishaps. As the workers learn they incorporate their learning into the system. At the same time information technology provides the workers with the data, from sensors and from stored traces of past activity, to maximise their chances of pattern-spotting and of developing an intuitive gestalt *feel* for the whole of a complex system, just as the craft worker had a feel for the individual small machine. If the factory is a text, the worker is helped by the computer to read it, and then to write it. Thus 'post-industrial machine evolves' as the worker learns. Hirschhorn claimed in 1980 that in the US there were five hundred so-called 'sociotechnical' factories which ran on these lines, placing a premium on the capacity of the workers to develop the machine. He speculates that such regimes 'may help bring out in the culture a developmental concept of the self, a concept that leads people to seek out learning opportunities throughout their lives'.

Again, we can envisage parallel developments in schools, resulting perhaps in a curriculum which becomes progressively less opaque and arbitrary-seeming to the students as they are helped by supportive information systems to understand it as a whole, to find individual routes through it and

finally to customise it for themselves and have their customisation incorporated as resources available to all.

Rather than 'design capability', the essential core of the technology curriculum might be critical awareness of the role which technology is playing in changes in the economy and society — with emphasis on the critical. What tends to be promoted in and out of school is adulatory, social and apolitical hype about the coming 'information society'. The claims are about democratisation through universal online access to data and even to decision-making, decentralisation (go to the office via the modem while remaining in the bosom of your family in a rural retreat), and dispersal of power. The reality is that information technology is developed and promoted more for *military* purposes than any other, that databanks are controlled by the entrepreneurs and corporations who own the media, that IT enhances the power of the powerful to control and to exercise surveillance, that ethnic, class and gender differences, and on a global scale, North/South differences, are reinforced and that the 'electronic cottage' conceals the desperation, tedium and discomfort of VDU piecework compounded by the proximity of squalling kids[12].

What above all needs to be resisted is technological determinism, the belief that technology is an inexorable force in its own right, that its advance can only be accepted and that questioning it is luddism. It is a matter not of simply *resisting* but of understanding that technology is socially shaped and contestable: IT clearly has the *potentiality* to enhance either democracy or subjugation.

The critical tradition within the subject might make English teachers particularly effective promoters of the inquiry and appraisal which students need to undertake in relation in technology. The biographies and case studies which students construct as part of their English work might include tales of

self-fulfilment through technological activity and production but also those of marginalisation and alienation: people displaced from jobs by new machines, for instance, and the computer junkies and hackers for whom machines are a preferable alternative to people. English itself should use technology, and especially the word processor, but in this too should promote the critical attitude which is a vital part of technological education. How often, for instance, are students invited, after their introduction to word processing, to evaluate what it adds to *and takes away from* their capability as writers? And if a pair of jeans, a six-pack and other technological products are texts, shouldn't we be helping students to read them in the way that we help them read media?

Technology and Textual Practice in School

My final section can be no more than a brief note. Technology and textual practice come together in school in three ways. First, as I have suggested, students talk, read and write in the pursuit of technological activities. Any technological activity beyond the simplest depends heavily on language, a language very different from that which is practised and studied in English. Secondly, students ought as part of their technological education to generate texts *about* technology. They might do this in English, as well as elsewhere. Thirdly, a point I have hardly touched on and have space only to mention, computer-based technology is now transforming textual practice itself. Word processing, for instance, goes far beyond computerised typewriting and enables the rapid merging of multiple texts and machine-driven modifications of style. New forms of texts are possible, structured in layers or networks (hypertext) rather than sequentially. The dissemination of text online or on disks makes problematic the notion of publishing and enables 'readers' to make their own modifications of texts. Computer-generated text and computer translation raise questions about the association of language with human intention[13]. To offer students the experience of these new processes and, more importantly, the chance to reflect critically on their implications might well be seen as a central part both of technology education and of language education.

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6. It is of course significant that Andrew is a boy. In the research during which we met Andrew Dave Yeomans and I found very few girls on elective technology courses. The issue of technology as a masculine practice is a huge issue which I cannot begin to broach in this paper. The research is reported in Peter Medway and David Yeomans (1988) *Technology projects in the fifth year,* London, Manpower Services Commission.
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10. As Peter Watkins suggests in, for instance, 'Flexible manufacturing, flexible technology and flexible education: visions of the post-Fordist economic solution', in J. Sachs (ed) *Technology education in Australia.*
11. Hirschhorn, op cit.
12. Cf. Lyon, op cit.
13. There is a stimulating discussion of these issues by Richard Lanham (1989). The electronic word: literary study and the digital revolution, *New Literary History, 20 (2), pp.265-290.*