Values and design and technology

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VALUES AND DESIGN & TECHNOLOGY

Design Curriculum Matters: 2
David Layton

Department of Design and Technology
Loughborough University of Technology
Design Curriculum Matters

THE SERIES

The Department of Design and Technology publishes three Series:

Design Curriculum Matters
Learning Design: Occasional Papers
Design: Occasional Papers

The three are related, but each has its own focusing framework.

The focus of Design Curriculum Matters is the design curriculum, by which we mean not only the formal Design and Technology curriculum and its courses, but also the larger design dimension of pupils' experience both in and beyond school. Furthermore, the Series takes the position that any education system's formal design, (or design and technology, or technology) curriculum - including of course the National Curriculum version in England and Wales - is itself problematic and therefore a proper object for scrutiny.

More particularly, the subject matters of the publications in this Series include: the nature of design phenomena; the nature of the design capacity and its functioning; the relations between design and technology; design pedagogy: that is the teaching and learning which is intended to develop design and technological abilities; the developmental 'stages', the needs, the attributes, the aspirations, the hopes of those who are engaged in learning-through-designing; the diversity and, essentially, the constraining factors of educational institutions - with all of these being set in the cultures of Design and of Technology.

There is a need to develop an ideas and research culture in this area and, especially, one that would not be intellectually and conceptually limited by the boundaries and horizons of school subjects. There is a range of specialist communities, but their professional conversations and practices would benefit from a greater relatedness (which is not necessarily to say integration), as well as from attention to their research, scholarly, and theoretic underpinning.

The objects of the Series are to contribute to the knowledge and understanding of the design capacity and of how design and technological abilities are developed through teaching and learning. We take the view that much theory of a kind useful to practitioners derives from practitioners reflecting upon their practices as researchers: an essential object is to contribute towards a practitioners' theory. Such a practitioners' theory will, however, be supported and complemented by research and scholarship in fields other than those which are centrally implicated in areas of design and technology practice.

It is intended that this Series will make a major contribution to the development of a community of discourse and thereby to the development, more generally, of knowledge and understanding of the phenomena of design and designing.
VALUES AND DESIGN & TECHNOLOGY

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The occasion of the presentation of David Layton's paper was the 1992 International Conference on Design and Technology Educational Research and Curriculum Development held at Loughborough University. One of the Conference themes was 'Values in Design and Technology Education', and David Layton's Keynote Lecture attracted considerable interest.

One of the several reasons for this interest was that the paper was immediately recognised as a significant contribution towards addressing a familiar situation: that state of affairs, in schools and in conferences, in which individuals and groups speak about 'Design and Technology' but too often appear to make little or no contact with each other. There are some legitimate reasons for this absence of communication - aside from those which are less defensible, such as promotional rhetoric or special pleading. For instance, the field represented by Design and Technology relates to many differing specialist communities, each with its own traditions; its own agenda; and its own purposes. The lack of contact between such constituencies is hardly surprising; but it is nevertheless an illustration of a longstanding and damaging weakness in design and technological education.

David Layton offers categories that are helpful towards a better understanding of differing frameworks of reference and, hence, the differing value systems that influence design and technological activity. The use of these categories enables us to stand back from what may be our own partialities, and towards a more holistic conception of the diversity and complexity of the field and its associated educational practices. Further, the paper introduces distinctions between 'schools technology' and 'real world technology', and so points to underlying epistemological issues that have received remarkably little explicit attention by practitioners. The paper is a major contribution to the development of a larger professional discourse, the value of which development will readily be recognised by members of the specialist conversation communities related to Design and Technology education.

Phil Roberts
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VALUES AND DESIGN & TECHNOLOGY

DAVID LAYTON
EMERITUS PROFESSOR OF SCIENCE EDUCATION, UNIVERSITY OF LEEDS

KEYNOTE LECTURE, INTERNATIONAL CONFERENCE ON DESIGN AND TECHNOLOGY
EDUCATIONAL RESEARCH AND CURRICULUM DEVELOPMENT, 4 SEPTEMBER 1992,
DEPARTMENT OF DESIGN AND TECHNOLOGY, LOUGHBOROUGH UNIVERSITY OF
TECHNOLOGY

Introduction

I have to begin with a word of explanation about the scope of this talk because I have
had difficulties with it.

First, I have already spoken about Values in Design and Technology on several
previous occasions. That lecture has now been written up and published in a
Development Group. [1] Clearly, for an expert audience such as this, I cannot go over
again material which I have used before and which is now readily available in print.

Second, as I reflected on what I might say today, I found the ground was being
progressively cut away from under me by others. Ruth Conway and Anne Riggs
kindly sent me details of what they intended to do in this Conference, including the
material associated with the setting up of a special interest group on Values in
Technology, a development which I warmly applaud. Then Catherine Budgett-Meakin
thoughtfully posted me a copy of her paper on Values, scheduled for delivery a few
hours before mine.

I was immensely grateful for all this advance information, but it seemed that many of
the important things about the role of values in design and technology teaching had
already been said, or that claims on them were being staked by others. I began to
experience uncomfortable feelings of redundancy.

Fortunately, at this point I recalled a dictum of the philosopher of science, Sir Karl
Popper - one which, incidentally, deserves to be better known than it is. In his book
Objective Knowledge he wrote that:

Whenever a theory appears to you as the only possible one, take
that as a sign that you have neither understood the theory nor the
problem it was intended to solve. [2]

He was writing about scientific theories, of course, but, transposing, I concluded that:

If some views on values and technology appear to you as the only
possible ones, take this as a sign that you have neither
understood the relationship of values and technology, nor the
reason why an understanding of this is important.
Suitably challenged, I made a fresh start and I now come to the issue of values and technology from perspectives different from those I used before. Inevitably there is a little overlap, but I have tried to keep this to a minimum. Also, my talk today is less closely related than before to the detailed requirements of National Curriculum design and technology in England and Wales. Given that this is an international conference and that in any case our Technology Order is back in the melting pot, I hope this will not be seen as too serious a defect.

My argument, in brief, will be along the following lines. First, I will explore the way in which school technology is itself presently being shaped by a process involving some major value conflicts. I am not referring here to those territorial disputes between subject contributors such as CDT, Home Economics or Business Studies, but to some powerful external-to-school influences. I then turn to the practice of 'real world' technology where, I will argue, the need is increasingly being recognized to incorporate explicit value considerations, especially ethical and environmental ones. A question then arises about the extent to which 'school technology' must, or can, reflect 'realworld technology'. A central issue here is the relationship between science and technology. This raises another set of value considerations as well as pedagogical problems which, I contend, have not so far been widely recognised, much less attacked, in the implementation of school technology.

The social shaping of school technology

Those who advocate the inclusion of technology as a component of general education frequently refer to technological literacy as a desirable goal. Indeed, technological literacy has become an educational slogan of the 1990s.

UNESCO, in collaboration with ICASE (the International Council of Associations for Science Education) has launched a major project, 2000+, subtitled 'scientific and technological literacy for all'. [3] This is a follow-up to the very important World Conference on Education for All held at Jomtien in 1990.

In the USA, national Technological Literacy conferences have been held annually since 1986 [4] and a recent Yearbook of the Council on Technology Teacher Education bears the title Technological Literacy. The prevalence of the concept and of its undoubted ambiguities provoked a critical analysis of it in an issue of the Journal of Curriculum Studies [5] earlier this year. Incidentally, its usage is not confined to industrialised and high income countries. A recently established African association designed to help schools and other institutions strengthen their capabilities for innovative work is called the African Forum for children’s literacy in science and technology. [6]

I will return later to some value considerations arising from the persistent bracketing together of science and technology. At this point I want to concentrate on the politics of technological literacy.

The role of ambiguous concepts in the initiation of educational reforms is, of course, well known. Think of 'discovery learning', 'science for all' or even 'National Curriculum'. Each in its different ways is capable of multiple interpretations. Indeed, this is their strength as prime movers of educational bandwaggons. Different
constituencies see in the proposed reform something which may serve their particular ends and hence they lend support to it. It is only when the innovation becomes operationalised in specific classroom or workshop practices, when the definition becomes more precise, that advocates turn into critics and devotees begin to transfer allegiances.

Technological literacy is no exception to this general picture. It is the site of current conflicts over meanings to be attributed to the slogan. The politics of technological literacy - who creates and controls the meanings of the phrase, how the imposition of meaning is achieved - is a central concern of technology education today and is inescapably rooted in value considerations.

Figure 1. Stakeholders in the socio-political shaping of school technology

Figure 1 is an attempt to identify and label some of the principal agents involved in the socio-political shaping of school technology and I now comment on these in turn.

1 Economic functionalists

Representatives of this category take a very instrumental view of education with national economic competitiveness and wealth creation the sovereign values. Their views are exemplified in publications on pre-vocational schooling from the UK National Institute of Economic and Social Research. [7] For them, school technology
should lay the foundations of knowledge and skills for future training, particularly in relation to intermediate vocational qualifications. They support their position by evidence of the higher productivity of our Western European competitors in the field of manufacturing industry. This is related to a substantial shortfall in the UK workforce of those holding vocational qualifications at the intermediate level (Table 1). Studies of matched manufacturing plants in Germany and Britain have been undertaken to illustrate how a better qualified workforce contributes to higher productivity (Table 2).

Table 1  Vocational qualifications of the workforce in Britain, the Netherlands, France and Germany, 1985-89

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<td>20</td>
<td>44</td>
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<tr>
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<td>63</td>
<td>38</td>
<td>26</td>
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Table 2  How a better qualified workforce contributes to higher productivity

- greater flexibility of the workforce, permitting the production of more complex products, quicker change-overs, and fewer relief personnel;
- better maintenance of machinery, leading to fewer breakdowns, and making it worthwhile to link successive machine operations via transfer devices;
- detection by operatives at an early stage of incipient faults in machinery, and arranging for adjustment before an actual breakdown occurs;
- less faulty work and less re-making; better production scheduling, and delivery on time.
Viewed from this perspective National Curriculum technology is judged to be deficient on several counts; it is too broad in scope; it places too much emphasis on designing activities and their 'verbalisation', at the expense of planning and making; and the level of craft skills which it is possible to achieve is too low. It is alleged that many practically minded children will be frustrated and demotivated by this poor foundation for future vocational qualifications. Comparisons with Continental approaches to technology teaching in vocationally oriented secondary schools suggest that a third of Continental 16 year-olds are 1-2 years ahead of their British counterparts'.

As for remedies, the economic functionalists favour greater choice in curricula for 14 to 16 year-olds (the key stage on which they concentrate almost exclusively), including the availability of courses with 'a heavier vocational and technological component'. The superiority of the attainments of Continental pupils is also attributed in part to more homogeneous teaching groups than exist in English and Welsh schools. 'Technological' and 'vocational' become almost synonymous terms for the economic functionalists.

2 Professional technologists

Recent publications of the UK Engineering Council provide examples of views which are typical of this constituency. The dominant value concern is one which reflects the need to overcome 'society's limited perception of engineering' and to enhance the professional image of technology (or, more precisely, engineering). [8] The importance of rigour, working to industrial standards of quality, the acquisition of knowledge in mainstream engineering areas and the development of a high level of constructional and other skills all feature. Particular emphasis is placed on engineering as 'a major wealth creator' for the country and a provider of services and systems essential to a high quality of life.

From this standpoint, National Curriculum technology is too ill-defined; it is said to be little more than generalised problem solving without any distinguishing knowledge and skills. It lacks identity. An Engineering Council report in 1992 on Technology in the National Curriculum. Getting it right opened with the words 'Technology in the national curriculum is a mess' and claimed it needed rescuing.

As described, the salvage operation would entail delimiting the scope of school technology, first by distinguishing and separating it from vocational education and 'basic life skills'. (One example given of the latter is the ability to 'use a computer and word processor' - for what purposes is not stated. The loss of the computer for modelling and for control in design and technology tasks, to mention just two functions, would be a severe and damaging limitation indeed on school technology.)

More positively, the report suggests that school technology 'should centre on technology as it is commonly understood and is represented in higher education and employment'. The interpretation to be given to this prescription is made clearer by a listing of knowledge areas and skills drawn from the Engineering Council's own Technology Enhancement Project for 14 to 19 year olds. Teaching modules have titles such as Manufacturing Engineering, Structural Engineering, Basic Electronics, Control, Mechanical Engineering and Electrical Engineering. The analytic study of commercially successful examples of good engineering is commended; the Kenwood
Food Mixer, the electric hover mower, the personal stereo and the fork-lift truck are stated to fall in this category. The assessment arrangements associated with school technology should reflect the high priority to be given to 'planning and making' and the present four attainment targets for design and technology should be differentially weighted accordingly or reduced in number.

3 Sustainable developers

A value position which is encapsulated in the phrase 'global responsibility' unites the diverse representatives of this category. Prominent among them would be the Intermediate Technology Development Group associated with the name of E.F. Schumacher, the economist who wrote Small is Beautiful [10] and who coined the phrase 'technology with a human face'. The various Appropriate Technology and Alternative Technology agencies would also be included.

For them, technology education should empower people with the knowledge, skills and values needed to undertake and control technological developments with the aim of achieving an acceptable quality of life not only for themselves, but for succeeding generations, North and South. Gro Harlem Brundtland's interpretation of sustainable development -'a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future as well as present needs' [11] - is central to their beliefs and actions.

Their response to National Curriculum technology has, on the whole, been favourable. They see the Order as providing good opportunities for the incorporation of work on the lines they would wish to see in teaching at all the Key Stages. It has to be recognised, however, that the compatibility of the value position of the sustainable developers with that of the economic functionalists is a central concern in the 'real world' of technology today. Can commercial objectives be reconciled with the needs of the environment and the developing world? [12] The same tension afflicts the design of a technology curriculum in the context of general education.

4 Women

It may seem far-fetched to designate women, constituting almost 3 billion persons, as a single constituency engaged in the social shaping of school technology. Of course, in any collective and concerted sense, they are not. Increasingly today, however, women's distinctive perspectives on technological activities are commanding attention. Since its formation in 1976, the interest group WITH (Women in Technological History) in the Society for the History of Technology has been the source of important publications on the relationship between women and technology. [13] The more recently created Institute on Women and Technology in the USA argues that although women have never lived without technology, 'we have barely a toehold in the discourse and direction of it ... We have been robbed of the history of female technical initiative, imagination and invention. We have lost our place in defining and shaping technology'. [14] The aim of the Institute's members is to reconstruct women's place in technological developments and 'to advocate for technology that... empowers women intellectually, financially and politically and that sustains the natural world'. Specific Third World developments, often consequences
of the new economic doctrine that educating females is one of the best investments a country can make, have focused on the role of women, especially those in rural areas, in utilising and contributing to the design of technological innovations. [15]

Within the field of education, international conferences on Girls and Science and Technology (GASAT) have been held regularly since 1981.

A dominant value position associated with women in relation to technology is captured by Ursula Franklin in her Canadian Broadcasting Corporation Massey Lectures when she argued that

The great contribution of women to technology lies precisely in their potential to change the technostructures by understanding, critiquing, and changing the very parameters that have kept women away from technology. [16]

The following passage provides an illustration of her point. She writes:

A common denominator of technological planning has always been the wish to adjust parameters to maximise the efficiency and effectiveness. Underlying the plans has been a production model, and production is typically planned to maximise gain. In such a milieu it is easy to forget that not everything is plannable. Actually, most things are properly described by a growth model - and that means many activities of living - and are ultimately not plannable. A quick example from my own experience. Although I was intellectually quite well prepared for the birth of my first child, I was stunned by the degree of randomness that this event created in my life. It took me a while to understand that it was pointless to plan my days the way I used to. This did not mean that I didn't plan or prearrange, but that I needed different schemes to deal with the unplannable.

Women in particular have developed such schemes over the centuries - arrangements that are not a surrender to randomness, but an allotment of time and resources based in situational judgements, quite akin to what I described earlier as the characteristics of holistic technologies. Such schemes require knowledge, experience, discernment, and an overview of a given situation. These schemes are different in kind from those of prescriptive planning. What makes them so different is that holistic strategies are, more often than not, intended to minimise disaster rather than to maximise gain. [17]

Approaching the question of values, and particularly moral values, from quite a different perspective, and not with technological contexts specifically in mind, Carol Gilligan has arrived at conclusions which likewise have significance for technology education. Her empirical studies of the ways in which men and women develop conceptions of self and make judgements and act in situations of moral conflict and choice indicate that women bring to life experiences a different point of view from men and order their lives in terms of different priorities. For the women she studied,
moral problems tended to be constructed as problems of care and responsibility in relationships. For men, moral problems were constructed more as problems of rights and rules. Similarly, relationships for women were structured as a world of webs, in contrast to men for whom relationships were set in a world of hierarchies. [18] Whilst this bald summary does not do justice to the subtlety of Gilligan's account of the differences between women and men, and especially the developmental aspects of this, it perhaps suffices to indicate a further dimension of the value position which girls and young women bring to their technological experiences.

For women, then, technology education should help to counter gender biases that have been incorporated in present day representations of technology and it should enable girls to incorporate women's values in technological activities. Viewed in this light National Curriculum technology, by virtue of the breadth of outcomes and contexts of working, is judged to be a significant step in the direction of providing opportunities for girls to define technological challenges, and to respond to these, on their own terms.

5 Liberal Educators

In contrast to those who require design and technology to serve external goals, the liberal educators see the nature of the activity itself as providing its ultimate curriculum justification. Their allies are philosophers of technology and social scientists who research into the nature of technology. Interestingly, some of them are to be now found emerging from the previously dark waters of vocational education.

Their value position is that education should initiate children into the symbolic worlds we have created; it should help them to construct and control these symbolic worlds, one of which is technology. (There are echoes here of Howard Gardner's theory of multiple intelligences: as well as technology, the symbolic worlds include those of language, mathematics, music and science.) [19]

Expressed differently, an epistemology of technological knowledge is now available to be drawn upon and we have come to recognise technology as a unique and irreducible cognitive mode. Technological knowledge is knowledge which is structured by the tension between the demands of functional design, on the one hand, (i.e. it must enable us to achieve some purpose) and the constraints of the context of working, on the other (i.e. deadlines, cost limits, ecological requirements, ergonomic considerations etc.). [20] It is characterised by particularity, uniqueness and concreteness.

According to the liberal educators, all children have a right to experience this unique style of human activity and hence technology education should enable children to construct, appreciate the distinctive qualities of, and work effectively with technological knowledge. In so doing, they will become acquainted with traditions of operating in relation to different kinds of design and technology problems, both in other cultures and in other times. They will encounter both the ingenious and the imaginative in their progressive development of standards of quality in the performance of design and technology tasks and a bank of resources to sustain their own capability.
From this standpoint, National Curriculum technology appears to be at least on the right lines. Its emphasis on design, on the holistic nature of technological activities, and on design and technology in historical and multi-cultural contexts provides a framework of opportunities for teaching and learning to take place in ways which could satisfy the criteria of the liberal educators.

To a degree, all enacted curricula are the result of the interplay of diverse influences such as those flowing from the five value positions reviewed above. In this sense, technology is no different from any other school subject. Those engaged in the construction of school technology are left, nevertheless, with a design problem that has many features of a typical design and technology task. How can we reconcile these different value positions? How can a design and technology curriculum be devised which will satisfy this varied collection of stakeholders? Specifically, is it possible to conceive a technology curriculum shaped by economic imperatives, which simultaneously would be acceptable to sustainable developers and liberal educators? Even more to the point, where does power reside in relation to the setting of priorities on the different value positions? And if, pessimistically, we see the locus of power as being remote from classrooms, workshops and those who work there, how skilful can teachers and others be in identifying degrees of freedom in the system and exploiting these to ensure a technology education which is well matched to students' abilities and aspirations as well as to the expectations of interest groups elsewhere?

One of the dangers facing school technology today is that it will be shaped too exclusively by economic values. This danger stems in part from the vocational origins that technology in general education has had in many countries; in part, from the pressures on schooling to service the economy in a period of deep recession (as the saying goes, education is an ornament in good times, a refuge in bad); and, in part, from alliances forged to elevate the status in society of activities like engineering which, in our Anglo-Saxon culture at least, have historically been deemed inferior to basic science and which now appear to have a chance of showing how economically useful they really are. To grant economic imperatives an overriding influence on school technology would be to sanction a curriculum which sold children short and failed the future. Equally, to ignore them totally would be to risk having no future, or, at best, one of inferior quality.

Technology and values

I turn now from school technology to technology as it is practised in the 'real world'. It is sometimes argued that 'real-world' technology is neutral or value-free. It is the use made of the technology that determines whether it is 'good' or 'bad'. For example, it is said that an axe, as artefact, is neutral; it can be used either constructively or destructively. Similarly, a motor car can either save life (an ambulance) or destroy it (joyriding).

Whilst this argument might seem plausible, it does not stand up to close scrutiny. The neutrality of the artefact becomes less obvious if the example is changed, for instance, to a gas chamber or a thumbscrew. It is always difficult to isolate the material artefact from the network of human activities in which it is inextricably enmeshed - and hence from the values of people. Also, an artefact - such as a motor car - can reshape people's values and call new ones into play. It makes possible new
kinds of actions between which people have to choose; they are inexorably driven into the realms of value judgement. The essential point here is that technological innovations alter the circumstances in which our choices have to be made. The availability of the chainsaw opened the way to rapid deforestation, with accompanying economic gain, but this was often achieved at the expense of ecological balance and the loss of rain forests. Because it created the new possibilities for action, can we call the chainsaw 'neutral'? 

More obviously, the conception and realisation of a technological product entails value judgements about what is worthwhile as an outcome. In the view of the historian of technology, David Noble,

> technology bears the social 'imprint' of its authors ... there is always a range of possibilities or alternatives that are delimited over time - as some are selected and others denied - by the social choices of those with the power to choose, choices which reflect their intentions, ideology, social positions and relations with other people in society. [21]

Writing with the experience of technology transfer from industrialised to Third World countries in mind, Susantha Goonatilake goes further, describing technology as a social gene, a carrier of social relations from one society to another, which recreates in the recipient culture aspects of the social system of the donor.

> Technology [he argues] is a transmitter of social relations between social systems. In being adopted by its new host, it 'takes' elements from its new environment - hardware and knowledge as well as human operators - and rearranges them so that not only does it perform its technological function but also recreates aspects of the social system of its place of origin. It is thus like a virus, which enters a host cell whose component material it uses for its food as well as to reproduce itself. [22]

Goonatilake overstates his case because there are well-documented accounts of imported technologies being re-shaped to fit their new contexts. Nevertheless, examples in support of his thesis are not difficult to find, one being provided by the effects of the so-called green revolution in agricultural technology in Asia.

American inspired research had produced hybrid grain seeds which gave crops of outstanding yields. The transfer of these cereals to India, especially following the severe droughts of the mid-1960s, undoubtedly contributed to increased grain output. The use of the seeds, however, was only effective in conjunction with the application of chemical fertilizers and pesticides, and often required electric pump-driven irrigation systems. Also, new seeds had to be purchased each year. The capital intensive nature of the green revolution made it of most benefit to those with large farms; the already prosperous grew more so, whilst the technology remained out of the reach of smaller and less well off farmers. Goonatilake's conclusion is that the technology of the green revolution was far from being 'neutral'. It was 'formed and governed by the social and economic conditions specific to the US of the time' [23] and it tended to reproduce these in its new contexts. For him, technology 'is history
and social experience in concentrated form'. The values and relationships of a society at a particular time become encapsulated in its artefacts.

This is similar to David Noble's conclusion derived from a detailed study of the development of automation in the US machine tool industry. Because of its very concreteness, people tend to confront technology as an irreducible brute fact, a given, a first cause, rather than as hardened history, frozen fragments of human and social endeavour. [24]

It could all have been different. Other options were available. What we encounter today is the result of decisions which reflect the value judgements of those who shaped a development which was in no sense inevitable.

Accepting that there is social determination of technology in this way, it is nevertheless the case that simple observation of an artefact does not usually allow us to discern the inherent values directly. Values - technical, social, political, economic, aesthetic, environmental or ethical - do not stand out on the surface of, say, a telephone handpiece, a hair drier or a torch. Much of the previous talk on values in design and technology which I gave was concerned with ways of uncovering the values within technological products and reviewing ways in which value conflicts - ecological benignity vs. economic efficiency; aesthetic appeal vs. safety considerations - had been resolved. Viewed from the perspectives of adoption (what determines whether a technology becomes widely used), obsolescence (what determines whether a technology is abandoned) and technology transfer, 'hidden' values become visible and can be clearly seen to play a critical part in the life of a technology. [25]

There is, however, another and disturbing aspect of this relationship between values and technology. True, value judgements do influence technological developments; they are in a sense the engine of design and technology, initiating and shaping activity as well as pointing to the way ahead. But it does not follow from this that technology is totally under human control. Indeed, the counter proposition in its extreme form argues for technological determinism. It maintains that technology has become autonomous, a force which - Frankenstein-like - has now taken over. Far from being society's servant, technology is society's master, increasingly shaping our destinies in ways which seem inevitable and irreversible. We are progressively being manoeuvred into ways of acting - both in the home and in employment - which are not of our deliberate choosing, but which are dictated by the technologies we have ourselves created. Far from our values shaping technology, technology is shaping our values.

Even if we baulk at the prospect of extreme technological determinism, there is general agreement that the full extent of the social and other effects of technological innovations is difficult if not impossible to predict. Technology frequently seems to lead a double life: whilst it can fulfil the most exorbitant intentions of its practitioners, such as landing a man on the moon, it also and simultaneously produces unintended outcomes. Medical technologies have reduced the death rate in developing countries, but have also contributed to uncontrollable population growth. Food production has become more efficient through genetic and chemical technologies,
but often at the cost of damage to related ecosystems. No one planned or wanted the effects that PCBs have had in food chains and no one intended to create a hole in the ozone layer.

In an attempt to exercise greater control over the effects of technological developments, a new branch of study called Technology Assessment has come into being and concern over the control of technology has been one of the strongest motivations for increased efforts to understand the nature of technology. But charting the possible outcomes of technological innovations is of limited use without a means of deciding on 'good' or 'bad'. Accordingly, we have a renewed search for what the philosopher Hans Jonas terms 'an ethics for the technological age'. In his book, *The Imperative of Responsibility*, he argues that

> If the realm of making has invaded the space of essential action, then morality must invade the realm of making, from which it has formerly stayed aloof, and must do so in the form of public policy. [26]

In other words, technology is now inextricably linked to an ethics of responsibility, which cannot remain only at the level of the private individual, if we are to avoid self-destruction and disaster.

I have been much struck by the revival of concerns about values, and ethical values in particular, in the recent literature of science and technology. At school level this has, perhaps, been a more prominent feature in material from Asian and Pacific Rim countries than in Western curricula so far. [27] But it is increasingly becoming a feature of prescriptions for technology, worldwide. The report of the ASCEND 21 Conference (ASCEND 21 is an acronym from Agenda of Science for Environment and Development into the 21st Century) organised by the International Council of Scientific Unions (ICSU) in November 1991 contains a long chapter on Policies for Technology. Among recommendations for needed research is one calling for 'a wide review of environmental ethics' and Professor M G K Menon, the President of ICSU, in his opening address, emphasised strongly that moral resources were needed, no less than physical ones, if we were to avoid disaster and achieve a just, long-term social order, sustainable in both North and South. [28]

Of course, conference resolutions and words alone will not bring about change. Amongst the various available instrumentalities, education clearly has an important role to play. It is vital that representations of technology in school curricula should incorporate value considerations both as a reflection of what is happening in 'real world' technology and in order that the future practice of 'real world' technology should not be able to ignore them.

'School technology' and 'real world technology'

I want now to bring together the two strands of ideas relating to values in 'school technology' and 'real world technology' with a view to focusing on one important node of their interaction.
The extent to which 'school technology' ought to, or can, mirror 'real world technology' is clearly debatable, and much turns on what is taken to count as the 'real world' category. However, a few general points can be made.

Much 'real world' technological activity has involved the incremental and progressive improvement of existing artefacts and systems, as well as the development of new uses for them. By analogy with Thomas Kuhn's distinction between 'normal' and 'revolutionary' science, such work might be described as 'normal technology'. [29] The quest for gains in artefactual characteristics such as speed, power or efficiency has been undertaken within a constraining paradigm of decisions already taken about operational principles and configurations.

Aeroplane design provides a ready illustration. The operational principle here derives from the fact that the flow of air over the top surface of a moving, curved aerofoil is faster than that over the lower surface. As a result, the pressure of air below the wing is greater than that above and this 'lifts' the wing. The familiar configuration to put this into effect is the tubular body with engine forward, tail aft and lateral wing planes. In terms of this operational principle and this configuration, much 'normal technology' can take place to improve, for example, the safety of the landing system or the efficiency of the engines. However, alternatives exist to both the operational principle and the configuration of the aeroplane. The helicopter flies without wings and, in the case of vertical take-off and landing aircraft, the engine may be in the tail. [30]

If incremental improvements, or extended applications, within a technological tradition, embodying continuity of practice in design and making, constitute 'normal technology', then artefactual discontinuity, the result of radical innovation in design conception and realisation, is what corresponds to Kuhn's 'revolutionary science'. The history of technology shows that increasingly, and especially in modern times, an important source of innovatory principles for revolutionary technology has been scientific knowledge. Examples are plentiful, ranging from thermal imaging devices used in rescue operations, magnetic resonance imaging (MRI) and positron emission tomography (PET) for medical diagnosis, to non-lethal 'microwave bombs' which will destroy computer circuits and telephone systems in a city block without killing their operatives.

Whatever form school technology takes - whether 'normal' or 'revolutionary' (and there is nothing in the Order for Technology to prevent either interpretation in schools in England and Wales) - it is important that the resources of science are accessible to and exploited by it. The relationship between science and technology in both academia and industry is now so intimate that they can almost be regarded as one enterprise, or, at least, as two fields of endeavour in very close, symbiotic and synergistic relationship. A 'school technology' which was not intimately related to 'school science' would fall short of 'real world technology' in disabling ways.

I must make clear what I am talking about here when I refer to the relationship between 'school technology' and 'school science'. I am not alluding to courses on science and technology where the prime aim is the learning of science and the technological applications are added to motivate students and stimulate their interest. Nor am I thinking of courses on the science of technology in which a technological application or context is the starting point and, out of this, scientific concepts or
principles are extracted. Again, the main aim is the learning of science and the technology is an aid to this.

What I am considering is science for technology, where the science is a resource, servicing the main aim, which is the development of children's technological capability. One aspect of National Curriculum design and technology which is a cause for serious concern is the lack of articulation with science and the limited extent to which science is being used by pupils in their design and technology activities. In fact, the situation predates National Curriculum technology and cannot be blamed entirely on the Order of 1990, although this did not help. In the national evaluation of the TVEI Curriculum in which I and colleagues at Leeds University were involved, we paid particular attention to developments in technology, but found, for example, little connection between the science which students had studied and the work they did on their extended technology projects in year 11.

There may be good practical reasons why this lack of co-operation exists, some of them specific to particular school situations. But there are also some more general ones and it is to these I wish to direct attention because they relate directly to the question of values.

I cannot do better here than to quote the words of a distinguished American historian of technology, Hugh Aitken, writing about the origins of radio - how the theories of Clerk Maxwell, the experiments of people like Hertz and Oliver Lodge, and finally the practical contributions of Marconi, yielded the device from which modern radios developed. What he says is this:

> Information that is generated within one system exists in a particular coded form, recognisable by and useful to participants in that system. If it is to be transferred from one system to another - say from science to technology... - it has to be translated into a different code, converted into a form that makes sense in a world of different values. [31]

In other words, knowledge that is constructed by scientists in their quest for understanding of natural phenomena is not always in a form which enables it to be used directly and effectively in design and technology tasks. This is because the value systems of science and technology are different, the former being characterised by concerns for generality and comprehensiveness, the latter by particularity, specificity and the uniqueness of contexts. As a result, the design parameters in terms of which technological activity has to take place do not always map neatly and precisely onto the parameters and concepts in terms of which scientific knowledge has been constructed.

This contrast between the detailed specificity and design functionality of technological knowledge and the abstract generality and design-unrelated nature of scientific knowledge is well illustrated by consideration of the steam engine. The practical task of designing and building a simple Newcomen engine to perform a prescribed amount of work in a particular context would entail taking decisions about variables such as the diameter and length of the steam cylinder, the length of the piston's stroke and the number of strokes per minute. Sub-tasks would have to be
accomplished, such as the construction of something like a stuffing box to prevent escape of steam while the piston was being driven upwards, at the same time permitting the piston rod to pass and repass. Some means of condensing the steam would be necessary to allow the downstroke of the piston and the resumption of the cycle. Preferably - as James Watt realised - this should not cool the cylinder and piston; otherwise, heat would be needed to restore the temperature before steam could drive the piston up again. Safety and other valves would have to be designed and positioned, and materials chosen for the construction of the various parts of the engine.

These and related considerations were the preoccupations of those who laboured to build and improve steam engines that would pump water from deep mines and, later, drive ships, railway engines and factory machinery in the early 19th century.

In sharp contrast to this, Watt's younger contemporary across the Channel, Sadi Carnot, was searching for principles which were, as he put it,

applicable not only to steam engines, but to all imaginable heat engines, whatever the working substance and whatever the method by which it is operated. [32]

The universal insights which Carrot achieved laid the foundation for the branch of science known as thermodynamics. They prescribed the conditions for the most effective operation of a heat engine, irrespective of working substance. However, on their own, the rarefied and design-unrelated nature of his conclusions, as Carrot himself acknowledged, would not have been of much immediate value to those building an engine. His scientific knowledge needed to be integrated with other kinds of knowledge and suitably transformed to realise its potential in the world of practical action. At the end of his famous Reflections on the motive power of fire and on machines fitted to develop that power, when discussing the extent to which the steam engines of his day were able to make use of the energy which, theoretically, was available from the coal burnt, he wrote:

We should not expect ever to utilise in practice all the motive power of combustibles. The attempts made to attain this result would be more hurtful than useful if they caused other important considerations to be neglected. The economy of the combustible is only one of the conditions to be fulfilled in heat-engines. In many cases it is only secondary. It should often give precedence to safety, to strength, to durability of the engine, to the small space which it must occupy, to small cost of installation, etc. To know how to appreciate in each case, at their true value, the considerations of convenience and economy which may present themselves; to know how to discern the more important of those which are only secondary; to balance them properly against each other, in order to attain the best results by the simplest means; such should be the leading characteristics of the man called to direct, to co-ordinate the labours of his fellow men, to make them co-operate towards a useful end, whatsoever it may be. [32]
It would be difficult to better this as an account of the technologist's task of resolving considerations which may often be conflicting. The adaptation and reformulation of theoretical knowledge from science in order to produce technological knowledge for practical action are not matters which so far have seriously occupied school teachers of science and technology. The point of this brief consideration of what is involved is that these tasks will need to be addressed if school technology is to achieve its full educational potential and the two value systems of science and technology are to be brought into a fruitful relationship. [34] A first step in this direction is a clear recognition of the natures of the value systems we are dealing with. Beyond this, I hope I have been able to make it clear that the Special Interest Group: Values in Technology, under the auspices of DATA and launched here at IDATER 92, has a fascinating and challenging agenda awaiting it.
REFERENCES


17 Ibid, p 83. Dr Franklin, Professor Emeritus at the University of Toronto, is an experimental physicist who worked in the Department of Metallurgy and Materials Science there. She is an Officer of the Order of Canada and a Fellow of the Royal Society of Canada.


23 Ibid, p 136.


25 D Layton, 1992. op. cit. (see note 1 above)


33 Ibid, p 59.

34 For more detailed considerations of the relationship between school science and school technology see:

