Technology education in secondary schools

Christopher Norman Lee France

Technology Education in Secondary Schools.

Christopher Norman Lee France.

Abstract.

The author outlines his background and refers to current relevant attitudes.
He considers changes which have influenced the curriculum for manufacturing in resilient materials in schools.
The word 'technology' is currently in common use. Having examined a range of sources for common themes, the author synthesises a definition and examines some implications.
He uses the example of the development of the electronic computer to illustrate the difference between science and technology before arguing that 'new technology', in schools, properly belongs within the framework of 'Craft Design & Technology' (CDT).
Using references from industry, education and elsewhere, he describes the process of designing and upholds its predominance as a skill to be fostered. Arising from its cyclic nature are implications for the assessment of performance.
As labour saving devices, windmills and robots are widely separated by time but both require control and the author seeks to explore this link. The components of control are also identifiable in the work of pupils over many years. He contrasts industrial robots with those of their prophets.
The need for a review of the education service was established in 1976. The consequent chain of political initiatives in Britain is described highlighting the nature of politics. He considers a case history when those who 'do' become championed by those who 'would have it done'.
Durham Local Education Authority's progress in CDT in-service training is described and the world of 'lower school' technology is explored by considering both pupil and updated teacher.
The author describes industrial reality and intimates a curriculum possibility - the design, by lower school pupils, of automatic systems.
He sees the computer in the CDT curriculum both as design tool and as part of solutions to human needs.

TECHNOLOGY EDUCATION

in

SECONDARY SCHOOLS

CHRISTOPHER NORMAN LEE FRANCE.

B.A.(Hons) A.Dip.Ed. Cert.Ed.

A THESIS BY RESEARCH

for the degree of

MASTER OF ARTS IN EDUCATION

at the

UNIVERSITY OF DURHAM

SCHOOL OF EDUCATION

JANUARY

NINTEEN HUNDRED AND EIGHTY EIGHT

The Law of the Hammer:

'Many of our assumptions regarding the use of computers are not explicit. One of these assumptions operates in a manner similar to the "Law of the hammer" which has been around for many years. The statement of the law is (roughly), "If you give a hammer to a two-year old, suddenly a lot of things will need hammering." If you change "hammer" to "computer", "two-year old" to "educator" and "hammering" to "computing", you have a description of the effect.'

R.G. Ragsdale.(1)

1. Lewis R. & Tagg ED. (editors) 'Involving Micro's in Education'. North Holland. 1982.

CONTENTS.

DECLARATION.

This is to certify that none of the material offered has previously been submitted by me for a degree in this or in any other university.

Signature ____________

Date 29/2/88

STATEMENT OF COPYRIGHT.

ACKNOWLEDGEMENTS.

If my parents, Annis and Norman, had not enabled me to play with tools when I was too short to see onto a bench, I would never have made the aeroplanes, liners, rockets and other useful devices out of nails, string and other bits and pieces that I did. If Ivor Jones and Jeff Crouchley had not impressed me with their love of materials, pride in skill and the beauty of precision at Stand Grammar School, I would never have wanted to teach. And if the sixth form curriculum had not forced me to take Maths and Physics with Engineering Drawing I would have been a better craftsman. Godfrey Beaton at Alsager taught me to respect history through his understanding of the craftsmen of Old England. Without the Open University I would have continued to prove the rest of my teachers right and I would not have had access to the broad picture of the Man-made World. It took Tom Guyer and Graham Fielder, at Durham University, to provide the spark which eventually fused this last to my work in school and Kenneth Ibbotson, Advisor to Durham Local Education Authority, supported and encouraged the link. To John Mills also go my thanks, not only for his example over countless hours in questioning the apparently unquestionable but also, for reading through the first draft before continuing to practise what he preached.

No one person provided sufficient individual stimulus for this thesis, but it is an inescapable fact that for

personal, professional, and political reasons the Department of Education and Science was the closest to such an entity. There is no higher education authority in this land and since the attitudes of a nation in the future are the product of its current education service, it behoves those so entrusted to know exactly where they are going - and to be sensitive to feedback. Without the current attitude of this nation towards designing and making, spawned and nurtured by our politicians, media, sleeping partners, financial consultants, comedians and not forgetting the manufacturers of white coats, this exercise would never have been undertaken.

One who has not undertaken research whilst working full-time cannot appreciate the effect it has upon ones spouse - unless that person is such a spouse! My grateful thanks and appreciation therefore go to Joan for her support, encouragement and - above all - patience.

To Steven and Caroline, may I say that the man who sits and types, is your father, and if you had insisted in playing everything to the limit, the work could never have been done.

Thank-you, all.

Chris France.

24-12-87.

1. INTRODUCTION.

This thesis was originally intended to be the written report of a two year research programme in the area of Computer use in Secondary Education, but the progress of my research soon began to be require an understanding of a wider historical context into which both education and computer use can be fitted.

I have spent twenty years teaching in what was once called secondary and subsequently known as comprehensive education, and for all of that time I have been responsible for the content of that part of a school curriculum associated with work done in workshops and drawing offices.

The work both of my pupils and my department colleagues has never been regarded by the rest of my colleagues and others, both within and without the profession, as 'academic' in the sense that the word might be used to describe one who never produces tangible, working products. A situation which I have always found philosophically satisfactory after having quickly recognised that to become an educational icon one must first attain the status of the academic.

The product of these last two or so years research is this thesis, and it would be both insensitive and wrong to try to argue that a thesis on paper is neither tangible nor of use to others. For me however, the justification for the whole project lies in the production of a curriculum package which embodies to a most considerable extent the philosophies and practical directions which emerged from my researches. In this respect I believe that my attitude to my curriculum area has not been compromised in that the more usual alternative, to have produced a lengthy, wordy - indeed 'academic' - document, whose only future would be to collect dust whilst statically loading a bookshelf, has been resisted.

We are all aware, to a greater or lesser extent, of the changed products of man's ingenuity. Whether through their intended advertised presence by television, radio and printed promotional materials, or by the more informal routes of gossip, observation and the television documentary, the citizens of this nation appreciate the difference between current products and those of the days of their parents and grandparents.

The computer is but one example of that group of currently available products for which it is difficult even to find an old-fashioned version which was available to our fore-fathers. The automatic washing machine which incorporates a tumble drying facility is an example of the other, much larger group, which fulfil a need, long recognised and previously catered for, but now incorporating a higher degree of perceived efficiency.

One of the questions which sprung to my mind some time ago had to do with the products which schoolchildren were making in their workshops. Did they reflect these changes to the same degree, and would it be possible to effect changes without losing sight of the long established belief in a broad educational experience for children?

I saw the opportunity afforded by Durham University School of Education to broaden my knowledge of 'New Technology', to bring up-to-date my awareness of educational thinking and to develop or create a relevant educational package which would be of practical use within school. I wanted the package to reflect the current state of educational thought and to embody techniques typical of current technological development.

As I write, in 1987, the Education service in England and Wales is in a state of turmoil. On the one hand, there have been a number of Educational initiatives instituted by Her Majesty's Government over a period of ten years, initiatives resulting from it's perception of the changes 'New Technology' has made to our society. The government, however, is a body which has, at present, no direct way of influencing the content of the curriculum of the schools.

On the other hand, many teachers have become bitter as they have perceived a deterioration in their remuneration and consequent standard of living. This has resulted in the loss of their co-operation and directly affected the traditional ways teachers have used their (private) time to learn and update their curriculum content.

Regardless of the background of our times, the business of Education continues and a review of the recent developments in the particular curriculum area of Craft Design and Technology puts the subject into perspective. It also provides the context into which future developments in technology can be introduced to pupils, and it gives me the opportunity to work in the area of the curriculum with which I feel the most empathy. Such a review will beg the questions 'What is Craft Design and Technology?', and 'Is this the most appropriate title for this educational domain?'

The most significant fundamental development since the harnessing of steam to provide controlled power, has been the harnessing and control of electrical pulses in the form of cheap microprocessing. It was this development, and in particular its encroachment into the school curriculum that provided the stimulus for research. 'What is happening in schools?', and in my particular case, 'What changes has it made to the teaching of C.D.T?'

It seemed to me that if teachers are to prepare pupils for life after school, they ought to be aware of how the 'new technology' came into being and how it lies amongst the rest of currently important 'making' skills. For if the curriculum content is to be changed it will have to be appreciated that teachers will still be the same human beings and the practical problem of equiping them with a new body of knowledge will be enormous.

The consideration of these questions together with some limited appreciation of various microprocessor applications, lead me to the area of control and systems analysis. At this time I began to form an opinion that this was an area of experience which could be developed into a 'learning experience', which would have to take account of the lack of 'new' knowledge within the existing teacher, and which would capitalise upon the versatility and real-world attitude which requires that there is always another way of doing things.

The act of developing such a programme required the consideration of another area of technological activity - design. If designing is the production of product outlines, then it follows that it is an activity which will need to be used to reach the required target.

There can be no planned change without design and its fundamental importance as a strategy which is applicable to any situation requiring a sucessful conclusion, needs to be recognised.

With some of these thoughts in mind I exploded, looking in all directions at once, attempting to find a thread which would form the underlying theme of a written document. It took longer than I expected to find the thread, and when I did, not only did I find it elastic, it was also looped and knotted. A story-teller's nightmare - but not to be treated as fiction and as such there are parts, particularly concerning the technology, which cannot realistically be divorced.

This thesis then, although seeming to be a progression, should rather be seen as a whole. You, the reader, are expected to take what systems analysts call an Holistic Approach. Roughly interpreted, you are expected to read all the pages at the same time!

1. WHENCE COMETH CRAFT, DESIGN & TECHNOLOGY?.

The word "technology" began to assume a new meaning in the secondary curriculum in the nineteen-sixties.

For many years the word had been associated with those parts of Handicraft syllabusses which sought to explain the properties and behaviour of tools, machines and materials. The syllabusses of both the established General Certificate of Education (GCE) and the more recent Certificate of Secondary Education (CSE) sought to develop in pupils - mainly boys - the skills of duplicating well established methods of manufacture with an optimum degree of quality. The tools and methods to be used were those which had been developed over the centuries and were for the most part centred upon hand tools. The material to be used in schools was predominantly timber although schools which considered themselves to be at the fore in educational provision boasted metalwork shops and with justifiable pride and satisfaction pointed to their (expensive) machinery.

In the real world, since the end of the second world war little change in materials had occurred to affect methods of production, and although the quality of tools continued to improve, their profiles and methods of use remained the same. There was little innovation in materials handling machinery and factories were still very labour intensive.

To satisfy the requirements of the GCE syllabusses the schools saw product design as an appreciation by the pupil of the evolution of style in the history of furniture and the manufacture of the implements and tools they used in the workshops. Innovation on the part of the pupil as an educational aim was not recognised as being neccessary. There having been little development in industrial production methods and, for Britain, the successful end to the war may well have contributed to a miguided feeling of national self agrandisement. It seems now that in industry and commerce there was a belief that all production methods were known and established, and that what was now required would be their consolidation and optimisation.

Without a central agency to require and direct change, it is difficult to imagine how a national recognition, if indeed there was one, of the needs for the future could have been capitalised upon. What is now beyond any doubt is the then acceptance of a national understanding. What had just been defeated with the expenditure of immeasurable grief and sacrifice, had been the type of political establishment capable of directing national change. Alterations then, would be the result of individual, or local, recognitions and it would not, therefore, be true to assert that there were no changes at all that affected production. Since the end of the war, man-made timber products, for instance, were becoming more common. In the schools it was a different story, for even in the nineteen fifties, plywood, blockboard and chipboard were still not in common use for those parts of pupils work which were either visible or load bearing. In contrast, new synthetic adhesives which were water-proof, non-staining and allowed more time for adjustment during assembly than the traditional "animal glue", were being adopted.

So in the three areas of Handicraft - materials, adhesives and finishes - changes were taking place if only slowly. It was becoming apparent that with the greater availability of materials which exhibited different properties of strength, stability and size, there would need to be changes made in the way these materials were handled, assembled and finished. These techniques once developed began to be seen in mass-produced furniture which could be purchased in boxed kits and assembled with a screwdriver. The trade knew the technique as 'KD' (knock - down), but to the public the image to be portrayed was promoted as 'DIY' (do - it - yourself), commercially a more attractive title. It was for the teachers to find ways of translating or developing those industrial methods such that they became suitable for the school workshop.

Nisbet(1), who looked at the establishment of the Schools Council, records that on 24th October 1964, after a period when political misgivings had made its foundation improbable, The Schools Council was finally set-up. It was a body without the ability to direct curriculum change on one hand, but free from the Local Education Authorities on the other. It was given finance and charged with the responsibilities of listening to, researching into, developing and publicising matters of educational interest. Amongst its interests was its insistance of reform within the public examination system and the establishment of teachers centres. Being, as it was, a body which was designed to reflect the opinions and aspirations of serving teachers in the area of educational innovation, it was well placed to recognise the need for communication between educators and the aspirations of pupils not well placed to be entered for GCE ordinary level examinations.

Professor John Eggleston in his preface to the Schools Council's publication 'Design for Today', recognises the ability of the Council to respond to teacher initiatives. He referred to its financing a project to "explore the possibilities of development that might spring from existing school curricula in woodwork, metalwork and related activities with particular reference to the needs of the older age groups in secondary schools".(2) And of the original recognition of the need he wrote, "The Schools Council decision was in response to the enthusiastic initiatives of a large group of teachers in schools, colleges and universities who, with heads, advisers and administraters had met together to formulate proposals on a number of occasions at Leicester throughout 1965".(2)

As if to mark this period of change, the title "Technical Studies" became the name by which many workshop and technical drawing areas were described by teachers.

In 1967 the Schools Council founded Project Technology at Loughborough College of Education under the directorship of Geoffrey Harrison. Its aim was to promote a better understanding in boys and girls of all ability levels of the relevance of Technology to our society. By 1974 there were produced fifteen handbooks which the project team saw as being used by teachers who would sometimes 'turn to Project Technology publications for general guidelines, at other times for more specific guidance'.(3) They also recognised that since the work was not emanating from the usual source of curriculum alteration, the syllabusses published by the public examination boards, the backgrounds of the teachers who were becoming involved was not subject specific. 'Sometimes technological activities have originated in science departments, sometimes in school workshops, but usually they have developed to embrace or touch upon every department of the school.'(3)

In the following ten years, pilot studies, reports and text books were published by the Schools Council. Initiatives took place at school and Local Authority level and not only concerned with work to be aimed at pupils aged 11 to 16 years. In 1970, for instance, an Engineering Science project was funded jointly by the Council and Loughborough, now a University of Technology. A wide range of GCE Advanced level courses included elements of physical science and this project's primary aim was to 'Produce stimulating and enjoyable text books by adopting an engineering approach'.(4)

Fox and Marshall at Danum Grammar School for Boys at Doncaster developed a course called 'Control Technology' which was edited by Viles to become another part of Schools Council Project Technology, this time aimed at 13, 14 and 15 year olds.

'Modular Technology' courses started development in Hertfordshire (1970), and Avon (1974) Local Education Authorities. Influenced by the work of the School Technology Forum - based at Trent Polytechnic, Nottingham - a project team started to develop the work ready for trial in 1977. The books, or modules, were published in association with the National Centre for Schools Technology which had been established at Trent Polytechnic under the direction of Geoffrey Shillito. The modular approach was intended to 'allow schools to start a two-year course based on either three modules spread over four terms followed by a major project, or a five-module course spread over four terms followed by a shorter project ...... for which public examinations at 'O' level and CSE are available.'(5)

In 1977 the titles "Craft", "Handicraft" and "Technical Studies" when applied to the work done in school woodwork and metalwork shops, was officially superceded. H.M.Inspectorate wrote, 'This subject area has developed considerably over the last decade and the title, Craft, Design and Technology, describes more adequately than Handicraft the wide spectrum of activities undertaken in the school workshops and drawing offices. The principal aim of Handicraft was the physical and emotional development of boys,mainly through the gradual aquisition of skills. Craft, Design and Technology extends this to provide a fuller experience in which cognitive development features more strongly. Its central aim is to give girls and boys confidence in identifying, examining and finally solving problems with the use of materials. Craft,Design and Technology has an important contribution to make to the education of pupils as part of their preparation for living and working in a modern industrial society.'(6)

This reference was the formal recognition of a change in curriculum content and direction which had its roots firmly within the education system. It was assisted and enabled by an agency whose champions had been embroiled in political in-fighting before its birth. An agency which stood apart from both the Local Education Authorities and the Department of Education and Science, and had no mandatory powers.

If the Schools Council was not empowered to pour salt on the tail of curriculum development, it did at least demonstrate the usefulness of the dangled carrot before the lubricated machine.

1. J. Nisbet. 'Schools Council. U.K.' Case Studies of Educational Innovation, OECD 1971.

2. J. Eggleston. 'Design for Today'. Schools Council. 1974.

3. 'Project Technology Handbook No14 Simple Computer and Control Logic' Heinemann & Schools Council 1974.

4. D.T. Kelly.'Engineering Science Project - Structures'. Schools Council & Loughborough University of Technology. Macmillan 1974.

5. R. Page. 'Schools Council Modular Courses in

Technology - Teacher's Master Manual'. National Centre for Schools Technology, Trent Polytechnic. Oliver & Boyd. 1981.

6. 'Curriculum 11-16', Working papers by H.M.Inspectorate. HMSO. 1977.

2. WHAT IS THIS WONDERFUL THING TECHNOLOGY?

H.M.I., in their publication 'Curriculum 11-16' wrote a chapter dedicated to an area of the school curriculum which they called 'Technology'(1). They informed us that the word "Technology" was coined by Joseph Beckmann, a theologian turned mathematician and scientist - as we shall see, a significant if, by the standards of today, perhaps an unlikely combination of interests.

According to 'Who's Who in Science', Johann Beckmann was born 4th June 1739, the son of the director of taxation and custodian of postal services, in Hoya - Germany. He was educated by his mother and went to the Gymnasium at Stade at the age of fifteen. In 1759 he entered the University at Gottingen to study theology but turned to mathematics and the natural sciences, public finance and administration, and philosophy. He also enjoyed languages. He travelled to Sweden and Denmark inspecting mines, factories and foundries. He was appointed extraordinary professor of philosophy in Gottingen (1766). His work turned more towards applied botany, agriculture and public economy, and an ordinary professorship of economic sciences was created for him in 1770. He held the post until his death in February of 1811. 'He founded the independant science of agriculture with his textbook Grundsatze der teutschen Landwirthschaft(1769), and he stressed that practical agriculture needed a scientific foundation: natural history, minerology, chemistry, physics, and mathematics were recognised as necessary auxiliary sciences of agriculture.'(2)

He recognised the links between his agriculture and both the production of natural mineral products and mining technology. 'Who's Who in Science' draws the conclusion that it was but a small step for Beckmann to become interested in the production of metals and from that to the processing of materials in general by individual trades. 'By 1869 he was calling his science of trades "technology" and in 1777 his Anleitung zur Technologie appeared, the first advanced textbook in this field. It is noteworthy for its systematic approach to the various vocations and for its descriptions of a number of trades.'(2)

Almost lost in this biographical summary is the comment that 'Bechmann was not without precursors in his attempts to spread technological knowledge, but he was the first one to succeed in introducing technology as a separate subject into the highschool curriculum.'(2)

The interdisciplinary nature of technology was the subject of another book later in his life 'His attempt in 1806 (Entwurf der algemeinen Technologie) to compare the processes that are utilised in the various areas of technology that are based on the same objectives also deserve special attention. Thus, for example, the various areas of crushing or grinding were examined with a view toward profiting from the transfer of an especially efficient procedure from one field to another.'(2)

Another reason for Beckmann to be brought to our attention is that he compiled the first history of inventions: "Beitrage zur Geschichte der Erfindungen" (Appendix 1). It is not a complete history but 'it is an admirable collection of historical descriptions of individual inventions'(2).

Returning to the 20th century, 'Curriculum 11-16' concludes: "It is essential that 16-year-olds can understand Technology, and that they are able to operate various manifestations of it". Beckmann was identified by HMI because of his use of the word 'technology', neither his interest in inventions nor his background was mentioned by them to illustrate the way that they had influenced Beckmann in his use of the word. It is almost as if Beckmann was seen to have found an existing, though perhaps obscure, study which he felt suited his interests and could be promoted - perhaps for his own gain.

We have already seen that through the work highlighted and promoted by the Schools Council, technology for schools seems already to be linked to three things:

understanding, operating and inventing, but if education is to serve the whole of society equally, the ground rules ought to have been defined by someone and then understood by those teachers who were to be the Schools Councils target. All teachers, for it is not sufficient only to address those directly involved - the ones who will be delivering the content - but to reach others whose attitudes will have to move in order to create the space needed within which the deliverers can work.

It is one thing to know that something is essential, but another to deliver it. The difficulties of bringing about change, compounded by the reality of a lack of access to the educators' most important resource, the teacher and his/her awareness.

Ater the recognition of a need for change the first step ought to have been the establishment of a common understanding - a definition. How do H.M.I. define what they dubbed as being an essential area of the curriculum?

In their second paragraph they state, 'Technology has been defined as 'the rational application of science to the human condition''.(1) (There is no reference to their source.) Clearly a definition to mean all things to all men, though with an undertone which helps to create the archetypical image of a white coated, bespectacled expert.

As if appreciating its own shortcomings, the paragraph then continues by exhorting the reader to weigh each of the words carefully and to be aware that 'it is not simply a concern with 'science', but with people, society, reason, decision making, processes in politics and in industry.'(1)

Having proscribed an 'essential' curriculum area and then failed to arrive at a working definition of what it is they would recognise as fulfilling it, H.M.I. procedes to recognise that every syllabus 'can make some kind of contribution to our comprehension of technology, if, that is, the syllabuses are appropriate to the needs of present-day society.' I am left with a feeling that H.M.I. do not really understand the nature of the task. Put simply, the translation appears to be, 'Technology, which we cannot define, is an essential part of the 11-16 curriculum. If your school is already doing its job properly, then technology will be being taught."

The implication is clear. If the curriculum of the school is inappropriate, it needs changing. And who would argue with this? But surely, if only the referee knows the rules and refuses to tell them to anyone, how would anyone know how to start? It is not sufficient to say, 'Just kick the ball and I'll tell you as you go along!' The frightening reality seems to be that the referee should not be surprised if no one wants to play the game!

H.M.I. avoid the opportunity of defining "technology" for the assistance of teachers, preferring instead to assume a universal understanding. Having arrived at this intellectually cowardly and erroneous decision, they then state, ".....it is not proven that technology is a separate discipline."(1) Another pompous statement creating the illusion of a profoundity and thus not seeming worthy of research until we recognise that we do not know what to search for. It does, however, have another significance for, on reflection, it sounds like an excuse for not advocating a massive teacher training initiative! Later we are advised that, "Responsibility for bringing technology into the curriculum ought to be shared by any department which can make a useful contribution in the matter."(1) At this point perhaps we should have arrived at the conclusion that the need for technology in the curriculum is so urgent, that an 'any port in a storm' attitude has prevailed!

Returning to the analogy of the ball game, perhaps there is another way of looking at the problem of provision.

Suppose the philosopher can humble himself in the eyes of his critics and say that there is a generally held image, a concensus, a gestalt, of what technology is. Suppose that he can then convince the listeners that the important thing is to strive towards it, and that the defining of it is of peripheral importance. If they could accept this, then he could blow the whistle and they would all be able to make a start by kicking the ball in the right direction. When a problem arose perhaps the players could be persuaded to find a way of resolving it. The analogy becomes a little tenuous as the number of players is seen to increase, and the position and direction of the ball might also become obscured by players who come and go as they perceive their interests being best served to a greater, or lesser, extent.

Still, with the absence of humility, Curriculum 11-16 whistled into the wind and those players who had read the book were able to start running about and kicking the ball in the general direction of no less than eight sets of goalposts. The eight human attributes which HMI say "technology" will affect.

1. Creative.
2. Aesthetic.
3. Linguistic.
4. Mathematical.
5. Scientific.
6. Social.

7. Political.

8. Spiritual and Ethical.

The similarity of this list to a list of the departments in Comprehensive schools may either be contrived or coincidental. In either event it does appear to give further grounds for any teacher to profess a legitimate, if insecure, ability to address the subject and take to the field, thus compounding the difficulty in arriving at a commonly accepted description.

It is in the paragraph titled 'Conceptual Knowledge' that we find the sentence, 'The very concept of 'technology' requires explanation, and some department ought to be given this responsibility; it is by no means clear that this is generally done at present.'(1) So, with that in mind I have attempted a collection of definitions, descriptions and relevancies, with the aim of synthesising a working definition.

Harrison and Black remind us that, to the question 'What is Technology?', came the reply: 'Technology is a disciplined process using resources of materials, energy and natural phenomena to achieve human purposes.'(3) A useful collection of understandable words in a sentence which makes obvious sense. This has much to do with their practical involvement in teacher training and the work of Project Technology which required skill, knowledge and intellect. When set against their individual backgrounds as the developers of this particular curriculum area perhaps this accomplishment is less surprising. In contrast, the Concise Oxford Dictionary defines the word as: 'Science of the industrial arts; ethnological study of development of arts'(4), not to my mind a helpful explanation.

Those most able to see the nature of the beast will be those who have had first hand experience of dealing with it. The following is a collection from a representative group.

Keeping definitions short and easily understood may make them easy to recall. Buckminster Fuller was quoted by Rt. Hon. A. Wedgwood Benn, Minister of Technology 1966/70, 'Technology simply means getting more out of less.'(5) However I am left with the feeling that this brevity was designed with humour, rather than realism, in mind. The Open University, for whose publication Benn provided the introduction, asserts that 'Technology leads to the making of things which tend to change the world in which we live'(5) and 'it is concerned with the problem of creating new things of value to man.'(5) I like definitions to be authoritative, and the use of 'leads to' disappoints me. Worthy of special mention is the inclusion of the word 'new'. The writer associates it with the artifact and not the method or tool.

The Welsh Joint Education Committee consider that, 'Technology is principally concerned with design and problem solving processes, which draw upon scientific and technical knowledge together with other resources. It also involves management of the environment and requires that the different constaints imposed by knowledge, resources and the environment are recognised.'(6)

The Society of Education Officers states that, 'Technological capability encompasses analytical skills and scientific knowledge but also the design, manufacture and marketing of goods and services.'(7)

Hicks, staff HMI for C.D.T. maintained that 'Technology is thought of as that body of knowledge and experience with which man has progressively mastered and enriched his environment.'(8)

Nicholson, C.D.T. Adviser, stated that 'Technology has been defined as the purposeful use of man's knowledge of natural phenomena, materials and sources of energy.'(9)

The East Anglian Examinations Board, et al, sought to provide a complete description. 'Technology is concerned with the identification of the needs of man and the endeavour to satisfy those needs by the application of science and the use of material resources and energy. It is concerned with solving problems where there is no right or wrong answer, only good or bad solutions to a problem. Technological behaviour requires activities that are creative and demanding, where the laws and principles of science, the constraints of society and economics are applied to problems of satisfying human needs. Technological behaviour involves approaches and techniques such as systems analysis, problem identification, decision making, planning, idea communication and solution evaluation, that involve considerations other than pure science or craft.'(10)

H.M. Inspectorate believed that the study of Technology would provide 'an understanding of principles relevant to the application of scientific phenomena to materials in a design situation.'(1)

The Department of Education and Science describes Technology as being 'principally concerned with design and problem-solving processes leading to the making and evaluation of artefacts and systems. It draws upon scientific principles. Technology also involves management of the environment, and familiarity with the concepts of materials, energy and control.'(11)

Examination of all these statements illuminates four areas which seem to be of common importance.

There is reference to humanity on both the social and personal levels, there is reference to the intangible; a body of knowledge and the ways it can be used, there is reference to the tangible; the creations of man, and there is reference to the environment or natural phenomena. It would seem that all of these areas ought to be represented in any description of technology.

It would seem therefore that technology is the application by mankind of capabilities to available resources with the aim of producing improvements.

Having arrived at a working definition of the word, what are the manifestations of its meaning?

The products of man's capability are reflections of his progress. But what is meant when 'human progress' is being discussed? Undoubtably there is an understanding that change has taken place and there is the implication that the current situation is better than the former. From the results of research and the evaluation of past practices, we draw conclusions. We are the recipients of 'news', items which describe what was not done, or known, yesterday. Milestones on the road to the future. Progress is seen to be a function of the body of available knowledge, the sophistication of available equipment, the understanding of suitable processes and the passage of time. However when further considered, the word 'progress' as applied to the human social condition, is not so easy to define as it is when applied to changes in physical position. Social progress is often a case of one man's meat being another man's poison, and in the western democracies the recognition of this has given rise to the provision of mechanisms whereby opposing public perceptions can be aired in a controlled way. Planning committees judging the erection of house extensions at the local council level, the method by which the county councils were to establish the structure plans of the early 1970's which were meant to lay out parameters for the future physical and economic characteristics of large areas of the country and public enquiries typified by Windscale in 1978 and Sizewell in 1986, are three examples of the British way.

Clearly there is a place for moral and ethical judgements in the process of change which technological movement precipitates.

Public perception of change is a matter of concern to anyone whose progress and well-being depends upon its reaction. Whether they represent their own interest or the interest of others, the furtherance of the change is a goal representing a challenge to their reputation and when seen as such it becomes clear that the greater the impact of the change, the greater will be the challenge and the stronger their motivation for success. They will consider the strength and disposition of possible opposition and the scale of the actual reaction will be compared with the scale of the proposed change and appropriate strategies for favourable progress will be developed.

This awareness of 'real world' reaction is not solely the way of the proposer of a new chemical plant but is also the concern of the designers of the latest generation of video recorders.

In a technologial society there is also a case for an appreciation of the mechanisms whereby criticism is levelled, and an understanding of the limits associated with different fields of complaint, eg. the objectors to a Motorway are locally associated and have an established forum to work through. The rules of the forum were not written by the objectors but only with them in mind, by those whose main interest is in the control of dissent. Critics of the performance of domestic artefacts, on the other hand are likely to be much more dispersed and would find it much more difficult to establish a concerted and representatively strong point of view. Their rules of collective dissent are far from clear, although as individuals they have local trading officers to speak to.

It would be naive to assume that those in control of innovation would, or could, represent the collective social concience of the nation and even if they did, the standards of one nation may not be those of its neighbour. Yet the reality of history shows that even societies which espouse the 'social' ethic as opposed the the 'capitalist' ethic are not without faults in the way they control their technological innovations. The explosion of number 4 reactor at Chernobyl in the USSR in 1986 is evidence of that. But before sagely knodding of heads signals the commencement of mutual self-righteousness it is well to recall the poisoning of Seveso in Northern Italy, the catastrophe of Bhopal in India, the explosion at Flixborough, Humberside, and the panic at Harrisburg, USA.

Where Chernobyl should begin to ring new alarms is in the matter of the containment of ethics, for the shortcomings which were this disaster's precursor had their roots in the procedures of the society of the USSR. Not only does political ideolology seem to hold little sway over the magnification from humble beginnings to awful finality of some of technology's obscure shortcomings, but its effects are now seen to reject political boundaries. Although there may be room for argument about the origins of the acid rain said to be devastating the forests and lakes of Scandinavia, the indisputable results of Chernobyl put the 'social', 'political' and 'ethical' aspects of the HMI's eight human attributes into perspective. If there no realistic possibility or desireability of halting technological change, and if its control is less than perfectly applied, it will require a greater understanding of what is possible before the reality of 'progress' is grasped.

There are those who, following the publication of the Club of Rome's report 'The Limits To Growth' in 1972 (12), began to voice continual concern over the ways in which the resources of the earth were being depleted. Pressure groups and publications currently mount campaigns of education and protest in their attempt to make known their fears over the scant regard the human race pays to the non-renewable mineral resources and oppressed life forms of the planet. The voices are often reported in terms on the critical side of neutral, which will be seen with pity if they are proved correct.

What is not in doubt is the fact that natural resources are the target of technological activity and although some can be be re-cycled, those which give up part, or all, of their energy content are probably lost unless their resultant products are made to become of permanent use. The description will inevitably involve the manipulation of quantities, the understanding of rates of change and the modelling of trends both actual and projected - the stuff of mathematics.

Throughout their book 'Science and Society', Rose and Rose (13) pursue the relationship between science and technology. They are prepared to acknowledge the existence of pure science, the 'Everest Complex' or doing science for its own sake, 'like collecting stamps', but they quote Sir Eric Ashby, 'Crawling along the frontiers of knowledge with a hand lens.' However they identify two other directives for research policy. One is the directive from a government which wants to target activity for a particular purpose: war, defence, illness, the environment, and the other is the perception of a research route from the evaluation of an application of an earlier result of science. Technology will also have the need for more research.

Science has long been seen as the province of the white coated 'expert', steeped in obscure, probably secret and certainly inexplainable matters. The BBC Radio Goon show introduced us to the man from the 'Ministry of Certain Things', and Michael Flanders and Donald Swann described a conversation with a Scientist, "H-2 SO-4, professor!". To which came the reply, "And the reciprocal of pi to your dear wife!"(14).

Technology is not a matter for the experts. It is practised by the people who should appreciate its potential and ought to recognise its results. People equipped to this level and having a right to determine their futures will be able to influence at least two of the three ways their nation will develop.

But first they will need to understand that such involvement is both important and intellectually possible, and the first steps to change will have to be made in the schools because the understanding, knowledge and immediacy does not yet exist in the homes.

1. HMI. 'Curriculum 11-16 Working Papers'. HMSO. 1977.

2. 'Who's Who in Science'. Marquis Worlds. 1968.

3. Harrison & Black. 'In Place of Confusion'. NCST Notts. 1985.

4. 'Concise Oxford Dictionary'. 1960.

5. Benn. A. 'The Man Made World'. Open Univ Press. 1971.

6. Welsh Jt. Edn. Comm. 'Technology Syllabus'. 1986.

7. Soc. Edn. Officers. 'Key Issues for Industry & Education'. Occ Paper No. 3.

8. Hicks. 'Good Courses are Available'. Brunel Conference. 1979.

9. Nicholson. 'School Technology - A Position Paper'. Advisors for CDT. 1978.

10. East Anglian Examinations Board. 'Joint Examination in CDT, Syllabus'. 1984.

11. CDT. 'The National Criteria'. Dept Education &

Science. 1985.

12. Meadows et.al. 'The Limits to Growth'. PAN Books Ltd. 1974.

13. Rose & Rose. 'Science & Society'. Pelican. 1970.

14. 'At The Drop of Another Hat'. Flanders & Swann. HMV(Record) 1962.

3. OF THE TECHNOLOGY OF THE COMPUTER.

'A computing machine is a device for facilitating the performance of mathematics, the greater part of which would be very much better not done'. F.C.Williams. (1)

There are references in many school text books to the origins of the computer, indeed it seems to be mandatory - almost a test of the authority of the writer - to find a new target for its invention. I have the awful vision of playground discussion groups locked in earnest debate over the use of Sumerian clay tablets, the similarity of the Aztec, Russian and Chinese abacus to the Japanese soroban and the differences between the digital computer produced by Blaise Pascal in 1642 and the Analytical Engine of Charles Babbage in 1833.

Perhaps they would be separated by a teacher, an under - graduate of the Open University, of nervous twitch and bleary eye whose constant glancing at her wrist clinging watch reminds us of Lady Macbeth's damned spot. Hussey(2), she might inject, made the point that Babbage never managed to produce a working prototype and that even if he had, the machine would not have fulfilled the reqirements for a 'Computer' as outlined by Newman(3).

Peace instantly returns, leaving the pupils to play and the teacher to return to her worry - whistle.

Someone told me, a long time ago, that the learning of names and dates would never be of much practical use. They were right.

However, what is of relevance to C.D.T. is the process of development, the designing, of the computer because it is a new product seemingly without a history. It is almost as if it appeared from nowhere and reproduced at an alarming rate. Truly the stuff of science fiction!

We are now accustomed to computers, having seen them in shop windows, on the television and in schools. We are treated to views of smart plastic cases, textured and coloured, and the comforting confidence of both salespersons and other computer users who expound their virtues with an unending series of acronyms. It is not easy to appreciate that, as there was a Wright Bi-Plane to our super-sonic Concorde, so there was a primitive and unattractive predecessor to our current personal computers.

The bi-plane, wooden with fabric, wire and having the aspect of a childs cats cradle, is as far removed from what we now regard as safe and efficient aviation as a childs den in the bushes is from even the humblest of dwelling houses. Yet the den, not unlike the bi-plane, it is an attempt by an unsophisticated mind to use available skills and materials to satisfy a need.

Technology in play - but consider the child's result as seen by the unthinking.

When the results of this young technologist at play are judged, lacking as they do quality of finish, are we to expect the same should the exercise be transferred into a school situation? If so, and unless understanding is established, teachers will continually be looking over their shoulders, waiting for criticism and complaint. There is no satisfaction in being continually criticised. Without external appreciation of the seeming lack of emphasis on craftsmanship, the opportunity for creativity of this sort will be almost stillborn.

If it could be established that there was a 'string and sealing wax' stage to the development of all products, the efforts of the young may yet be seen for what they are, innovations from within a developing mind.

We have seen early photographs of aeroplanes, steam engines, looms and agricultural machinery, all in operation. But it is almost as if it is not in the manufacturers interest to release evidence of his primitive efforts and failures. It goes without saying that only the failures which result in tragedy are ever publicised and so it is little wonder that there is no public appreciation of how early work is 'lashed-up'.

Professor F.C. Williams' account of the development of the computers at Manchester University is fascinating, not because it describes the 'invention of the computer', but because is tells us how it was before the advent of the smart plasic case and the regimented ranks of semiconductors soldered uniformly to geometrically lined boards. It illustrates the ad-hoc nature of innovation and the well recognised problem of minimal funding!

Williams left the Telecommunications Research Establishment (TRE) at Great Malvern and his Radar research in 1946, to take the Chair of Electrical Engineering at Manchester University. He recalled his interest in computers being aroused at TRE, because as the war ended, the Radar experts had 'endless solutions and no problems'. He freely admitted to being no mathematician, but recognised the need for an electrically operated 'storage system' when it was brought to his attention and, by using his past experience, at the end of 1946 the cathode-ray tube was made to store and display one binary digit. This method of storage was rapidly developed to handle more than one thousand digits, or luminous dots, which could be assembled into patterns on the screen of the tube. The patterns could be manipulated to form alphanumerical characters, and by the end of 1948 he was able to store as much as 340 kilodigits within his cathode-ray system. However it is as well to appreciate that the achievement so far was only the ability to store pulses electronically.

Williams, and his colleague Kilburn, knew nothing about computing but much about electronic circuits. Newman and Turing, in the mathematics department of the University, knew much about computing but substantially nothing about electronics. The co-operation between these two interests resulted in 1949 in the operation of a machine which could access 5120 digits immediately from a two CRT stores and a further 40,960 digits held on a rotating magnetic drum. The machine utilised three other CRT's, one for an accumulator where totals were made and held, one for keeping control and the other for holding instructions which the machine might want to modify. This last is now usually called an 'index register'.

Williams notes an interesting conflict which arose between mathematics and electronics - interesting because it brings into focus the real-world limitations of 'theoretical' knowledge. He wrote that the machine worked in a serial way. That is to say that pulses of electricity representing the make-up of numbers were sent one after another. 'In mathematics the least significant digit occurs on the right. In serial machines the least significant digit must be operated on first in order that carries may be determined. It is well known in electronics that time flows from left to right, so the least significant digit must be on the left. The solution adopted was to employ a system of numbers called "binary backwards"'.(1)

Williams observed that the creation satisfied his own definition of a computer (see paragraph one), but did not satisfy that of the Royal Society (RS) discussion in 1948 which described computers as having to be automatic, digital and general purpose.

It is at this point in his paper that we begin to appreciate another of the practical realities of development work which, in my mind, reflects something of the childs den. He recognises that since the 1948 machine required human intervention during the solution of a problem, it could not be described as automatic, and he describes why this is so. The reason was that the magnetic store, the revolving drum, was in a room on the floor above the electronic store - the CRT's. Transfers between the two had to be made by setting switches 'and then running to the bottom of the stairs and shouting "We are ready to receive track 17 on tube 1!"'.(1) This shortcoming was described by Williams as being 'trivial', and well it may have been in terms of the effort required to replace it with something more akin to automation.

But the fact remains that here was a rather 'boots and braces' stage which had to happen before we could have our modern personal micro's.

If this fact is of significance to the C.D.T. teacher of today, Williams' next admission is at least of equal importance. He reports that the machine we have just been considering was not the one which had the greatest impact on computing at Manchester University! Having spent such time and effort, this product was not the one which went forward to the next successful stage. For those teachers who have practical experience of this in the workshop, they will recognise their initial refusal to believe in their own diagnosis. They will also recognise that there are times when 'the best of a bad job' must be made, but that, sadly, there are others when all the sincere hard work can be recognised as having not been in quite the right direction, and the product has to be put to one side - scrapped. This is not the stuff of my youthful craft room when the outcome was clearly known in advance, and the strategies for success were well established. Failure in those days was the result of a lack of craft skill.

For the sake of completeness - if not to fuel playground ardour - it is as well to record here, that the machine which first performed according to the three parameters laid down by Newman at the RS, did so in Manchester in the July of 1948.

Now, apart from the reassurance that high technology has its roots firmly on the floor (or perhaps floors), what else do we learn from Professor Williams paper? We find that the machine was built by 'doing' and that the 'do-ers' were not all academics. Indeed it would seem that the development would have taken longer if this co-operation had not happened.

It is worth noting that Professor M.V. Wilkes, who was also working on the design of a Computer at Cambridge University, said in 1974, 'Various proposals for memories of other types had been discussed in Philadelphia and I heard afterwards of the highly original work that F.C.Williams was engaged on; these, however, all seemed to involve a good deal of speculative research'.(4) From this paper, which describes the progress of the EDSAC machine at Cambridge and in particular the development of 'high speed memory', not only do we recognise that Williams methods, which included 'speculative research' - what my grandfather used to call 'suck it and see' - were not without their critics, but also that the Cambridge machine started to work in May 1949, one year later than its Mancunian relative. Incidentally Wilkes, who like Williams had been engaged in wartime Radar but whose background was in pure and applied mathematics and radio physics, notes briefly: 'We, along with other groups, had great trouble in making the mechanical peripherals meet our requirements for speed and reliability. The advances that were made in this direction, particularly as regards reliability, have been felt far outside the computer field'(4). An interesting observation for two reasons. The recognition of the need for an understanding of the nature of mechanisms whilst working on what at first sight is not recognised as being a mechanical problem, highlights that aspect of 'technology' which demonstrates the need for further research before it can proceed.

We have already seen what might be described as the 'natural development ' of school technology as having come from both science and C.D.T. teachers who have not, in every case, been working together. Here is another possible link, what might be called the 'sci-tech continuum'.

In his letter to me concerning the development of Microelectronics within Durham Local Education Authority, Grimshaw identifies ten areas of the curriculum where he believes aspects of microelectronics to be of interest, and I quote him at length;

'a) Electronics as a subject in its own right .

b) Electronics in Control Technology - an area of major interest to CDT teachers.

c) Electronics in Computing - computer control is of interest in many areas of the curiculum.

d) Electronics in Science - many Physics syllabuses involve some aspects of Electronics though usually on an analytical rather than a design and application level. There is also a lot of potential for using Electronics in scientific measurements and data collection.

e) Electronics as a teaching aid for teachers of children with special needs.

f) Electronics in Rural Science and Environmental Studies - the scope for sensing and control of environmental conditions is at least as great as it is in Science. Weather conditions can be monitored (temperature, pressure, humidity, rainfall, light conditions, wind speed and direction). Soil moisture content and acidity can all be monitored with relative ease.

g) Electronics in the Primary School - it can be used as a new approach to achieving many educational objectives in the primary school. The "Wirral Electronics Pack" in particular has been used to introduce children to problem solving situations, design, numeracy, group work, language and many other pupil-centred activities.

h) Electronics in Music - musical application of Electronics and Microelectronics are well developed in industry and offer new approaches to the teaching of music.

i) Electronics in Physical Education - this is an area which as yet is relatively untouched by new technology and where a lot of scope exists for new teaching approaches.

j) An awareness of Microelectronics, its impact in society, potential and limitations should be a part of every child's education.'(5)

The Penguin dictionary of Electronics states: "Electonics. That branch of science and technology which is concerned with the study of the phenomena of conduction of electricity in a vacuum, in a gas, and in semiconductors; and with the application of devices using those phenomena.'(6) It goes on to describe Micro-electronics as; 'A branch of electronics concerned with the design, production and application of electronic devices of very small dimensions, in which a high packing density of the component parts is achieved by eliminating individual containers and connecting wires.'(6) For the purposes of the curriculum, perhaps it would be better not to draw a distinction between the two.

I am a little unsure of Grimshaw's meaning of 'subject in its own right'(5). There is a world in which electronic components are designed and made, but I cannot believe that such a capability can be developed in children of secondary school age. Nor am I sure that the equipment would be affordable. Perhaps what is meant is the use of electronic components to make circuits. This is surely akin to the toothbrush rack and is, as we have seen, now a discredited curriculum aim. The final possibility is the design and construction of electronic artefacts. Limiting the solution of any project to a particular technique is not efficient and is certainly not the aim of C.D.T. I must question both the logic and the cost-effectiveness of setting-up a curriculum area in opposition to one whose aims are both recognised and accepted - with the aim of educational regression.

The distinction between b & c is interesting. It is possible to control using electronics, and I would not disagree with his perception of the C.D.T. interest in this area. However I wonder how much of the electronics of a computer must be mastered before one can use it to control. This is a thought which will need to be pondered as more is understood of the use to which computers are put.

Using electronics for the collection of data and for making measurements seems to me to require as much capability in the area of electronic instrumentation as would be required to make a wooden rule before having to measure length. (See also 'f', 'h' and 'i')

The same is true of e, but is not of the same relevance since the presumption is that of a teaching aid for the benefit of the teacher. A parallel might well be drawn with the need to understand the workings of a red ball-point pen before marking books.

The design-based approach to learning, as we have seen in the development of C.D.T. as a curriculum area, is justified. However, just because C.D.T. does not appear as a title in primary schools, there is no reason not to use alternative media to attempt the same aims - so long as there is a breadth of materials and possible solutions available. If not, we shall merely have succeeded in shifting the problem, that of knocking the inventiveness out of children, to an earlier age.

There is much to be said for making people aware of the social impact of technology, and it could be argued that the last people to handle this should be the technologists. A cynic might well draw the parallel with the bio-chemist who succeeds in justifying his work and obtains a continued grant only to demonstrate the awesome effect of a genetically engineered virus.

Grimshaw's reference to electronics in the area of control begs an understanding of the nature of control itself. If control is to be appreciated it has to be demonstrated, and without first having the electronic contollers (for electronic siuations) to hand, it cannot be done. Building the controllers first would be electonic toothbrush rack building, and so we have a 'chicken & egg' situation.

The advent of the versatile microcomputer, an electronic box-of-tricks capable of being carried about, has enabled the teaching approach to be revolutionised by removing the philosophically irreconcileable dichotomy of the attainment of an innovative end by the use of discredited means. Its comparative cheapness and ability to be used for different activities has enabled it to be justified in its use in a wide range of school situations.

Computers are used in process control for three main reasons. The first has to do with the ability of the computer to store information, and the second is related to its ability to perform calculations at very high speeds. It is the third, however, its ability to act independantly and reliably without constant supervision, which is its greatest asset.

The combination of these three is what has caused the revolution in process control, for whatever can be observed and translated into small impulses of electricity can be monitored within the computer and related to instructions already present. Furthermore, if small electrical impulses can be translated into larger scale operational activities, the computer is capable of influencing its environment.

This is the classic 'input - process - output'(IPO) situation and when operated by micro-electronics, is probably the ultimate goal in the artificial use of the IPO triad.

There is, however, one further and most intriguing use of the computer for which many can give thanks, for although it may well be that most computers are used for automatic control, the computer is capable of 'simulation', and simulation is often cheaper than the real thing!

Since output can be sent to any device which is sensitive to pulses, alternative devices can be substituted for the real thing. Simulation is possible at any time during the development of the process strategy, an advantage which can be appreciated more when the modification of an established process is required in a complex and potentially hazardous environment.

The development and modification of control processes, when done in conjunction with alternative output devices, and perhaps utilising alternative forms of input is known as 'modelling'. Another use of the same word results in the construction of small (and in some cases large) scale prototypes. Their behaviour, as they are subjected to the rigours of use, can be related to that of the target, providing that enough is known of the relationships between the two. The computer is particularly useful here, because these relationships, when reduced to mathematical models, are rarely linear but complex. The computer is capable of processing at high speed, and these complex relationships can be rationalised at speeds which still allow tests to be conducted in such a way as to represent the speeding-up of time, thus modelling a year's use in the space of a number of weeks.

The story of the development of the electronic computer is a wonderful example of the meaning of technology in the raw, warts and all! A computer system is now both affordable and, as we shall see, capable of use as a multi - purpose tool in the development of further products and systems.

1. Williams F.G. 'Early Computers at Manchester University'. Royal Society. 1975.

2. Hussey M. 'Automatic Computing'. Open University Press. 1972.

3. Newman M.H.A. 'A Discussion on Computing Machines'. The Royal Society. 1948.

4. Wilkes M.V. 'Early Computer Developmentsat Cambridge: The EDSAC' Inst Elec & Radio Eng. 1975.

5. Grimshaw. K.G. Letter to the author. Reference

TRIST in Durham LEA. 1986. (Appendix 2)

6. Pelican Dictionary of Electronics. 1971.

4. CHILDREN HAVE DESIGNS ON OUR FUTURE.

The stories of Williams at Manchester and Wilkes at Cambridge are not only that of the development, or as some would say invention, of the electronic computer but also a description of the way in which scientific research spawns technological opportunities. The immediate task was not reqiured to satisfy the technological requirement of producing an improvement. Never-the-less the team were involved in the manufacture of pieces of novel equipment which would enable their research to progress. In this respect, the satisfaction of their needs by practical means, their work had a technological aspect.

The contrast between the scientific and technological activities at Manchester is stark and provides a useful opportunity to differentiate between the two. The one is open-ended where the result may be intuitively or intellectually predicted but in the end stands by its own honest and indisputable truth, and the other is the satisfactory operation of a device doing what was seen to be required.

The success of this second is the result of a combination of diligence, skill and knowledge, and its practice is by far the most significant differentiator between technology and other human endeavours.

In his Presidential Address to the Institution of Mechanical Engineers in 1986, Professor B. Crossland outlined his desirable objectives in education and training which he believed should be directed at 'design for profitable manufacture'(1). After noting his concern at the 'very real and rapid deterioration in our secondary education system', and the unaffordable 'narrowly-based science/engineering students or narrowly-based arts students in the modern world'(1) which he deplored, he made clear his feelings on the activity of design.

'It needs to be recognised that the essential objective of engineering education and training should be design for profitable manufacture. It is not much use to have a wonderful design if one cannot make it or when one has made it it is either too expensive for the market place or worse still it has no place in the market place. Design for profitable manufacture should be just as much the focal point of engineers as the human body is to the medical profession. Engineering sciences should not be considered as freestanding unrelated subjects as is frequently the case; they need to be focussed on the design process. An understanding of manufacturing processes and systems is an essential part of design and the integration of design and manufacture needs to be demonstrated during education and training. Design is a multi-disciplinary subject which does not recognise or should not recognise the artificial boundaries between, for instance, mechanical engineering and electrical and electronic engineering, and this is even more true in this day and age. It is important that this is clearly recognised in the educational requirements of this institution.'(1)

He does not give us the benefit of what he understands the design process to be, but he makes abundantly clear that there is a great place for designers once they have been identified.

It is clear from Professor Crosslands speech that whatever design is, it takes place before the product of man's labours is presented for consideration by the wider public. The purpose of this time is to ensure that to a recognised degree, the emergent product will fulfill its intended purpose. The length of time spent in this consideration is likely to be variable but it seems that the skills employed can be selected from a pool which must be recognisable by some!

Design, observed Hicks '...is what that name implies, the antithesis of accident; and that implies decision making'.(2)

Like the word 'technology', it seems as if we may be hard pressed to define what we mean by the word, but let us examine what Hicks may mean. Consideration of the antithesis of accident must include reference to 'purpose', and from this perhaps we are to accept that anything displaying purpose can be considered to be design. Purpose presupposes the recognition of a goal, and the process or campaign which leads to this attainment would be that which we recognise as 'design'. Can a plant be said to design as it reaches towards the light? Does a fox exhibit design as it stalks its prey?

The plant is rooted to its spot, but never-the-less leans towards the natural light. The fox has the advantage of movement. It can plan a strategy by looking at its goal from a variety of stances. It is then necessary for the fox to process its information, and in the light of what it has learned formulate its strategy. It is here that the fox displays its ability to make decisions, an ability which sets it apart from the kingdom of the vegetable.

When Walker and Cross asserted that 'To the person in the street, the design of a building probably means it's style - it's shape, it's form - together with its colours, textures and arrangement of windows, etc'(3), they may not have been mistaken. Not so the person in the street! They go on to illustrate further misconceptions when they cite the constructor of the building who sees the 'plan' (or drawing) as the design, and the users of the building who may well describe the design in terms of the 'internal arrangement of rooms, corridors, doors and so on.'(3)

They accept these four different uses of the word, and although they link 'product' with 'arrangement' and 'process' with 'plan', they analyse the word no further.

They do recognise the element of process which design embodies, when considering 'the nature of designing', and they acknowledge the need for organised progress, as evidenced by a sub-heading, 'The design strategy'.

The Secondary Examinations Council describes the discovery stage as 'observing a context'(4). After the discovery of area of need, the designer requires to have a succinct written description againsed which he can test his progress.

Walker and Cross presume the existence of an identified context since 'The designer is authorised to begin his work by some kind of brief.'(3) This is in contrast to the stated assessment objective in the GCSE National Criteria which reads, '4.2 Candidates should be able to : 3) identify problems which can be solved through practical/technological activity;'(5). This is clearly of some significance both to teacher and taught for it assumes the existence of a strategy (and the ability to use it) for which industry either has no use or entrusts to those who are considered to be invisible.

Rose and Rose record the establishment by the Admiralty in 1914, of a Board of Inventions and Research. 'its terms of reference, as quoted by Arthur Marwick, were:

(i) to concentrate expert scientific enquiry on certain definite problems, the solution of which is of importance to the naval service;

(ii) to encourage research in directions in which it is probable that results of value to the navy may be made by organised scientific effort;

(iii) to consider schemes of suggestions put forward by inventors and other members of the general public.'(6)

The meaning of 'scientific enquiry' is not clarified and might well have given cause for confusion. Did it mean open-ended research on matters of genuine enquiry such as weather forecasting, or did it perhaps intend to attract those who could develop and produce weapons. Science would not of itself help with the production of the latter. The second is clearly the province of the scientist, but the last is certainly not and the implication that inventing cannot be paid for with a regular salary is notable in that there must have been an assumption of irregularity, if not spontaneity, as being the act of inventing. Inventing was not seen as a planned (or for that matter acceptable) occupation.

However, that was a long time ago and history is nothing if man cannot profit by it.

Much more recently, in 1978, a Working Party on design education at the secondary level was set up by the Education Advisory Committee of the Design Council. It was made up of a Chairman, Professor David Kieth-Lucas CBE FEng FIMechE FRAeS, 10 members, an adviser to the working party from the Department of Education and Science, an observer from the Design Council Scottish Committee and its secretary.

In his foreward, the chairman makes reference to the universality of design as a human activity. He justifies its inclusion in the secondary curriculum in these terms: '..there can be few more important educational experiences for the children than to grapple with the the sort of problems they will meet as adults - problems of the environment, of man-made things and how they can be improved, of the quality of living - or, in other words, 'design' in all its forms.'(7) It follows from this statement, that an immersion in design is not to be reserved solely for budding designers, but is for all. Indeed it would seem to be cruical if useful criticism is to be made in the future. Criticism when thoughtfully and knowledgeably levied at design can be a source of inspiration, which should be reflected as product improvement. Without this criticism then, there will be two detrimental effects.

Firstly there will be less impetus for improvement, leading to misplaced confidence and a consequent lack of introspection and innovation. This attitude does nothing to interrupt initiatives for progress to be developed elsewhere.

The second effect concerns the attitude of the population to the activity of design, for if others are seen to design better, it is they who will be regarded as the masters, making local progress towards excellence so much more difficult. The decline in sales of the British motor industry during the 1970's may have something to do with this, and indeed Kieth-Lucas takes the matter further.

His report discusses the wider implications for good design. 'Education in design can also be justified on the grounds that good design is crucial to the national economy.'(7) This statement ought not to have needed amplification, but perhaps setting themselves apart from the history of this nation, there have been many who have regarded themselves as not needed in the ranks of those who take an active part in the productive aspect of our national economy. Keith - Lucas pointedly identifies a deplorable truth when he says that there is a 'tradition' in our country to 'accord much higher priority to the pure sciences and mathematics than to the practical arts.'(7)

In his use of the term 'practical arts' he brings together all the stages necessary to the production of the practical solution of human need. It is the use of the word 'tradition' which intimates with tragic truthfulness the size of the problem before the country. There is a human system in our land which perceives the practical arts as something less than the respectably high plateau on to which our most able must climb.

The report acknowledges the work done in the teaching of design, thus recognising the truth which the Admiralty failed to see in 1914 - that it is both practical and possible to establish a methodology for inventing. An understanding of the nature of the method by which practical improvements are born may well assist with the planning of future teaching strategies. However it is possible that there will be a diversity of strategies since in reality education is compartmentalised within the school curriculum.

The Department of Education and Science, HMI, Examination Boards and Local Education Authorities describe Comprehensive schools in terms of Departments or Faculties. Commonly, although by no means exclusively, these divisions are still labelled by subject names which bear little less than similarity to the titles of the external examinations they offer. Where change has taken place we still find that the

Humanities Department offers History and Geography as separate areas of study, and that Science Departments still offer Chemistry, Physics and Biology. The possibilities of change described by HMI, which forsaw departments described as: 'Language Development, Mathematical and Scientific Activities, Creative and Recreative Studies, Cognitive Activities Examinations and Assessment'(8), are suffering from the illness which tends to plague innovations in general. Non-the-less, since problem solving is a human activity, it is inconceivable that teachers in each of our traditionally labelled curriculum compartments could deny a role for problem solving within their brief. Whether or not they all actively pursue 'Problem Solving' as a delineated aim would be an impossible question to answer without the existance of a nationally agreed and delivered curriculum, but clearly those who teach in Craft Design and Technology departments should be. For them at least there needs to be an understanding of what human activities make up the activity of design.

Kieth-Lucas identifies the presence of design in three areas of the curriculum. Art, Craft Design & Technology, and Home Economics are said to have evidenced change with a 'growing awareness of the importance of designing, planning, making and testing in practical activities.'(7)

Although 'Curriculum 11-16' says of science that it ought to be able to provide the answer to the question, "Can he devise, or contribute to the devising of, experiments which will put to test the explanations he suggests for the patterns of observations?"(8), (and even this paper makes no reference to the design of methods of making those initial observations), the subject is not identified as being one which has exerted pressures for change. This would seem to be a glaring error on someone's part.

Kieth-Lucas provides us with a synthesis of the design activities associated with the three identified subjects mentioned above. 'Design activities within these three subject areas vary in form and emphasis, but they have in common the aim of giving pupils experience of:

- examining a given problem or situation in order to identify and state the opportunities and difficulties involved;
- undertaking research and compiling data on the problem or situation and the factors affecting it;
- analysing the information gained;
- preparing a brief against which design proposals can be tested, so as to overcome the difficulties identified;
- proposing responses to the brief and choosing the most appropriate;

- developing this response and, where appropriate, bringing it to some practical conclusion;
- analysing and evaluating the results and communicating this to others.'(7)

The teaching of design, which is a) that which embodies all those activities outlined in the previous paragraph together with b) the appreciation that those activities are only relevant if they are considered as a whole, implies a project based approach. What is of vital importance to appreciate is that if the pupils are to become capable they must be enveloped by the complete activity. The law of packing (for an airflight) - says that the mass of the packed case will always be greater than the sum of the masses of its constituent parts. A similar rule of politics describes the power of a mob being more than the sum of the power of the individuals. On a more serious note, the teaching of the design methodology as done by modelling a desired situation and putting pupils into the predicament of a technologist after giving them an insight into the strategy they will be expected to follow, is the proper, 'whole world' way to fill a knowledge gap and utilise the design approach.

The methodology outlined by Kieth-Lucas is not quite the same as that outlined by the Association of Advisers in Craft Design & Technology who saw the work of pupils, once a problem had been identified, as involving four areas of activity. They described them as problem solving, evaluation, construction and communication.

They were seeking to analyse the needs of the pupil for the assistance of the teacher, and having identified these areas they sought to analyse the activities which each encompassed.

Of Problem Solving they described five contributory skills:

1) Analysis

2) Investigation

3) Ideas

4) Synthesis

5) Selection.

Of Evaluation they described four:

1) Continuous activity at all stages of designing and making

2) Problem appraisal and decision making

3) Testing

4) Comparison with the set problem

Of Communication they described four:

1) Oral

2) Written

3) Graphic

4) Modelling

and they highlighted an associated skill: Observation.

Of Construction they described five:

1) Materials

2) Tools

3) Machines

4) Processes

5) Safety

The implication that construction itself is a part of the wholeness of design is clear, or is it? In their first aspect of evaluation they refer to 'designing and making'. It is now not clear whether they see a role for 'making' as a stand-alone activity.

The National Criteria also draws the same distinction. For the purpose of public examination, the General Certificate of Secondary Education establishes three courses -

i) C.D.T: Design & Realisation. (D&R)

ii) C.D.T: Design & Communication. (D&C)

iii) C.D.T: Technology. (T)

The titles include the abbreviation CDT to signify that the content of any syllabus so labelled, will conform to the National Criteria for CDT.

The National Criteria for CDT includes a 'common core' which is made up of skills and knowledge, which it amplifies under sub-headings, and subject - related skills which are less well explained. 'Whilst the boundaries' (of the three main aspects of work) 'are frequently indistinct, the three aspects which can be observed, measured and assessed are identified as the aquisition of design skills, subject-related skills (which will principally be the making skills and the application of knowledge about techniques and processes when using materials) and knowledge.'(5) The subject-related skills as bracketed are identical for both D&R and T, but for D&C it reads '...subject-related skills (which will principally be the communication skills, the application of knowledge related to these skills and those making skills used as a means of communication)'.(5)

The skills required by the Common Core for each course are-

1. Design,
2. Making,
3. Communication,

and the word Design is amplified as 'Identification of problems, searching for and ordering of information, analysis, specification, synthesis, evaluation ' followed by -

in the case of D&R - '.'

in the case of T - '/final report.'

and in the case of D&C - 'at the drawing board stage of manufacture.'

and then continuing - 'Consideration of constraints, including costs, personal skills resources, time.'(5)

If making is seen as an activity divorced from design and evaluation, as seen by the National Criteria or from evaluation as seen by AACDT, then it seems to me that we are in danger of returning to the realms of building to someone else's plans, producing castings from someone else's mould or vacuum forming using someone else's former. The inevitable conclusion of which is mass production. We are back to the toothbrush rack once more! If making is a part of a design process, evaluation during making would imply re-makes or modifications - if not immediately then evidence would be available for future use. In reality it probably means written or drawn information included in the project report for the attention of the representative of the public examination board to whom it would then be submitted.

Design is clearly to do with planning, and its primary objective is to produce what was not there before. It is manifestly illogical to exclude making from design since it would allow the production of a completely useless solution, thus reducing the preceding efforts to the level of a farce.

Design is a cyclic process which contains, or better - enables, a range of activities to be utilised. It becomes difficult to describe by anyone who has not had practical experience in it and therein, I suspect, we may find the reason for the publication, shortly after the GCSE National Criteria for CDT, of the booklet 'Craft, Design and Technology. A Guide for Teachers'.(4)

The encompassing of a broad range of activities is described as a 'design loop'(4) It is prescribed as being a loose framework and a generalised procedeure. 'Depending upon the approach used by the designer, and in part on the nature of the design exercise itself, different elements around the loop will assume greater or lesser importance, and there may well have to be a great deal of jumping about across and around the loop before it is possible to arrive at a sound conclusion'.(4) The loop has the following labels around its circumference -

observing a context
detailing a problem
research

exploring possibilities

refining ideas

detailing a solution

planning the making

making

evaluation

detailing a problem

etcetera - around the loop, again and again.

Chordal arrows link some of the labels. For example from 'refining ideas' towards 'research' there is one, and the comment 'more information may be needed before refinement is possible' is added.

'Making' is firmly established as a part of the overall activity, which serves to satisfy me, but in the light of the hostility which the introduction of the GCSE aroused, it must be pointed out that anomalies of this sort make for an unnecessarily uncomfortable transition.

Having established the place of 'making', we return to the points made about it by AACDT. At first sight it might seem unlikely that 'making' will need much new consideration from the teachers unless there are developed new tools, machines and materials. Any combination of these would have implications for processes and from these specific 'rules' of safety may have to be developed. Perhaps safety might be seen by some as being a frame of mind, but if the mind is on a different plane perhaps a rule which automatically causes the physical detatchment of the person from the process - a guard - will be required.

Furthermore, we have already begun to appreciate the versatility of the computer and have come to recognise that as long as anything can be reduced to the level of an electronic pulse, it becomes food for electronic processing. The difference between 'on' and 'off' for instance is the presence of electricity or not. The change from one state to the other being a single pulse. If a lump glued to a turning shaft hits a switch once every revolution, the turns can be counted and if the answer is compared with time, the speed of the shaft can be calculated. The computer, as we shall see, will have implications for this once well established and packaged area of teaching.

Design at the school level is possible and desireable. There needs to be an appreciation of the totality of the exercise and teachers should be confident that the alternative results created by their pupils will be seen in the light of the new objectives. The teachers must be assured that those looking are competent to judge.

1. Prof. B.Crossland. 'Engineering education for fitness for purpose'. The Institution of Mechanical Engineers, 1986.

2. Hicks. G. HMI. 'Good Courses are Available'. Craft, Design & Technology, An essential component of a Balanced Curriculum, Brunel University, 1979.

3. Walker & Cross. 'Design: The Man-Made Object', T100, Open University Press 1976.

4. 'Craft Design & Technology, A Guide for Teachers.' S.E.C. & Open University Press 1986.

5. 'Craft, Design & Technology'. The National Criteria. D.E.S. 1985.

6. Rose & Rose. 'Science and Society'. Pelican. 1969.

7. Kieth-Lucas. D. 'Design Education at Secondary Level'. The Design Council. 1980.

8. Curriculum 11-16 H.M.S.O. 1977.

5. WINDMILLS AND ROBOTS.

The educational domain known as Craft, Design and Technology is instantly recognisable by its accent upon the manufacture of products. If there is any argument about where it, C.D.T., is going or indeed where it has come from, the making of things in a workshop environment has always been the end to which pupils were, and still are, aimed. In the past, as we have seen, the greatest influence upon school workshop based products has been the choice of materials from which those products were to be made.

The inherent properties of timber make it unsuitable for the manufacture of modern machines which require stiffness and stability of dimension to maintain the register of moving parts although early machines were able to take advantage of the length of the tree for the spanning of gaps and transfer of movement. The ability of timber to absorb shock and the ingenuity of man in developing jointing and ways of connecting it to other materials, allowed its use in both huge, predominantly static structures such as cathedral roofs and Tudor period warships, as well as dynamic structures such as hand looms and spinning wheels. It may be said that man's progress in the technology of production was enabled by the tree, since only later, in a time described as the 'Industrial Revolution' was metal - predominantly iron and steel - able to replace wooden struts, ties and connecting rods.

Available and amenable, timber responds to human effort in ways which complement, as well as compete with, those of the other material available to man the constructor, stone. The examples of early machines indicate mans ability both to harness the power of wind, water and muscle as well as to work these traditional raw materials. However, majestic though these early machines, such as windmills and watermills, were - and in their preserved state still are - their bulk and mass and their reliance upon nature for an energy input, made them no match for the increase in speed and the strength/weight ratio afforded by the metal and steam driven machines of the industrial revolution.

Although it is true that we no longer associate the construction of modern machinery with timber, important principles in control are exhibited by these early unwieldy devices. The windmill, designed for the grinding of wheat into flour, was turned into the wind and would continue to follow the wind even as it altered its direction. Waterwheels, such as those at the Abbeydale Industrial Village on the outskirts of Sheffield, Yorkshire and the Glebe Mill, Birsay in the Orkney Isles - which still grinds flour for the Dounby bakery - rely upon a constant flow of water to maintain the constant speed of the wheel. These are examples of two forms of natural energy being harnessed and controlled by the use of two different strategies, namely closed-loop and open-loop control respectively.

In the school woodwork shops, with the accent upon the aquisition of tool skills, there was little attempt to consider the concept of control, except in the context of controlling the tools in order to achieve the desired - the best - 'finish'. The nearest pupils might come to aspects of 'industrial control' would be their use of the woodturning lathe. The manufacture of products which exhibited movement possibly being confined to such things as toys and model boats. I recall making at school in 1962, a toy which was essentially a little model man made from plywood. It had separate arms and legs and was suspended from the top ends of two upright parallel strips of wood by two parallel and short lengths of twine. Half way down the strips was a short horizontal strut joining the strips and acting as a common fulcrum. When the lower ends of the strips were squeezed towards each other, the suspension string tightened, and because the hanging man had held the twine in a half twist, the tightening pulled the twist 'out', and the man did a summersault resulting in a half twist in the opposite direction. Continual squeezing summersaulted the man backwards and then forwards! The opportunity to use even this crude, but fun, artefact as an introduction to levers, torsion, tension, compression, bending, momentum and the transfer of energy was not capitalised upon, for I further recall that it was done as a job in 'Woodwork Club' which took place outside school hours.

Craftsmanship in the 'real' world outside the school during the 1950's and early 1960's, had little to do with these extra-curricular activities. Indeed the Central Youth Employment Executive described the opportunities for woodworking craftsmen in these categories:-

'a) Carpentry: Jobbing, doing repairs, Civil Engineering, harbour jetties, strong platforms for cranes, fitting racks, shelving, constructing drama scenery.

b) Joinery: Working at the Bench, window and door making, possibly working in hardwoods.

c) Cabinet Making: High class jointing, hardwoods, Veneering, Carving, Hand made furniture.

d) Patternmaking: The original shaped object from which subsequent metal copies were cast. Smooth surfaces with filler put into any sharp corners.'(1) (This is still a technique used today. The need to round internal corners was explained by Griffiths whose investigations into 'stress concentrations'(2) in castings, lead to a greater understanding of material failure and the effects of dynamic loading.)

'e) Coachbuilding: Making ash and oak frameworks for railway coaches, lorries and omnibusses.

f) Shipbuilding: Building launchways, replacing and caulking planking, small boat building.

g) Organ Building: Specialist maker of keys and pipes, installation and repair.

h) Cooperage: The repair of casks, kegs and vats. We are told that, 'Nowadays, new casks are usually shaped and put together by machine'.

i) Woodcarving: Ornamental joinery for churches and high quality furniture.

j) Woodturning: Working from a pattern to produce rounded table legs and the like. 'Automatic lathes are now used for mass-production turning, but high-class work continues to be done by hand.'

k) Other Woodworkers: Those who make packing cases, moulds for casing artificial stone, textile bobbins and shuttles, made-to-measure shoe lasts, and cricket bats.'(1)

Perhaps coffin makers would also have fitted into this last group, had delicacy not precluded its inclusion in the booklet.

It can be seen from the future facing 'boys who have the ambition to learn a craft' (1), that the choice of timber as a way to the aquisition of skills in the school curriculum, effectively precluded study of movement and control.

In the metalwork shops, however, the story is rather different, for it is possible to model steam engines, and through them obtain a 'feel' for motive power. The major criticism levelled at such projects, which were not design based, was the length of time it took to complete the engine, a single artefact. In the time it takes, a pupil can make two or three separate items exhibiting a range of different skills and processes. However, the small engine, successfully working, exhibits many of the processes and skills then seen to be necessary to a boys education. The boiler, made from copper, had to be rolled or cut from a length of tube, the ends were fitted and the joints soldered. The piston needed to be turned, the cylinder drilled or perhaps cast and then machined and the flywheel cast, turned and perhaps a locking screw thread drilled and tapped. Whilst there may have been those who argued that the manufacture and subsequent testing of pressure vessels in the school workshop might be fraught with danger, others may well have seen a unique opportunity for the production of a job which had a 'character' all of its own.

The alternative to engineering was to learn the skills of the blacksmith, the tinsmith and the beaten metalworker. The metal equivalent of the carpenter and joiner because the accent is placed upon the quality of the workmanship and not the innovation of its design or its benefit from the principles of control.

The point which needs to be emphasised is the missed opportunity for the educational accent of school workshop work to be placed upon the subject and study of control. An opportunity 'hidden' by the unquestioning acception of skill aquisition as the major aim, although it would have been possible for the same work and facilities to have been used to introduce an experience in technology.

In contrast to the education of secondary pupils, the aim of the 'real-world' was to make progress in product design. Vaccuum cleaners, electrically driven sewing machines, washing machines and food mixers all aimed at the domestic market were marketed as 'labour saving' and the term 'consumer goods' became common parlance. Education, however, could only perceive the need for machine and tool operators, it could not, or at any rate did not, serve to encourage the generation of new ideas amongst its pupils.

Currently, 1986/7, consumer goods - microvave ovens, personal cassette players, portable sound systems, video recorders, children's games and toys - display an increasing use of electronics and it is easier to relate aspects of control to pupils in terms of their actual experiences. The most sophisticated machines are those which are able to 'think for themselves'. Their response to the stimulus of their input being improved by taking into account a description of how the output is progressing towards the aim. The efficiency of the machine is improved by a description of its output being returned to that part of the machine responsible for the organisation of the output. For instance , the shower which is too hot has its heat input reduced by the user. A more desireable, and sophisticated, arrangement would be to have the shower adjust the heat input to the water independently of the user once the desired temperature had been specified. This higher order of control sophistication is described as 'automation' when the modifying response is independant of human intervention once the parameters have been set.

In order to design such systems, not only must both the operation of the machine and its objective be clearly understood, but it is necessary to understand the relationships between the two. Only when both are understood can the form of the control information be described. A reverse link is used to pass a quantitative description of the output back to the input side of the process stage. The form and magnitude of the description must be such that it is seen to be appropriate, compatible, and an extra input to the system by the process stage. It might be appropriate to combine the returned information with that from the input device. The combined information would then be directed to the original process stage, which would never need to 'know' that an extra, pre-process, stage had been introduced.

Kibasi and Mills identify three different roles for the computer in the laboratory or industrial environment. 'Taking for granted an obvious computing ability, there are two levels at which the microcomputer can interact with the outside world. It might take the "passive" role of a data gathering machine (a data logger), monitoring a process or experiment; alternatively it may form the active controller in a closed loop control system. For the second activity to make sense, it must include an element of data monitoring, in order that the control loop is closed and that "intellegent" decisions are made.'(3)

Kibasi & Mills have accepted that a capability of process modification in the light of the state of the output currently exists and then they go further. They identify a consequent need to make sense of the output sampling results before determining the best modifying input which will be returned and injected into the front of the process stage. For the results to be manipulated, it will be necessary to store them until a sufficiently large collection is assembled for a statistically worthwhile conclusion to be drawn. The number of stored samples will depend upon the method and accuracy of the analysis.

There is what is sometimes called a 'trade - off' involved here. Since the fundamental reason for this improvement is to achieve automatic progress towards the optimum output, an increase in the accuracy and sophistication of the sampling technique and its analysis, should result merely in a reduction in the time to achieve system optimisation. There will be a judgement made comparing the benefits of the improvement with the costs of achieving it.

When the time to optimal performance approaches the infinitesimal, the machine may well be perceived as having 'intellegence' - if intellegence is seen to be the sum total of doing things correctly in the fastest possible time. Not, I must agree, a wholesome definition but one which might go some way to describe that which a child is using as it puts irregular objects through a set of exclusively different apertures for the benefit of it's doctor and/or parents. The human perception of a machines 'intelligence' can now be considered if the movements of the machine and its progress through a task, is compared with the accuracy, speed and purpose of a human being accomplishing a similar task. The act of making a comparison establishing an acceptance that somehow, and to some extent, a machine has replaced a human being.

The original concept of a man-made, human-like creature was the result of a combination of circumstances. Isaac Asimov reminds us that in 1791 Luigi Galvani demonstrated movement in the muscles of frogs legs co-incident with them being in contact with two different metals. He drew the conclusion that 'animal electricity' existed in muscle tissue, a theory shortly to be dispelled by Alessandro Volta. The cell, demonstrated by Volta, which produced electricity without muscle tissue, was later to be improved by Humphrey Davy in 1807 and 1808, and with its help, Asimov relates, he was able to carry out 'all sorts of chemical reactions that had been impossible to chemists in the non-electrical age'.(4) He opined that, 'Electricity was therefore a word of power..', and 'Interest in the relationship of electricity to life was intense'.(4) It was shortly afterwards, in 1818, that Mary Shelley had a novel published. Her anti-hero, a young scientist named Frankenstein, 'a student of anatomy, who assembled a being and succeeded in infusing it with life by way of electricity'.(4)

Asimov continued to trace the development of man's imagination on the theme of created beings, by describing a play written by a Czech writer, Karel Capek in 1921 called 'R.U.R.'. He wrote, 'R.U.R. stood for Rossum's Universal Robots. Like Frankenstein, Rossum had discovered the secret of creating artificial men. These were called 'robots' from a Czech word meaning 'worker,' and the word entered the English language and gained a strong hold there.'(4) He draws the parallel between the fate of Shelley's Frankenstein and Capek's population - both destroyed by their own creations. 'Once again the scientific Faust has been destroyed by his Mephistophelean creation'.(4)

The contribution of Asimov, as a writer of science fiction, to this thesis may well need some justification at this point. His career in science fiction writing began in 1939, at the age of nineteen, with short stories. He was an undergraduate at Columbia University reading chemistry. After graduation and some time in the army, 'he gained his doctorate in 1949 and qualified as an instructor in biochemistry at Boston University School of Medcine where he became Associate Professor in 1955, doing research in nucleic acid.'(5) Thus within the single person there is the ability to concoct interesting narrative whilst maintaining an aura of probability based upon an understanding of the past progress of man together with his appreciation of likely paths of development as prodded by current scientific research.

In the book, he contrasts the early Faustian image of the robot with his own alternative and states, 'Consider a robot, then, as simply another artifact. .... As a machine, a robot will surely be designed for safety, as far as possible. If robots are so advanced that they can mimic the thought processes of human beings, then surely the nature of those thought processes will be designed by human engineers and built-in safeguards will be added. The safety may not be perfect (what is?), but it will be as complete as men can make it'.(4)

He was at pains to create a scenario where his robot technology could exist within a logically developed form of human society. He needed a scenario which would be credible for readers who had thus far only known a future world where calamity befell those who dabbled with robotics.

The seriousness with which he took his prophetic prose is perhaps best illustrated by the following which was included in a short story written in March 1942 called 'Runaround'. Coining the word 'Robotics', he laid down the 'Three Laws of Robotics', which are respected by other writers of science fiction.

'1. A robot may not injure a human being, or, through inaction, allow a human being to come to harm.

2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.'(6)

It is worthwhile considering the state of technology in 1942. Although the watch and clockmakers were capable of minaturising machinery, the transistor had not yet been demonstrated, neither had the electronic computer, there were no aerosol sprays, aeroplanes still had propellors, and the world outside Europe had yet to be dragged into the Second World War.

Throughout the books of Asimov, and others who contemplate the future as influenced by technology and science, robots are described in a variety of forms and having different purposes. The three laws were written with the humanoid form in mind - robots ultimately indistinguishable from the humans but with the ability to wield great power. Alternatively, in the Star Wars films, (7) 'R2-D2' was not created in human form, and its purpose was to assist with the mechanisms of the day. Indeed their faith in the capabilities of man to create humaniod robots had been tempered by the reality of the actual progress in our own time. 'C3-PO', a golden human-form robot, was shown to be awkward, inflexible and was never put in a position where any possible super-human strength could be demonstrated. Its excellence was shown to be in communicating with the skills of a politician.

Throughout science fiction writing the robot always seems to be able to do the following - move, make decisions, exhibit strength, communicate and act independently. Furthermore, it always seems to be able to do one or more of these things better than humans can. Robots are there to relieve humans of effort and from drudgery but not from the higher order responsibility of philosophising.

So how far has technology progressed in the practical applications of automatic control theory? The reality of the robot in the 1980's is described by Griffiths and Lewis who wrote, 'The main interest in robot applications has been in spot welding, arc welding, injection moulding, surface coating and machine tool service. These applications are automotive produce orientated.'(8)

1. C.Y.E.E. 'Woodworking Craftsmen'. Choice of Careers No.25, H.M.S.O. 1958.2.

2. Griffiths. 'The New Science Of Strong Materials'. Pelican. 1968.

3. Kibasi & Mills. 'Micros in Control'. Personal Computer World. 1980.

4. Asimov I. 'The Rest Of The Robots'. Panther Books. 1968.

5. Preface. Asimov I. 'Robots and Empire'. Panther. 1985.

6. Asimov I. 'Runaround'. Astounding Science Fiction. March 1942

7. 'Star Wars'. 20th Century Fox. 1977.

8. Griffiths & Lewis 'Robots in Foundries'. Production Engineer Journal. February 1986.

1985.

<u>6. TILTING THE WINDMILLS.</u>

We have seen that in schools there are facilities for making and there is evidence to support the belief that school children have been effectively involved in aspects of control. We have also become aware that the sophistication of domestic and industrial equipment commonly reflects a greater utilisation of electronics, and there are stories from the past which, with the benefit of hindsight, now seem closer to prophesies rather than fantasies.

If there has come a time to consolidate change, what is needed to influence change and to what extent should change occur? These were some of many questions which the nation were asked to consider in the regional conferences chaired by the Rt. Hon. Shirley Willims M.P., then the Secretary of State for Education and Science. These conferences were collectively known as 'The Great Debate on Education'

In his letter to Chief Education officers of July 1978 from the Department of Education and Science, Stone refers to the 'debate on education initiated by the Prime Minister (Rt. Hon. James Callaghan. M.P.) towards the end of 1976'.(1) Stone asserted that there had been a 'recognition of the importance of improving school/industry liason'(1) and in particular he refers to the establishment of a number of 'Science and

Technology Regional Organisations'(SATRO's).

In its guide to 'Schools and Industry', the Careers Research and Advisory Centre lists the aims of the proposed 40 SATRO's as being threefold -

'1) To encourage innovation in science and technology education.

2) To improve understanding between schools and industry.

3) To provide practical help to teachers.'(2)

In 1986 the 'Directory of organisations' was published by HMSO as part of the 'Industry Year' initiative. The aims of SATRO and its locations were described as, 'To enhance young people's understanding of science, engineering, industry and technology through closer working links between schools and the outside world. SATRO is a network of locally accountable centres operating under the auspices of The Standing Conference on Schools' Science and Technology. (SCSST) Currently there are 40 centres serving 97 local education authorities throughout the United Kingdom, and several more are under development.'(3)

All three of the original aims have cost implications for the education service. There can only be external innovation from outside schools by the alteration of public examination syllabusses. This is not the same as writing new syllabusses because schools can choose whether or not they wish to introduce them. In fact the new syllabus approach can actually militate againsed progress, for if it is proposed to introduce an extra course school management knows too well that pupils will be attracted from a range of other subject areas. In fact any school subject which seeks to make itself more popular must aim to reduce the number of children opting for the other subjects, even if it replaces a current course. In any case it is not clear how the public examination boards could be pursuaded by a body without executive power to make such changes. The alternative is to access the teachers directly and this can be done, either in the teachers own time - which is unlikely to be universally popular thus leading to unco-ordinated progress, or in their employers time which will have cost implications. As CRAC admits '.. but they all rely on the voluntary help of individuals and organisations in the region.'(2) The second aim relies upon the establishment of contacts within the school. The senior management, if they already understood the value of the initiative would be actively engaged. If not, they are well placed to pass it on to teachers who already have a full teaching commitment. The provision of practical help by answering questions, identifying agencies for the purchase of materials and the establishment of an industrial contact directory are three examples of ways in which SATRO's are better placed to be used as a teacher originated resource rather than as an external director.

Shillito, Deputy Director, National Centre for Schools Technology (NCST), Trent Polytechnic, writing in Trends in 1979, quoted from James Callaghan's speech given at a careers convention organised by the National Union of Teachers. Speaking of the need for young people to be attracted into industry Callaghan continued, 'For its part, industry has to turn its mind to ways of attracting and keeping this kind of young person. It must be prepared to offer opportunities for advancement and ensure that able young people are properly motivated and given sufficient responsibility from the start.'(4) Shillito argued that 'There have always been links between some schools and between some education authorities, some employers and some trade unions. Some of these links have a direct impact, through the curriculum, on the children themselves. Others remain as good intentions in the rarefied atmosphere of the boardroom and the head's study.'(4) He was not talking about careers visits to the local factory or office block for he continued, 'Links need to become stronger, more widespread and more firmly anchored and effective within the school curriculum itself ......new forms of liason should be developed.'(4) He continued and described an initiative set up between Ashfield Comprehensive School, NCST and industrialists. His report made two main points. The first referred to the need for a higher profile for industry in schools, 'If aspects of engineering and industrial technologies are included in the curriculum they will assist not only in stimulating an awareness of technology and motivating pupils to creative activities, but also in inspiring them to make their careers in industry.'(4) The second could well have been the epitaph for the messenger, 'There is a growing desire on the part of industry to help in the educational process. Goodwill exists between all the parties concerned in the relationship between education and industry. It is, however, the responsibility of the education sector to provide the basic organisation to encourage this cooperation and goodwill. ...... For collaboration to happen and be fruitful, specific manpower must be allocated. Links will not become widely established on the basis of goodwill and moral support alone.'(4) The implication of this is clear - money to pay salaries. The money would have to come from local authority education budgets. There would be many who would not see the broader curriculum advantages of this proposal but would link it with their out dated image of workshop based courses. They would identify many other areas of the curriculum which needed priority support. The proposal, on its own, was at a considerable diadvantage.

The General Election of 1979 had been fought predominantly on issues connected with employment. The Conservative Party were challenging the Labour administration on the nations' low industrial productivity, an unfavourable balance of payments, and the rising number of unemployed. A Conservative poster displayed on prominent street hoardings showed a seemingly unending queue of unemployed people and was sub-titled, 'Labour isn't working'.

When the Conservatives were elected to office with a huge majority, the political judgement that the reviving of industry would be the salvation of the British nation, was taken by the new government as having been confirmed by the electorate. Policies reflecting the 'monetarism' strategy of Professor Keynes were continually referred to, and the linking of industry and productivity with all political initiatives was given a high profile. The linking of education to industry was also to be a part of the strategy.

The County Careers Officer for County Durham, Dick in his letter to me of 21.6.79, refers to 'the setting up in 1978 of the Durham Industry Commerce (Education) Associations (or DICE)'.(4) He included a simple handout which described the history of DICE and a statement of its major objective. 'After the meeting (the South West Durham Careers Association Oct 1976), Messrs. Wooley and Breckill of Black & Decker Ltd., wrote to suggest that something more positive should be done to tackle some of the problems faced by Industry and Education'(3). Following this, a committee was set up which felt that a formal association should be inaugurated. 'Education is something everybody experiences and at the moment is the subject of considerable debate. At the same time the business world has also expressed concern about a certain lack of understanding between itself, and the educational sector. Dice is an attempt to lead to a better understanding of each others needs and objects.'(5) There is not much difference between the aim of DICE and Aim 2 of SATRO.

A breeze of change then, detected by the stirring of the odd political ash. For the forest to murmur, as in Wagners Germany, the connection between industry and education was about to be identified as the juggernaut upon which changes could be presented, and subsequently carried forward. The most dramatic use of the schools - industry link would be within the power of Government and although the storm of the forthcoming innovations had not yet broken, not too distant signs were contained in the second paragraph of Stones' letter to the Chief Education Officers. 'As you will know, the Government recognises the key importance of manufacturing industry to the economic developmemt of the UK and is committed to the regeneration of industry through the industrial strategy programme which has the full support of the CBI and TUC. The Secretary of State believes that as part of their general educative function schools can contribute to this process by providing a broadly based curriculum for pupils of compulsory school age so that doors are kept open to allow a significant proportion of them to elect to follow scientific and technological courses in sixth forms and further and higher education; by increasing the extent to which the curriculum enables pupils to understand the workings of industry and the important role it plays in society; and providing opportunities for pupils to develop an interest in industrial careers.'(1)

Another of the questions raised by the Great Debate concerned the extent of change, was also addressed in the letter, as the D.E.S. exhorted Local Authorities to set-up liaison bodies which would consider matters of common interest to education and industry. It gave the following as examples,

'i. the adequacy of arrangements for work experience and work observation for pupils in the area;

ii. opportunities for teachers to gain experience of industry, and the ways in which such experience can be assessed and used in education;

iii. ways in which the understanding of young people about living and working in an industrial society can be facilitated;

iv. conversely, ways of securing that industry and commerce have a more intimate knowledge of the aims, methods and circumstances of schools;

v. ways in which interest in wealth producing sectors of the economy, and in the openings to employment at all levels in industry through relevant further education, polytechnic and university courses, can be stimulated;

vi. ways in which industrialists and trade unionists can make a positive contribution, both in respect of careers education and as members of governing bodies and through informal school/industry meetings;

vii. the analysis of existing local school/industry activities and the encouragement of new initiatives, with points such as (i)-(vi) above in mind.'(1)

In his letter to Educational Bodies of October 1978, Baker informs them that the D.E.S is considering the educational implications for micro-electronic technology. 'The Government is now considering the implications of a strategy to ensure the most beneficial exploitation of the new technology. The aspects under consideration include:

i. The need to promote a better understanding of the technical and economic issues involved among those (both managers and engineers) who will be making or influencing decisions on the application of technology;

ii. the training and retraining of the existing work-force to give them a working knowledge of the new technology and an appreciation of its potential application;

iii. the longer-term implications of the new technology for the education service;

iv. the wider social economic and social implications, eg for the future structure of the employment market.'(7)

The letter also explains the Departments view that an adequte response to developments in micro-electronic technology implies, amongst other things, 'giving all children and young people the essential educational grounding to enable them to understand and adapt to the rapid and profound technological changes which may now be expected'(7).

Baker also identifies the challenge to society of 'new technology' and then goes on to describe the responses to be directed at those areas of society which will be most directly affected by it.

In the area of Education, the D.E.S. was considering - 'The feasibility of a national programme of schools and colleges to become fully aware of micro-electronics and to make the best use of the new opportunities it offers.'(7)

The result of this consideration was a consultative document published by D.E.S. in March 1979. Entitled 'Microelectronics in Education: A Development Programme for Schools and Colleges'(9), it was described in a D.E.S. press release of March 1979 (8), which makes no mention of of any other beneficiary from the Development Program than the Local Education Authority's, schools and colleges. It points to four activities from 'within the programme'. Summarised, they concern:-

a. funding to promote familiarity with applications,

b. developing teacher training, funding for microelectronic courses,

c. assessment of computer assisted learning,

d. assessment of equipment and funding for new equipment in particular projects.

The paper itself (9), is broader in its audience, as can be seen from the following quotation in the first paragraph. '....and it, (Government), is taking appropriate action. First, it is launching an "awareness" campaign aimed at mamagers, designers and Technologists at all levels; secondly, direct support is being given to help industry exploit the potential of microelectronics; thirdly, public procurement will be used to encourage use of the new technology; and fourthly, initiatives are being taken in the fields of industrial training and education'.

However, having described the links its programme has with industry, the remainder of the paper concerns itself with matters of concern to the education service, and the scope of the programme describes the context in which the initiative is to be seen. 'The programme will be concerned primarily with the applications of the new technology rather than with its science. It will not cover specialist training in microelectronics, for which arrangements are being studied separately, since neither the schools nor the majority of FE courses need to be concerned with how microprocesssors are made or the detail of how they work. The programme will of course help indirectly by contributing to a foundation of good school science courses including electronics and ready access to computing facilities.'(8) The cost and lifespan of the programme was described in the last paragraph. '...the Government has decided that up to an average of £2.5M per annum over a period of 5 years may be available to cover a programme in England, Wales and Northern Ireland.'(9).

The aims of the Government should now be clear, providing the statements have all filtered through to those who 'need to know', and it is precisely this filtering through which may prove to have been a flaw in the strategy for improving technological capability within the schools. In view of the Governments' perceived need for such an upheaval in the content of the educational curriculum, it might have been prudent to investigate why technological progress had stagnated. For if, as I believe, the business of internal educational communication and the operation of curriculum development is less than efficient, the new initiatives would still fail.

In a letter to me from the D.E.S., 17 July 1979 (10), the consultative document and its 'plans for a national development programme to help schools and colleges become aware of the potential of micro-electronics'(5) was referred to in the context of wider political concerns. 'However, this programme is currently under review in the light of cuts in public expenditure'(10). The penultimate paragraph of the letter seems to assert the relatively high importance of the initiative with a view, perhaps, to engendering a sense of optimism. 'The DES recognises that an appropriate response to the new technology must necessarily include the provision of technical courses to train the specialists who will be neded for industry. However, it is also important to develop non-technical education to familiarise adults and children alike with the potential widespread uses of microprocessors, to help them to adjust to the rapid changes society can expect to see in the next few years'(10).

In the event, the government established the 'Micro-electronics Education Programme' in November

1980, with an annual budget of £5.0m and a life expectancy of six years. Its aims were:

'* to promote, within the school curriculum, the study of microelectronics and its effects.

* To encourage the use of the technology as an aid to teaching and learning.'

To achieve these aims, MEP works closely with local education authorities and stimulates programmes of teacher training and curriculum development, both regional and national.'(11)

The major statement of the MEP strategy reads, 'The aim of the programme is to help schools to prepare children for life in a society in which devices and systems based on microelectronics are commonplace and pervasive. These technologies are likely to alter the relationships between one individual and another and between individuals and their work; and people will need to be aware that the speed of change is accelerating and that their future careers may well include many retraining stages as they adjust to new technological developments'.(11)

As the consultative paper(9) anticipated, the project was administered by the Council for Educational Technology, a body set up in 1973 as a charitable trust and funded jointly by DES England & Wales, Scotland and

Northern Ireland. The regional concept of the MEP strategy divided England Wales and Northern Ireland into fourteen areas with roughly the same population, and groups of LEA's were expected to work with the MEP in such a way that when the six years ended they would continue to support it. 'Each Region, supported and guided by MEP, separately provides a major Information Service, monitors, supports and guides curriculum development and has established an INSET (in-service training for teachers) pattern for Microelectronics Education.'(12)

The North Region was defined as including Cleveland, Cumbria, Durham, Gateshead, Newcastle upon Tyne, North Tyneside, Northumberland, South Tyneside, South Tyneside and Sunderland LEA's. The Directorate of the whole programme was based in the grounds of Newcastle-upon-Tyne Polytechnic, as was one of the four Special Education Centres.

The teacher training was seen to be required at different levels of difficulty or sophistication to meet the different levels of knowledge already held by existing teachers, and it would need to be delivered with an appreciation of the variety of different skills demonstrated by the teachers. However, four Domains were identified which would cover 'the following general areas:

1) Electronics and Control Technology.

2) Computer as an Instrument (Computer Studies, in control of scientific instruments and in art and music).

3) Computer Based learning (CAL, CML).

4) Communication and Information Studies (information retreival, data bases, word processing).'(12)

Each general area was assigned a 'National In-Service Training Co-ordinator' who were based in Hampshire, Dyfed, Hertfordshire and Leicestershire respectively. The Electronics and Control Technology domain had its Northen Region co-ordinator based in Sunderland and in the same building there was established one of the National Evaluation and Development Centres.(NEDC) The Sunderland NEDC was developing the range of facilities and strategies which were to be copied in the other Regional Information Centres.

By October 1985 MEP had produced 21 'files', which were commonly referred to as 'Green Files'. Bound by sprung plastic and covered with green card bearing the MEP logo, each was a book which contained information on curriculum innovations utilising computers, electronics or both. MEP described the potential of electronics in CDT in its publications description of 1985. 'This medium', (microelectronics) 'enables pupils to engage in meaningful design activities where real choices have to be made about what approaches and materials are chosen and how they are utilised. Microelectronics may be used in the CDT approach exactly as any other resource/medium/tool and appropriately and effectively integrated into project type activities which incorporate a variety of other materials, techniques and skills.'(13) Although the initial purpose of MEP had been to provide in-service training for teachers, both the Salford and Sunderland centres had developed support materials.

However, for teachers employed by local authorities not supporting a centre, or being unwilling to provide support for attendance at their in-service courses, there was neither reason nor incentive for them to implement innovations.

It is not inconcievable that many teachers remained unaware of the work being done by MEP. I, personally, know of one and I am thankful to Tom Mead, Director of Sunderland Microelectronics Education Centre and NEDC, and author of the green file called 'The Book', an encyclpaedia of electronics for the CDT teacher, for his time when he allowed me to interview him in November 1985.

1. Stone. R.H. 'Schools/Industry Links'. Letter to

Chief Education Officers. DES. 28.7.78.

2. 'Schools and Industry - A guide to schools - industry links'. Careers Research and Advisory Council. 1979.

3. 'School / Industry Links - A directory of organisations'. HMSO. 1986.4. Shillitoe. A. 'Education and Industry: A project in Ashfield.' Trends. 1979:1

5. Dick. G.R.D. Letter to the author from Durham County Careers Office. DCC. 21.8.79. (Appendix 2)

6. 'The History of DICE', Durham Industry, Commerce Education Association. Notice of Inaugural Meeting. January 1978.

7. Baker. M.B. 'Educational Implications of Micro-Electronic Technology'. Letter to Educational Bodies. DES. 24.10.78.

8. 'Microelectronics Development Programme For Schools and Colleges'. Press Release. DES. 6.3.79.

9. 'Microelectronics in Education: A Development Programme for Schools and Colleges'. DES. March 1979.

10. M.D.Goldspink. Letter from Department of Education and Science. 17.7.79. (Appendix 2)

11. MEP. 'The Programme.' Education November 1985.

12. 'Electronics & Control Technology Domain. Information File.' MEP Ronsella. 1984.

13. 'Of Particular Interest To CDT Teachers' MEP Ronsella 1985.

14. 'Electronics and Control Technology Domain. The Book.' MEP. Ronsella. 1985.

7. OF CHIEFS, INDIANS AND LEMMINGS.

January 1980 saw the publication of the Finneston report into the future of the engineering profession(1), and in the following March, the School Technology Forum - a forum of teachers' associatons under the aegis of the Standing Conference on Schools' Science and Technology - held a conference at Trent Polytechnic. The conference, called 'Chips in Control' ~~had two tasks,~~ '.. first, to examine the necessity for the potential of microelectronics in industrial engineering applications to be made clear in the schools; second, to examine the nature of the engineering talents needed in industry if the full potential of new technologies is to be realised.'(2)

In his address to the conference prior to the group discussions on the Finniston report, G.L.Wilde O.B.E. - Rolls Royce consultant and lately their Chief Engineer - made reference to the reality of engineering. 'If you were to ask a group of people who was responsible for putting men on the moon, most would answer scientists. In fact it was engineers for it can be said that the scientific content of the project was the Newtonian mechanics of the eighteenth century'.(2) He identified six areas of engineering - civil, mechanical, electrical, chemical, aeronautical and space - and explained that each area employed ''design' engineers,'technical' engineers', 'research' engineers, 'development' engineers, 'production' engineers, and 'planning and organising' engineers.'(2)

He continued to illustrate the reality of engineering with an analogy. 'These engineers are supported by the practical skills of fitters, machinists, pattern-makers, tool-makers, and technicians in the workshops just as in hospitals the doctors, surgeons and consultants depend upon the nurses, sisters, technicians'.(2)

He continued to argue that theory and practice are both essential skills for design engineers, and complained that the loss of the apprenticeship stage in engineering training had resulted in graduates entering industry inexperienced in the 'basic skills needed for engineering design'.(2)

The theme of these quotations provides the scenario for a comedy of errors. A pre-amble, which establishes that the overall opportunity for creativity in industry is not obvious because of the popular misconception of the role of the engineer. The main thrust, which explores, in a helter-skelter of action, the miriad scope for the satisfaction of particular interests in creativity. The tragic ending, where the the audience is treated to the sight of a giant roman dinosaur struggling against being hung by the life-line of its own self-perception.

The discussions which followed were intended to analyse the Finniston report, but following Wilde's illustrated lecture, it is not suprising that the group reports tended to have been tainted by the points which he dwelt upon. Whilst never actually being referred to as a modern Nero, the once emperor of the Confederation of British Industry, having lent his name to the report, became connected with some serious criticisms which were:

a) The lack of mention of the design process and experience.

b) No reference to the need for children to have creative experiences at school.

c) No mention of the qualities, as opposed to subjects, to be aquired at school.

d) No new ideas for the encouragement of Engineering qualities in recruits to industry.

e) The importance of skills in visual communication were not mentioned.

f) The strong emphasis on economic/industrial national needs rather than the needs of the whole child.

g) The concentration of the report on management, rather than design, skills.

The Forum responded to the Finniston report by identifying four 'key issues', which it summarised as follows:

'1. A national commitment to the recognition of the importance of a comprehensive profile of personal qualities needed by engineers at all levels should be instigated.

2. There is no reason to believe that those subjects which might be thought to keep open the options for engineering subjects are the same subjects which also influence pupils with latent engineering aptitudes to make career choices towards engineering.

3. Don't "re-invent the wheel". Use the "best practice" examples of schools already committed to demonstrate the lines which might be taken to other schools.

4. The argument for changes in the schools must not be based on the current, possibly cynical, manpower needs of industry.'(2)

The identification of an engineers profile stemmed from the need to develop a true perception of engineers and their work. The second key issue arose from a closely argued piece of evidence which the Forum had submitted to the enquiry. It is of key importance because it can produce a positive, rather than simply misinformed, anti-engineering career choice.

Summarised, the argument is as follows.
School subjects used as selection criteria for Higher Education aquire high status. Even for engineering, creativity subjects are not called for. The more able

pupils do not choose low status subjects. In the 6th form, those eligible for engineering in Higher Education are those who study Maths and Physics. They were motivated in the 4th and 5th year by the scientific objectives of curiosity and the aquisition of knowledge. But science, taught as a discipline, is not easily translated to the improvement of the human condition and without creative experiences the able pupils are not inspired to create or to gain wider perspectives.

Reference has already been made to the developments in Technology education. The third key issue acknowledges these. However in the precursory argument which describes both the progress and its dissemination, there is to be found this paragraph. 'Without the (doubtful) advantages of central direction of the curriculum enjoyed by some other countries, the amelioration of these constraints in this country can only come about through persuasion by example'.(2) In the light of the the current (1987) discussions on a National Curriculum, it would seem that as a wind of change, 'persuasion by example' blew too slowly!

It is often salutory to look at the statements of history. Those responsible for the synthesis of the fourth Key Issue can now be seen to have suffered from collective chamberlainism. The discussions had indicated an apprehension and doubtfulness on the part of the schools about 'designing their curriculum to meet the manpower needs of the moment'.(2) Having recognised the cyclical nature of manpower shortages and accepted the teachers belief that the basis of their credibility would be lost if they were to be seen as the providers of industrial fodder, they wrote - 'The Forum believes that these are unnecessary worries'. Instead, they identified the personal and social problem solving activities as being the mainstay of the argument that technology should be the subject of a curriculum change.

It was also in 1980 that the Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA) published in the national press its Education for Capability Manifesto. In 1985 the RSA produced it again, with minor ammendments and with a list of signatories. 'Circulated among leading figures in industry, the professions and education, it found many willing to sign and endorse its concept of balance.'(3)

'There is a serious imbalance in Britain today in the full process which is described by the two words "education" and "training". The idea of the "educated person" is that of a scholarly individual who has been neither educated nor trained to exercise useful skill; who is able to understand but not to act. Young people in secondary or higher education increasingly specialise, and to do so too often in ways which mean that they are taught to practise only those skills of scholarship and science. They aquire knowledge of particular subjects, but are not equipped to use knowledge in ways which are relevant to the world outside the education system. This imbalance is harmful to individuals, to industry and to society. A well-balanced education should, of course, embrace analysis and the aquisition of knowledge. But it must also include the exercise of creative skills, the competence to undertake and complete tasks and the ability to cope with everyday life; and also doing all these things in co-operation with others.

There exists in its own right a culture which is concerned with doing, making and organising and the creative arts. this culture emphasises the day-to-day management of affairs, the formulation and solution of problems and the design, manufacture of goods and services.

Educators should spend more time preparing people in this way for a life outside the education system. The country would benefit significantly in economic terms from what is here described as Education for Capability.'(3)

The RSA spring newsletter 'Education for Capability', 1984, explained that the manifesto aimed to encourage and develop four capacities which its authors maintained were under-emphasised in the education system. 'The great majority of learners - whether pupils at school, students at universities, polytechnics or colleges, or adults still wanting to learn - are destined for a productive life of practical action. They are going to do things, design things, make things, organise things, for the most part in co-operation with other people. They need to improve their competence, by the practice of skills and the use of knowledge; to cope better with their own lives and the problems that confront them and society; to develop their creative abilities; and, above all, to co-operate with other people. It is these four capacities that we want to see encouraged and developed through Education for Capability.'(4)

The Manifesto complained that young people were not equipped to use their school derived knowledge in ways which are relevant to the world outside the education system, and the document is quite firm in its argument as it sees the country benefitting economically from a change towards capability in education. When compared with Key Issue No 4. of the School Technology Forum, this is a firmer stance. What is missing is that recognition, seen by the Forum, of actual developments and trends already undertaken.

As has already been described, the education system has always had within it the facilities for fostering competence, creativity, coping and co-operation, and pupils have followed courses in secondary schools leading to external examinations for many years. Why then did the Royal Society of Arts see a need to establish such 'new' courses if they were already in existence? Furthermore, if 'leading figures in industry, the professions and education'(3) were prepared to append their signatures, could it be that they were unaware of the work done in secondary schools? And if they were, might this not be yet another erroneous action in the comedy?

Each signatory was associated with the name of an organisation with which he or she had been, or was currently, associated. The list ended with a note: 'The signatories were asked to support the manifesto as individuals and not on behalf of any particular organisation.'

That being the case, and assuming that the list is complete and has not been edited, its composition might illuminate the areas of interest and may reflect the strength of feeling therein. No firm conclusions should be drawn except to record that the publication of the manifesto elicited the resulting pattern of response.

The signatures were published in associaton with a brief description of occupation. The following is an analysis based upon broad occupational categories. (Where it was not obvious as to which category the description belonged, it was regarded as uncertain.)

Broad category.	Number of signatories.
Educational bodies	89
Manufacturing industry	46
Commerce	36
Government links	23
The Arts	12
Royal Society of Arts	7
Teachers associations	2
Conservative politicians	6
Media	5
Unions	2
Hospitals	2
Labour politicians	2
Liberal politicians	2
Charity	1
Religion	1
Uncertain	21

Total	267

In November 1985 I asked (5) a random selection of signatories for their views upon the need for this new initiative, in the light of the change in emphasis which had occurred back in 1967 with the foundation of Schools Council Project Technology.

The Rt Rev David Sheppard, Bishop of Liverpool, pointed out that '...it is in the nature of things that things in this world go wrong rather than right!'(6) He had been Vice Chairman of the Commission which had recently published the report 'Faith in the City', and he continued, 'Many points in the Report....have been made before in the course of the last one hundred years and more: we have to say them again and again in relation to present-day circumstances because people do not listen or don't want to listen or fail to give them our priority, or genuinely disagree.'(6) A realisation which in itself is not new, for Machiavelli wrote in 1513, 'There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all who profit by the old order, and only lukewarm defenders in all those who would profit by the new order. This lukewarmness arises partly from the incredulity of mankind who do not truly believe in anything new until they have had actual experience of it.'

However Sir Henry Chilver, Chairman of British Schools Technology, took a significantly different view. 'Such profound changes in national and international circumstances have occurred since 1967 that the presence of current educational initiatives does not of itself imply an inadequacy in those of an earlier age. As recently as June 1974, for example, unemployment stood at 2.1% of the working population.'(7)

Without quibbling over the meaningfulness of comparing the numbers of unemployed with those employed as opposed to any other description of the state of the nation, it has to be accepted that profound changes had indeed occurred. The rapid, and extensive rise in the price of crude oil in the years following 1975 affected a significant part of production, the cost of the energy it used. The first, second and subsequent order effects of this are still with us, and the strategies adopted to seek a return to a stable, although different, national lifestyle include changes in the way children are prepared for adulthood. Chilver is accepting this, but he also believes that what went before was not wasted, it was just the beginning: to have success at all there needs to be a beginning, both Sheppard and Machiavelli have to accept that! J.H. Horlock, Vice-Chancellor of the Open University, agreed that the initiative of the Royal Society of Arts was not a new theme and continued '..but I am sure that you will agree that any movement towards a third culture in this country (like the German TECHNIC in addition to arts and sciences) is to be welcomed.'(8)

The vexed question, as we have already seen, is the content of that which comes next and to this subject Robert Aitken, Director of Education for the City of Coventry, made a brief reference. He referred to some new initiatives and of them he wrote, 'Underlying all of these is a fundamental change in the teaching/learning process, rather than content.'(9)

As if to support this view, when responding to the question of providing equipment which would allow hands-on learning, Janet Jones wrote, 'Our particular stress is upon process, the way in which students learn, not on the hardware that may facilitate that learning but does not necessarily according to the hands of the teacher in which it rests.'(10) Lord Beaumont accepted that success following a course developed wherein hands-on learning was not needed, would be recognised and it would be recognised 'by the emergence of pupils competent in thought and action anxious to make experiments and accept responsibility.'(11) He continued, 'Such pupils would be promptly regarded as unemployable by British industry but enough of them might succeed to cause a revolution in our society. In any case, successful or not, they would be more whole people.'(11)

It is perhaps more than fortunate for those schools who entered the Technical, Vocational and Educational Initiative (TVEI) which was introduced in 1982, that the Department of Employment did not place a similar level of importance upon resourcing. A.McLellan, replying to me on behalf of Lord Young - then Secretary of State for Employment - wrote of TVEI, '.. a pilot scheme to widen and enrich the curriculum for 14-18 year olds has done much to bring schools, colleges and employers closer together to produce more relevant curricula, and at the same time has enabled schools and colleges to invest in new equipment and in-service training for teachers.'(12) Although the final paragraph seems to contain a typing error, there is sufficient evidence to conclude that what he means by a 'more relevant curricula' is one which is 'more responsive to employers' needs'.(12)

The RSA's Recognition Scheme started in 1980 with the recognition of 15 schemes. In the following year 11 were added, and by 1982 there were another 17. 1983 saw 11 more, followed by 17 in 1984, and in 1985 a further 9 were accepted. The projects were wide-ranging, from the 'We Make.....' project at Forsbrook Infants school, Stoke-on-Trent to the M.Sc Degree course in Environmental Resources at Salford University. From the John Makepiece School of Craftsmen in Wood, Parnham in Dorset to The London Computer and Electronic School of the British Oxygen Group, and from Forest School camps to the work of Workshop 6 Limited in Sheffield.

Perhaps the Recognition scheme was born out of the same philosophy which the Schools Technology Forum saw as Key Issue 3. However it does not seek to concentrate upon schools.

If it had, it ought to have recognised the associated problem of the dissemination of information. Without an efficient system there will be no explosion of ideas and no independant recognition of success.

During 1984 the RSA announced that 1986 would be called 'Industry Year', and that it, the RSA, would be responsible for its promotion.

1. Finneston. et.al. 'Engineering Our Future'. Report of the Committee of Inquiry into the Future of the Engineering Profession. (Finneston Report) H.M.S.O. January 1980.

2.'Chips in Control'. Conference report. School Technology Forum. Trent Polytechnic. March 1980.

3.'Education for Capability'. Royal Society of Arts. Spring 1984.

4. 'Education for Capability'. Recognition Scheme. Royal Society of Arts. 1986.

5. C.N.L. France. 16-11-85. Letter to 35 of the Education for Capability signatories. (13 replies.) (Appendix 2)

6. Rt. Rev.D. Sheppard. Bishop of Liverpool. Letter to the author. 13-12-85. (Appendix 2)

7. Sir H. Chilver. Chairman, British Schools Technology. Letter to the author. 9-12-85 (Appendix 2)

8. J.H. Horlock. Vice Chancellor OPen University. Letter to the author. 21-11-85.

9. Robert Aitken, Director of Education, City of Coventry, Letter to the author. 22-11-85. (Appendix 2)

10. Janet Jones, Education Adviser to Industry Year, Royal Society of Arts. Letter to the author. 16-12-85. (Appendix 2)

11. Lord Beaumont of Whitley. Liberal Education spokesman. The House of Lords. Letter to the author. 21-11-85. (Appendix 2)

12. A.McLellan. Manpower Policy. Department of Employment. Letter to the author. 23-12-85. (Appendix 2)

8. ARE WE ALL MET?(1)

'The National Centre for School Technology and the Technology unit, Bedfordshire LEA have recently been awarded a grant by the Industry / Education Unit, Department of Industry, to enable a programme of in-service education for teachers to be undertaken for LEA's in the field of 'O' and 'A' courses in Technology'.(2) This letter from Shillito, the newly appointed Director of British School Technology (BST), was directed to LEA's asking them to signify their interest in releasing a science and a CDT teacher from each of a group of schools, to attend four, one week training sessions.

The letter, recieved by Durham's Director of Education, then DJW Sowell, resulted in a one day conference on 19.10.83. at Durham New College where K. Grimshaw, then Deputy Director of Education welcomed the delegates, and said, 'We feel privileged to be one of a limited number of authorities to be involved in this particular project and our commitment is total.'(3) He remarked upon the few number of women who were present and upon the efforts the authority had already made 'to stimulate the use of microcomputers and microelectronics in our schools and to increase understanding and awareness of new technology.'(3)

A BST press release explained that, 'Four, forty foot trailers ..... fully equipped ..... are the major pieces of hardware ...'(4)

The trailers were self contained technology environments. It would be wrong to call them classrooms or workshops, and laboratory seems to imply experiment which is not what the teachers do. Each week has elements of knowledge input which require practical involvement with, often, unfamiliar equipment. The work is designed to be 'Project Driven', and the emphasis moves from a wide, tutor controlled experience towards the last week's experience where the solution to a tutor set design brief can be approached by any combination of method and materials available.

BST describe, briefly, the course as -

'Active learning in School Technology.
Wk1. Using problems to learn.
Wk2. Problem design and approach investigations.
Wk3. Course design involving control systems.
Wk4. Project management, Evaluation and Assessment.(5)

Over the first three weeks, the teachers experience modelling, soldering dedicated electronic circuits, electronics systems kits, mechanisms kits, pneumatics, computer control and role-playing. These are the overt experiences easily identified because of the hardware they use.

From another point of view, they have to cope with working with each-other. Colleagues, but with different backgrounds, skills and knowledge. They handle materials in ways which are novel. They are exposed to the concept of modelling both in the physical, and to a lesser extent, mathematical contexts. There is the opportunity to see different approaches and results to the same real problem even though the resources were identical. There is tha opportunity to work on the same problem but with different equipment, ie. pneumatics / electronics / computer, each providing a different means of arriving at a satisfactory, although differently operating, solution. The tutors are 'experts in Control Technology, Modular Courses in Technology ..... and the new 'A' level in Technology ...'(2)

When County Durham embarked upon this rolling programme, there were 50 Comprehensive schools, currently there are 48. In the first group there were 8 schools represented, the second group had 7 schools, the third 8, and the current fourth group, has 8.

BST also offers 6 week residential courses for 'Further experience in teaching approaches, curriculum design, management skills and technological knowledge in preparaton for INSET management responsibilities within LEA's and Institutions of Higher Education (Previous experience in School Technology essential)'.(5) Durham has made it possible for two teachers and a lecturer from the University School of Education to attend.

BST use computer systems as 'Black Box' technology. That is to say that the computer system is used because the utiliser knows what it will do - there is no requirement to understand how it does it. Consequently the designer can concentrate on the product rather than a product already on the market. The same approach is taken to pneumatics as it is to any other system the teachers experience. There is no requirement for them to understand how the soldering iron, the power supply, the oscilloscope, transistor or operational amplifier work. However, with most equipment the greater the use the more the user learns about it, and this 'need to know', or 'exposure of knowledge gap' becomes a natural event, learner driven and meaningful.

The BST / Durham approach may, or may not be universally accepted as the best INSET strategy, in any case only the future will be able to judge properly. Whatever the approach, there must come the time when the teachers return to the classroom to put their newly aquired skills into practice. There has been little difficulty in motivating the pupils in the Durham initiative because each school had to undertake to offer a public examination group after the INSET course. The initial provision by the LEA of a teaching package amounting to approximately £2000 per school, helped to 'sell' the course to the pupils and parents and the teachers were able to provide their pupils with a scheme of work which would satisfy the first four terms of the five term course. (Most of the fifth year would be spent by the pupil designing his/her own solution to a design brief for submission to the examiner.) However take-up of the new option by pupils in subsequent years would be affected, possibly mainly, by the experiences of these upper school pupils, and schools would no doubt need to look carefully at their lower school curriculum so that all pupils would be prepared to make a more sound judgement when faced with upper school choice at age 13+.

How can a strategy be designed to introduce technology to lower school pupils so that it challenges both sexes in an interesting way and is relevant to technology both in the upper school and in later life?

The point about later life is not to be missed. It is self evident that for those pupils who will wish to continue with an in-depth technological experience, their early work should be relevant. What might easily be overlooked is the broader educational aim of providing technological awareness for all. The synthesis of these two is an understanding of what children find relevant.

In his paper published in 1986, Pace (6) considers the problems the Engineering profession has in recruiting, and his argument is broad enough to consider attitudes in general, and not just of those who, one might say, should be engineers. 'The declining popularity of mechanical engineering with suitably qualified school leavers is beginning to cause alarm within the profession. An increasing proportion of able young people , with career ambitions in engineering industry are opting for electrical/electronics courses. This trend is beginning to manifest itself as a shortage of good mechanical engineering graduates, which could seriously inhibit the prospects for an economic resurgence of the UK manufacturing industry.'(6)

He asserts that the media portrayal of a decline in mechanical engineering as an industry, is a popular belief and he contradicts this theory of decline, whilst accepting the effect the portrayal is having. As a way of combatting this inaccuracy he identifies the opportunity which - 'is being overlooked to promote in the schools those distinctive qualities required of professional mechanical engineers as an essential ingredient of modern curriculum development.'(6)

He introduces Craft Design and Technology as a subject relevant for prospective engineers, as well as being valuable for the preparation of boys and girls for their increasingly technological society. He maintains that as the demand for electrical engineers has risen, there has been a parallel, though not on the same scale, opportunity for mechanical graduates. To service this need he considers that - 'A simple expedient would seem to be to secure the involvement of more girls, but despite orchestrated campaigns and rising status, the reluctance of women to become engineers becomes profound'.(6)

He shows that the demand for art-based design courses at universities is predominantly from women and continues to grow. 'It is helped by the high status of art as an 'A' level subject and by the art-based, designing and making activities of products that appeal to girls, within the expanding CDT spectrum.'(6) This last assertion he compares with the popularity of electronics as a vocational subject in schools. His conclusion that, 'the experiences in art-based design and electronics, which are so vocationally significant, must be paralleled by mechanical activities if the school environment is to wield the positive influence so vital in securing the future supply of mechanical engineers'(6), is self evident but misses the opportunity to point out that a lack of both structural and mechanical capabilty leaves the pupil with little sense of purpose!

His understanding of the needs of schoolchildren in respect of design and making is not to be dismissed on the basis of this omission, for he more than made up for it when, later in the same paper he wrote, 'If we accept design as the intellectual challenge that can stimulate the interests of school children towards mechanical engineering, then it is the capabilities that support the activity that should be developed above all. It is not sufficient to impart understanding as an end in itself, even if that is related to such wonders as the gas turbine, the Thames Barrier or even the atomic bomb. More important is the capability to apply fundamental principles to achieve solutions to practical problems that are a recognisable feature of the pupil's own world.'(6) This is highly significant, for when the context of his paper is stripped away - the recruitment problem in mechanical engineering - the underlying principle, that children need to learn through experiences which are relevant to themselves, stands like a statue to Ausubel. 'If I had to reduce all of educational psychology to just one principle I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly.'(8)

There are three important points which need to be considered before embarking upon the conception of a new educational programme.

a) There is a commonly held belief that any course of study seen to be interesting by pupils, is likely to result in higher motivation and that a high motivation is a prerequisite to efficient learning. If it is accepted that something different is needed in the form of a river upon which now rafts carrying the educational cargo can be delivered, it would seem necessary to look elsewhere for ideas. What then, interests children outside school?

b) Given that there is a future for the school-based experience in technological awareness, how can INSET initiatives like BST and MEP be used to build upon the pool of knowledge already aquired by children before they reach the secondary school?

c) Where will the capability and knowledge base, imparted during an innovative course, lead to?

THe first two questions impinge one upon the other. The third I hope to show will benefit from their consideration thus forming the basis for the next chapter.

Although equipped with some degree of experience in the upper school, without any expectation of pupil enthusiasm there will be less incentive for the teacher to become involved in the aquisition of differerent personal resources for use in developing lower school courses. What, the question poses, interests these children?

Publishers of books maintain that there has been a reduction in the number of books which children read for pleasure and there are repeated calls for a greater funding of books for use in schools. If the book publishers are to be believed, where else do children find the world once provided by literature, or must it be accepted that this is a redundant need?

Even if it were true that children no longer feel the need to indulge in escapism, fantasy and make-believe, is this a state of affairs which should be considered acceptable? The progress of man-kind depends upon inventiveness and innovation. Two words which allow adults to behave now as apparently children used to in the past - before we were told that they had stopped reading books. It would be unwise to accept without demurr, a world wherein those most receptive of new ideas and without prejudices were not given the practical experience and opportunity to exercise a free imagination.

The children I teach tell me that they watch television, play computer games and listen to pop music as well as reading comics and magazines.

A group of books which have stimulated their imagination are written after the style of an 'adventure', where the use of a dice or the result of a decision on the part of the reader, directs the reader to their next chapter. In this way different readers read different versions of the story. There are many such books currently on bookstands, which base their adventures in the world of science fiction. Others are based upon the worlds of the little people - elves, goblins and magicians - but without much of the gentle romanticism of fairy tales. As with the space adventures, there are seriously dangerous situations to be encountered.

An examination of the content of childrens television shows that - apart from Current Affairs, Drama series', General Interest and documentaries - there always seems to have been Cartoons. Indeed cartoons which were originally intended for cinema audiencesmany years ago - Donald Duck, The Roadrunner, Bugs Bunny - are still being shown on television together with modern offerings such as Transformers, Masters of the Universe, Gobots and Mask.

The cartoon allows moral judgements to be explored in a context of a pseudo-human society where human players are replaced by animals or fantastic beings whose welfare can be argued to be less important than that of the real human. In this way physical and mental abuse are seen to be removed from reality for the sake of humour or moralistic judgement - the cartoon is used as a model which can be tested, and manipulated. From the point of view of the engineer, there may well be more relevant attributes. Many cartoons which are set in the realm of fantasy, that is they do not seek to portray what could be observed with real players, make common reference to an exploration of movement, speed and the effect of momentum. Although the effects of these can be exaggorated, the result is to bring to the fore-front the effect - the consequence or output. To dismiss cartoons as of no educational value would be folly.

Another stimulus to learning and a source of learning in itself, is play. A superficial consideration of childrens play-things allows their division into 3 groups:

1) Games.

a) Sit-Down - 'Monopoly', 'Subbuteo', Cards, 'Ker-plunk', 'Simon', and

b) Run-Around - Football, Tiggy, Hide and Seek.

2) Toys.

a) Fixed - 'Dinky Toys', 'Matchbox' vehicles. Remote and radio controlled vehicles and

b) Dis-assembled - Dolls furniture and dolls clothing.

('Cindy' and 'Action Man' - no sexism!) Plastic aeroplane, ship, etc., kits - to be glued and painted. Model railway sets.

3) Construction Kits.

a) Open-ended. - 'Lego', 'Meccano', 'Fischer Technic', 'Stoky'.

b) Building to Plans. - Model aeroplanes capable of flight, steam locomotives, yachts and boats.

C.D.T. is primarially concerned with making, and to this end those activities in the second and third categories are most relevant. However as Technology is a function of human experience, there have been developed learning packages based upon the first group where games of consequence allow political, social and financial judgements to be taken.

The play activities associated with the second group are associated with the formulation of parameters or rules and the design of a play environment. Skills in controlling, sociability, articulation and construction are developed and of these perhaps those of construction and control are closest to C.D.T. since others can also be developed in other areas of the school curriculum.

It is with those activities associated with the first part of the third group that C.D.T. has the most sympathy, for those of the second part simply develop the skills of making and allow little scope at this level for improvement and modification.

Apart from the the open-ended nature of play, the materials closely model engineering materials in so far as they can be used to oppose stresses and transmit movement. What is not generally encouraged is the modification of the components, and there is an accepted condition that the constructed artifacts are not meant to be of a permanent nature. There are exceptions to every rule however, and the manufacturers of Lego, in particular, have produced kits of parts which are meant to be built into specific models. They differ from the kits listed in the second category because they are made up from basic components with the addition of sticky labels. It is possible, therefore, to utilise the components as the user desires. Two other examples of this marketing technique are kits made by Fischer-Technic. The first was marketed as the 'BBC Buggy', and was intended to be built up into a computer controlled vehicle. The second kit is intended to to be more versatile in that more than one model can be constructed, though not at the same time. The objective of both is to develop control skills rather than the design of novel machines. Incidentally, the complexity of the construction and the time involved to complete any model is such that, once complete, the builder would be loathe to strip it down!

The possibility exists through the use of these materials to construct rapidly, structures and machines which demonstrate principles of innovation and invention. Although the finished products will be more or less substantial according to the constructional strategies, skills with manipulation and the familiarity with the limitations of the kits, the speed with which the idea can be turned into reality is much less than a workshop would allow.

This is of considerable significance since workshop organisation, safety, precision, incompatibility of materials and the unfamiliarity with tools, all conspire to stifle the spark of an idea. Especially with the young who seem to need results, if not quite yesterday, at least within the half-hour!

There is a link here between the first and third questions.

There have always been those who have seen a need for the work done in schools to be directly relevant to the world of work. Whether they be the parents on behalf of their children, the children themselves seeing possible routes and creating pathways towards chosen careers, those who from time to time surface in order to criticise the education system for producing children who are unemployable since they can neither read nor write. However, there is no doubt that as some children near the end of their school career so they become ever more concious of their need for a strategy by which they will be able to enter higher education. Many of these are already certain where their preferred future employment lies, and are thus self-motivated. It would be wise to consider these if a curriculum is to reflect reality.

The last question concerned this reality - the possible ways in which skills and knowledge developed within a new teaching package could be transferred to the world outside the learning situation, whilst the second asked how the INSET initiatives could be utilised. It might be tempting to look at them as separate issues but since the INSET initiatives were politically motivated to halt the decline in the position of Britain as a trading nation, such would be an inappropriate act. To be a trading nation whose natural resources are not wanted, cannot be afforded or are seriously depleted is to be a nation whose task is to add value to whatever it can obtain. Value, recognised and evaluated by the potential customer, is what stimulates trade. The act of adding value is clearly important, and it must involve people. Hence the connection between employment and political initiatives.

Although some might cling to the belief that education still continues to be intended as a general preparation for adulthood, it would be more realistic to see this againsed the background of an immediate future being presently sculptured with a fervour not seen since the aftermath of the second world war.

1. Shakespeare. W. 'A Midsummer Nights's Dream', Act 111, Sc 1, Chancellor Press. 1982.

2. Shillito. G. 'National Programme of Dissemination of British School Technology. NCST. Trent Polytechnic. 1983.

3. Grimshaw. K. Speech to BST one day conference. Durham New College. 1983. (Appendix 3)

4. Press release. 'Technology Takes To The Road'. BST. 1983.

5. BST 'INSET Courses for the Technological Curriculum.' BST 1986.

6. Pace. S 'Design and Technology in Schools - its Potential for the Engineering Profession'. Proc. Inst. Mech. Engrs. April 1986.

7. Ausubel.D.P., Novak.J.D., Hanesian.H. 'Educational Psychology: A Cognitive View.' Holt, Pinehart & Winston. 1978.

9. COMING, READY OR NOT!

The third question posed in the previous chapter requires an examination of current industrial techniques which will be of direct relevance to CDT teachers.

Recalling Kibasi and Mills third role for the computer in the industrial environment - that of the 'active controller in a closed loop situation'(1) - the computer has three identities.

i) Computer aided design - CAD - utilises the graphical output of both the monitor screen and the devices which are capable of producing images on paper - printers and plotters. The computer is particularly helpful when it is able to project a three dimensional model from an image created in two dimensions. The speed with which it can alter both shape and colour together with its ability to perform calculations based upon the sizes which it has been given allow work previously done in different areas to be condensed to a single site.

ii) Computer aided manufacture - CAM - utilises the data output from the computer to control machinery. This can be done at different levels - from the control of a single machine to the control of more than one machine (but restricted to a specific group) and to the overall control of a complete production sequence.

Machines which are controlled fall into two categories materials processing and materials handling. Materials processing machines, referred to as Computer Numerical Control - CNC - tend to look very similar to their human operated predecessors whereas materials handling devices are required to replace the human operator and have a distinctly different aspect. Since they are still a recent phenomenon, as with the first steam driven vehicles, they tend to resemble their predecessors. Generally referred to as Industrial Robots, they consist of limbs, joints and grips which reflect the human arm.

iii) Computer simulation is a mixture of the first two, where graphical output is used to represent the behaviour of machinery. This is particularly useful during the development of physically large or hazardous operations, or the prediction of human responses to changing situations. It is also used during the planning of operational change to predict costs, effects and to facilitate decision making. Simulation is considered to be very important in the training and monitoring of staff who work in rapid response situations - airline pilots, power station controllers and defence system operators.

There is a second branch to graphics utilisation where the interaction of the microprocessor and the visual display unit (VDU), is exploited as an end in itself. The product is generally a sequence of graphic images. Such images may be used to describe a novel concept incapable of being conveniently described in any other medium. The progress of a dream or the imaginary vision of environments outside our own experience.

Whilst the use of computers to simulate product performance or to enhance the communicaion of ideas is a technological activity, it does not in itself allow much scope for the production of artifacts. The simulator is able to rely entirely upon graphics displayed upon a screen and although the software is creative, it does not require the use manual construction skills.

This is not entirely true of CAD, where it is possible to design equipment whose purpose is the production of two dimensional graphics. It is also possible to design equipment which will allow alternative methods (i.e. without using the keyboard) by which the user can input to the computer.

However the greatest scope for the development of computer-connected equipment is in the field of CAM, and in particular the development of those machines which have no precedent.

Consideration of the general principle of divide and rule needs to be taken at this point. It is often convenient to divide a system into categories because humans are more able to handle mentally, descrete packages of information than they can an amorphous whole. This example of the artificial sub-division of a computer systems' capabilities illustrates well the folly of erecting artificial conceptual boundaries. The essence of the computer system is not the input or the output, it is the process. The organised movement of pulses and their monitoring is the essence. What the pulses are made to represent is the business of the input and output devices, and since these are the devices most observable it is possible to forgive humans who know no better, for their belief that the computer is less versatile than its potential will allow. The creation of novel input and output devices is therefore to be encouraged, as is the wider franchise of computer system appreciation. The area of the creation of input/output devices is that of technology which, like man, cannot be an island - it will be necessary to appreciate, at least to the depth of the practical problem being faced, the system as a whole.

Any strategy designed by one for the use of another will need to be described and the very act of communicating thus becomes the subject of design. Since the computer is capable of being used as a visual output able to describe in both written and pictorial form as well a controller and simulator, the three capabilities should be seen as potentially mutually supportive.

Having established once again the 'oneness' of the system, it is a small step to its eventual comparison with the very essence of technology. Making, testing, communicating, evaluating - the problem is the design of the appropriate interfaces which will allow the computer system to interact with the human. These items will also include equipment which will be designed to interact physically within a world only observed by humans. Such items will be 'doing work' for humans, whilst the humans monitor and evaluate their performance and reap the benefit of their labours.

Browne, whilst working for Pye Telecom - Cambridge, described the advantages of industrial robots. '24h operation is possible, allowing the optimum use of expensive lathes and presses. Robots can operate in hostile conditions, having high temperatures, dust or fumes, which would have to be improved if humans were to work there.'(2) It is interesting to reflect upon the events which might have brought about the introduction of the robot to these environments. Was the environment newly created with the hazard recognised and the robot included as a direct consequence? Perhaps the hazard has either been newly created or recognised and, to comply with safety legislation, the robot introduced as a cheaper alternative to a clean-up operation?

Browne continues, 'They are constant in their performance and therefore a uniform quality is obtained.'(2) This is no doubt true in comparison with the tired, or changed, human operator but it does hide a truth. There will always be some wear in mechanical joints, leading to inaccuracies of position and vibration. Vibration results in a non-programmed movement profile. These problems are but two of the challenges to be faced and might seem to be irreconcileable when, as Browne points out, 'Robots can operate with very fine precision and can handle very heavy loads.'(2) It is not clear to what orders of magnitude he is referring, nor whether he means that each robot is capable of both feats.

Carberry of Hewlett Packard describes the method by which British Aerospace uses robots to manufacture substrates (boards with conducting tracks but without components) and then to produce complete and tested printed circuit boards. The robots are located in work areas, commonly called "cells", and in this process there are three cells which can contain more than one robot. 'In cell 1, the substrates are carried by overhead transporter through a Kerry Ultrasonics pre-clean process. .... Mechanical transport from the pre-clean unit through printing and on to the pick-and-place assembly machine is provided by a Patterson Viper 3000 robot. The Dynapert picks components from the feeder pallets and places them on the bare substrates. A second Paterson robot removes boards from the pick-and-place machine and deposits them at the input to cell 2. In this cell, a second overhead transporter carries the boards through an IV Products multi-stage soldering process, and on to a Kerry Ultrasonics deflux unit.'(3) The components to be soldered onto the boards are the modern surface mounted type. These have tags which are not required to fit through the board, consequently the loaded board needs to be transferred to the soldering station with a minimum of vibration. However, such circuit boards are not likely to have a great mass and the robot can be built of light materials providing the advantages of longevity and minimum internal wear.

In the same article Carberry describes another robot workstation being used by Hewlett Packard in Grenoble. Also for the manufacture of printed circuit boards, but with the ability to 'insert odd-sized components after they have passed through a Universal insertion machine which inserts all the regular sized components. .... The cell operates as follows: a component is selected from a rack of storage tubes and the PCB is manipulated into position above a fixed crimping mechanism... . Once the component is in position it is inserted into the PCB. using one-way force sensing to check for bent connectors... '.(3) There are two aspects of this operation which require precision, the act of lining-up the component with the holes in the board and the sensing of interference. However, once more the robot is not required to handle a massive item.

This robot, a Scemi, has a gripper designed by Hewlett Packard and 'has eight degrees of freedom. .... There are six robot axes, which are used to select and manipulate the component, while the other two degrees of freedom are introduced to the X-Y positioning table for moving the PCB itself'.(3) Comparing this with the degrees of freedom associated with that part of the human body it is designed to replace, there are also six - namely the waist - limited universal, the shoulder - limited universal, the elbow - elevation, the fore-arm - rotational, the wrist - elevation, and the finger/thumb - grip.

Browne's belief in the ability of a robot to move massive loads may well be justified by Griffiths and Lewis, both of the University of Wales Institute of Science and Technology. They were concerned with the reasons why the UK cast iron industry had not taken advantage of this technology. 'The main interest in robot applications has been in spot welding, injection moulding surface coating and machine tool service. These applications are automotive produce orientated. However, in the foundry industry which is a major component manufacturer to the automotive industry, the use of robots has not been explioted'.(4)

They surveyed the distribution of robots within industry in 1983 and published the following categories of use and approximate numbers:-

U.K. Robot Applications in 1983. (4)

Spot welding	350
Injection moulding	250
Arc welding	240
Surface coating	170
Machine tool servicing	165
Other	130
Assembly	100
Education	80
Palletising & packing	70
Press tool service	50
Die casting	40
Inspection & testing	40
Grinding	40
Other handling	20
Investment casting	10

It is interesting to see that there is not a category which implies the lifting or supporting of anything really massive!

Their aim was to produce a checklist which would aid the decision of whether or not a robot could cope with the environment and process. in order to test their findings they conducted a feasibility study at a foundry in South Wales. They considered applications in the manufacturing and cleaning of moulds, the pouring of metal into a mould, the removal of the casing from the mould, fettling - the trimming of the casting and inspection. Of the casing process, the article states - 'Another possible application is pouring of liquid iron into a mould - this is rather unique. Although there are robots on the market capable of carrying the high load of the ladle and the liquid iron, the technology required around the robot and the robot itself would be prone to metal splash'.(4) It is clear that loads consisting of solid material, rather than liquid, can be handled with precision.

It may be that humans would be less than efficient at carrying drinks if they were deprived of the senses of sight, sound and feel. Experience shows that when the brain is unable to carry on with its normal procedeures through unexpected distraction or the effects of alcohol, the human response to its senses is impaired.

Criticism of a robot for spilling molten metal would need to be tempered by a knowledge of its sensors and an appreciation of its response capabilities. As Browne puts it, 'The principle disadvantage of a robot is its lack of intellegence, which denies it the extreme flexibility of the human. The human has a greater capability to modify its actions according to circumstances and to learn from those events than has a robot, which can deal only with those situations that the programmer has forseen and been able to program'.(3)

Reviewing the American report by Tech Tran Consultants, Casey wrote, 'The author speaks to American robot users to find out where improvements in robot design and technology are needed and discovers that "the greatest limitation of robots being used today is the lack of an effective, reasonably priced sensing capability for determining the location or shape of an object." And the high cost of sensing systems on the market make them economically unfeasible for many years'.(5) The article also makes a reference to the load carrying capabilities - 'Today's robots are typically very large and heavy and can lift weights equal to only 10% of their weight - the users questioned call for smaller robots with greater relative load capacity'.(5)

As well as improved load carrying capability and sensing, there are other developments for which industry is waiting. Casey's article goes on to mention;

i) improved gripper dexterity
ii) easier programming
iii) lighter, smaller robots
iv) improved control systems
v) faster movement

Interestingly, Millar (6) makes a suggestion that puts into perspective one of the characteristics of the robot as described by Carberry (3). In his paper 'Robots are here to stay', he discussed his experiences of robotics as engineering director at Turner International Engineeering, Alcester. Turner's were investigating the further automation of their production line having already installed Computer numerical Control (CNC) machines to pierce holes and slots with plasma, to bend and form, to drill and turn.

The use of plasma to cut stainless and carbon steels produces a very clean cut, and when directed by CNC the profile is accurate. The other CNC processes benefitted from accuracy to the same degree. However the assembly of the components had yet to be automated.

Millar dealt with the question of accuracy by putting it into this context. 'Many companies work under the impression that they are looking for accuracy. In most cases, I would suggest that they are not. What they are looking for is repeatability'. He is not suggesting that manufacturing is not a matter of accuracy, he is pointing out that accuracy can be obtained in different ways. In Turner's case the accuracy was obtained from CNC in such a way as to proved accuracy of fit. Inaccurate (relatively!) means may then be utilised to make the joint permanent. With this philosophy accepted, Turner's then went on to introduce robotic welding equipment.

The reality of industrial engineering stands apart from the capability of the calculator and the superiority of the science session. I am reminded of a teacher of woodwork who was able to question his own double standards with me, his pupil. In the drawing office he required accuracy to within 1/64th of an inch but in the woodwork shop 1/32nd of an inch was more realistic and quite acceptable. In practise pupils were lucky to work within 1/8th of an inch which made for an interesting, albeit academic, discussion on the viability of the possible.

In his conclusion, Millar hammers home the reality for British engineering production. 'To stay in business in the furure, you cannot be complacent and must ensure that every effort is made to develop and progress. Finally, if you feel that from your particular experience robot welding is a gimmick, it is expensive and unprofitable, and you cannot use it flexibly for low volume production,you have simply not engineered your capital development programme correctly. Forget the buzz words. It is really quite simple: what is best for your business? How best can you use the equipment to work for you? And remember, if you do not plan effectively in all other areas, the robot simply will not work'.(6)

Clearly the value to industry of the manufacturing robot is considered to be great. Its effectiveness in a variety of situations has been evaluated and, as Millar describes, the need for environmental planning is of paramount importance.

The educational context of robotics produces wider planning considerations. As Miller pointed out, it is less than appropriate for the robot to be introduced as an entity devoid of a habitat, but the educational habitat is not simply its environment in terms of the industrial model as described by Millar. It will also include the need for human interaction, communication, and the understanding of that part of the essence of the computer system - its pulse processing capability - relevant to the creation of a robotic device.

There is a real world, after school, which uses, and increasingly so, computer controlled machinery. The impact of this is not simply a matter for those employed in industry, it clearly has implications for the whole of our society. Education has a responsibility to equip all children to be capable and the capability to take an informed place in our democracy is not to be dismissed at all.

Can a group of very young children cope with a design situation which requires their involvement in total industrial automation?

In my introduction I made clear my intention to produce something other than a written document, and the challenge of this last question was what I set myself and later became known as 'The Automatic Factory'(7)

1. Kibasi & Mills. 'Micros in Control'. Personal Computer World. 1980.

2. Browne. A. 'Robots - the present'. Electronics Systems News. Institution of Electrical Engineers. Summer 1986

3. Carberry. C. 'Robots ease bottleneck in PCB production'. Production Engineer. Intitute of Production Engineers. March 1986.

4. Griffiths. AJ. & Lewis. HJ. 'Robots in foundries'. The Production Engineer. Intitute of Production

Engineers. February 1986.

5. Casey. C. 'The future looks good for robots'. The Production Engineer. Institute of Production Engineers. September 1986.

6. Millar G. 'Robots are here to stay'. Paper to the third international manufacturing conference of the Institute of Production Engineers: Industry year - industry matters. July 1986.

7. France. CNL. 'The Automatic Factory'. Sunderland Polytechnic & MSC. 1987. (Appendix 3)

10. CONCLUSION.

I have looked at the computer both through the eyes of a teacher and a designer, and found it to be something of an electronic chameleon. Not only is it of use as a range of tools, but it also operates as an end in its own right and in a range of differing roles. It is difficult to summarise its applications and it comes as something of a relief to realise that describing the computer in terms of how it has been made to operate is not efficient. The approach ought to be to ask, 'What is it that a computer can NOT do?'

The answer has to do with the way that the machine is presented with input, and the way that the results of its processing are then presented to the world outside. It is the design of the peripherals which limits its flexibility.

At present, the common way to communicate with it, is with an alpha-numeric keyboard and it responds by using a visual display unit (VDU). In the days of Williams(1), input was with a switch and output was a single beam cathode ray tube (CRT). Nothing fundamental has changed - the keyboard is merely a set of arranged and labelled switches and the VDU is a CRT with more than one beam, and chemicals which glow with different colours.

The way the computer recognises each key and then decides upon the position of the character on the screen and its colour, is as vital to understand as the reason for the wheels on a car to stop if no petrol has been put into the fuel tank. For many, life under the bonnet, is not something with which they want to be distracted.

Whether this sort of attitude is good for a nation which depends upon economic viability for its international reputation is a moot point, as is whether there is more to life than using up the earth's natural resources for what, in that context, would be short term benefits.

The fact remains, however, that to use something complex does not always require knowledge of how it works. This, as I referred to in Chapter 8, is a black box attitude, and it becomes possible to describe happenings by the way in which the black boxes in a collection are seen to interact. Such a collection is known as a 'System', and Beishon summarised the concept in four points which, when taken as a whole, form a definition:

'1) An assembly of parts or components connected together in an organized way.

2) The particular assembly has been identified by a human being as of special interest.

3) In general, the parts are affected by being in the system and they are changed if they leave it.

4) Our assembly of parts does something (but remember that behaviour may be not doing something when the outside world changes.)'.(2)

As we have seen, the CDT approach is design based. Its aim is the solution of real world problems by the production of artefacts. Such artefacts may be visual or aural descriptions of a process, but the aim is always to produce improvements to the human condition. The solution should not to be limited by technique, knowledge or materials except where there are fundamental - real world - constraints, and they should be recognised as such so that their eventual removal can be striven for.

The implication is that the technologist is faced by an impossible task, to be expert in everything. This is not true, the technologist is expert in the successful assembly of black boxes.

The advantage to the student of the systems approach in his field of teaching electronics, was described by Foxcroft. 'It emphasises the function of some circuit or other and what it can do rather than how it manages to do it. It has the advantages that students are more quickly involved in the design of systems and in what they might recognise as electronics, and their attention is concentrated on that rather than on the device around which the circuit is built.'(3) This is not an approach which all teachers would find acceptable, because, as Foxcroft asserts later, the student is not concentrating upon what might be described as the 'science of the device'(3). Instead the devices are considered to be black boxes.

It is this concept of the system and its constituent sub-systems (or black-boxes) which causes a dilemma in the minds of some teachers. It is in their experience that the role of the teacher is that of the expert. The job of the teacher is to find ways in which their black box (their subject) can be opened and understood. However the reality is that when they open the box, it contains another, and that contains another, and so on - reminiscent of Russian Dolls.

If this were not so, it would be impossible to justify the existance of Further Education, let alone Universities! Indeed each of these would argue that at some stage the opening of a doll will reveal something more akin to a 'Tardis', that television space craft which is bigger inside than its external dimensions actually allow.(4)

To what depth should the taught descend in the understanding of the sub-system? The systems approach to electronics deliberately allows the creation of circuit boards and components which are easy to grasp, and this accurately mirrors real life.

In his article on Packet Radio, a method by which data can be transmitted by radio in small, high-speed, 'packets', each capable of being repeated up to ten times unless an 'acknowledgement of reciept signal' is recieved by the sender which allows it to send the next package, Wade uses a black box approach to describe system components. He describes a typical 'station', capable of sending and/or recieving as being composed of a terminal, a teminal node controller(TNC) and a radio. When we look into the terminal, we see a computer and a VDU. He shows that the TNC contains a 'UART, CPU, ROM, NOVRAM, RAM, HDLC controller, Modem & PTT control'.(5) Inside the radio sub-system we find a transmitter, a reciever and an antenna. Taking the radio receiver as a sub-system we find that, as Price describes in his design for a radio reciever, there are eight further sub-systems within its metal case.(6) Neither the antenna nor the power supply are his concern.

We noted in chapter 9 that Millar had written - 'and remember, if you do not plan effectively in all other areas, the robot simply will not work.'(7) Here is an industrial designer advising the taking a whole world view of a factory, in order for the operation of one part to function for the benefit of the factory as a whole.

Different learners should be encouraged see the system they are working upon in terms of a set of sub-systems. Their appreciation of the internal complexities will vary with his/her self-perceived 'need to know'. The teacher has already recognised the sort and depth of knowledge and techniques that will be to the learners long term advantage.

Returning to the subject of control. It is not straight-forward because, that which is to be controlled ususlly exhibits non-linear change. However, by declaring the subject of consideration to be a system, the identified sub-systems can be described, whereupon models can be constructed, operated, influenced and their behaviour assessed.

City and Guilds 230/3, 'Robot Technology and Control' identifies the following as 'elements in a robot control system:

a) program

b) input device

c) controller

d) interfaces

e) data storage

f) actuators

g) internal feedback transducers

h) external sensors.'(8)

Each of these elements can be modelled and once their actions are appreciated by observing their interaction, choices can be made and tested againsed a real world brief.

Input - process - output - in earlier years both the use of the woodturning lathe and the construction of model steam engines could have been used in their own peculiar ways to develop this concept. So could the modelling of wind and watermills, though their popularity as acceptable products of the traditional workshop would, it seems to me, have been doubtful. Within the context of a cross-linked curriculum leading to transferable skills they would have been seen as laudable.

The curriculum is required to have 'Breadth, Balance and Relevance'(9). By its definition, technology - if it is treated honestly - will be broad. The design of the curriculum in which the school technology is set will, or will not, ensure balance but the relevance can only be assured if the experiences of the pupils can be seen by them to reflect real life. The computer, with the ability to utilise its modelling, simulating and control capabilities can do much to enhance pupils perceptions.

The ability of the computer to monitior and react with great speed makes it a unique system - from which it is not possible to justify technologists being separated.

As a preface to his translation of Beckmanns 'History of Inventions and Discoveries', Johnston wrote -

'Germany, beyond all dispute, has given birth to more important discoveries and inventions than any other part of Europe; and gun-powder, printing, and a variety of useful machines, will remain lasting monuments of the inventive genius of the Germans. In chemistry and mechanics they seem however to have made the greatest figure, and for this a very satisfactory reason may be assigned. Germany, since the earliest periods, has been celebrated for its mines. To facilitate the labour of working there machinery was necessary; and to extract the metal from the ore, and turn it to advantage required a knowledge of chemical operations. Necessity is said to be the mother of invention; and it is natural to suppose that a people will always employ the efforts of their genius on those objects from which they are most likely to derive benefit.

In the history of chemical discoveries and mechanical invention, above all professor Bechmann has enjoyed, therefore, an advantage which might have been wanting to a writer of any other nation. It will require no great sagacity to discover, that allusion is here made to the opportunities he had of consulting many German works, little or perhaps not known in other parts of Europe and of searching ancient annals and public records never before drawn from their obscurity to give testimony in favour of the arts. He indeed seems to have applied to every source that was likely to enrich his subject; and the voluntary contribution of learned friends enabled him to enlarge his work with much useful information, for which he expresses on several occasions his grateful acknowldgement.'(10)

Technology in schools is the successful application of whatever systems pupils have an appreciation of. To this end it is required to have access to a wide range of sub-systems, and to engender in the young the ability to take the 'whole world view'. The design brief, the experience, the knowledge - the capability.

The technologist is indeed a jack of all trades - and master of one.

1. Williams. FG. 'Early Computers at Manchester University'. Royal Society. 1975.

2. Beishon. J. 'Systems'. T100/1 Open University Press 1971.

3. Foxcroft. GE. The Systems approach to electronics. Electronics Systems News, Jan. 1983.

4. 'Doctor Who'. BBC Television Series. BBC London.

5. Wade. I. 'Data Comms'. Radio Communication. Radio Society of Great Britain. April 1986.

6. Price. S. 'The RC14, a Beginners Reciever'. Radio Communication. Radio Society of Great Britain. June 1987.

7. Millar. G. 'Robots are here to stay'. Industry year. Royal Society of Arts. July 1986.

8. 'Robot Technology and Control. 230/3'. City & Guilds of London Institute. 1985.

9. 'The curriculum from 5 to 16. Curriculum Matters 2'. HMI Series. HMSO 1985.

10. Beckmann. J. 'History of Inventions and Discoveries' Translated by William Johnston. London. Printed for J.Bell, 148 Oxford St., 1797.

APPENDICES.

Appendix 1. 'Betrage zur Geshichte der Erfindungen'.

Johann Beckmann. (1820/91)

The three volumes of this history of inventions contain the following contents lists:-

Volume 1.

Italian book keeping.

Odometer - instrument for measuring roads.

Machine for noting down music.

Refining gold and silver ore by quicksilver.

Dry gilding.

Gold varnish.

Tulips.

Canary-bird.

Argol.

Magnetic cures.

Secret poison.

Bellows.

Coaches.

Water clocks.

Turmalin.

Speaking trumpet.

Ananas or Pine-apple.

Sympathetic ink.

Diving bell.

Coloured glass. Artificial rubies.

Sealing wax.

Corn-mills.

Verdigrise or Spanish green.

Saffron.

Alum.

Falconry.

Turf (fires).

Artichoke.

Saw-mills.

Stamped paper.

Insurance.

Adulteration of wine.

Clocks and watches.

Volume 2.

Artificial pearls.

Paving of streets.

Collections of natural curiosities.

Chimneys.

Hungary-waiter.

Cork.

Apothecaries.

Quarantine.

Paperhangings.

Kermes - Cochineal.

Writing pens.

Wire drawing.

Buck-wheat.

Saddles.

Stirrups.

Horse shoes.

Floating of wood.

Lace.

Ultramarine.

Cobalt. Zaffer. Smalt.

Turkeys.

Butter.

Volume 3

Green flowers.

Lending houses.

Chemical names of metals.

Zinc.

Book-censors.

Exclusive privilege for printing books.

Catalogues.

Aurum fulmians.

Carp.

Camp-mills.

Mirrors.

Glass Cutting.

Etching on glass.

Scap.

Madder-plant.

Jugglers.

Camel.

Artificial ice. Cooling liquors.

Hydrometer.

Lighting of streets.

Nightwatch.

Leaf skeletons.

Bills of exchange.

As translated by William Johnston.

APPENDIX 2. CORRESPONDENCE.

37,WILLOWTREE AVE.,
GILESGATE MOOR,
CITY OF DURHAM.
DH1 1EA.
16-5-86.

Dear Mr Grimshaw,

I am undertaking a research project into aspects of Control Technology in Education.

I would like to be able to assess where, and to what degree, the Authority has its teaching resource.

Is it possible for you to furnish me with answers to the following questions?

a) What are the purposes of the TRIST microelectronics courses which have been provided this calender year at Peterlee College?

b) Why have these TRIST courses been of different duration?

c) What was the policy of the Authority with respect to the advertisement of these courses in its schools?

d) To teachers in which curriculum/subject areas, did the authority believe these courses would be of interest?

e) Has the authority analysed the curriculum/subject areas represented by those teachers accepted onto the courses?

f) If such an analysis has been done, (or will be done), would the Authority be prepared to furnish me with its findings?

g) Does the Authority intend to monitor, and/or further the effects of these courses; and if so, how?

On a more general theme, may I enquire how the Authority co-ordinates its approach to the provision of resources in respect of electronics, micro-electronics, micro-processing, word-processing and etcetera?

Yours sincerely,

C.N.L. France.

DURHAM COUNTY COUNCIL

D. J. W. Sowell, B.A., M.Ed.,
Director of Education

Please address any reply to

The Director of Education,
County Hall,
Durham,
DH1 5UJ.

My reference KBG/AH Your reference Tel: Durham 64411 (STD Code 0385) Ext. 2319

27th June 1986

Dear Mr. France,

Thank you for your letter concerning the development of TRIST in the Authority.

Practical Electronics was advertised in schools on 3rd December 1985. The advertisement was directed to Heads of Science via Head Teachers and was sent by the Science Adviser. Only Science staff attended the course which ran for a total of 17 days at the college. The stated aim of the course was "to provide support for teachers who intend to or are at present teaching electronics to the above-fourteen age range".

Retraining for Microelectronics Teaching was advertised in schools on 14th January 1986 and was targetted at "lower secondary school teachers with an interest or involvement in the teaching of Microelectronics". Fourteen teachers attended the course (that is all those who applied). Of these only one was a CDT teacher. One teacher of computer studies attended and the rest were Science (mainly Physics) teachers. The course duration was 3 days. The stated aim of the course was to "introduce the systems approach to teaching Microelectronics and to assist in the integration of Microelectronics into the school curriculum.

With reference to question (d):

There are aspects of microelectronics which are of interest, either directly or in association with new teaching approaches, in many areas of the curriculum. Obvious examples would be:

(a) Electronics - as a subject in its own right.

(b) Electronics in Control Technology - an area of major interest to CDT teachers.

(c) Electronics in Computing - computer control is of interest in many areas of the curriculum.

(d) Electronics in Science - many Physics syllabuses involve some aspects of Electronics though usually on an analytical rather than a design and application level. There is also a lot of potential for using Electronics in scientific measurements and data collection.

(e) Electronics as a teaching aid for teachers of children with special needs.

Cont'd ....

This matter is being dealt with by the Deputy Director

(f) Electronics in Rural Science and Environmental Studies - the scope for sensing and control of environmental conditions is at least as great as it is in Science. Weather conditions can be monitored (temperature, pressure, humidity, rainfall, light conditions, wind-speed and direction). Soil moisture content and acidity can all be monitored with relative ease.

(g) Electronics in the Primary School - it can be used as a new approach to achieving many educational objectives in the primary school. The "Wirral Electronics Pack" in particular has been used to introduce children to problem solving situations, design, numeracy, group work, language and many other pupil-centred activities.

(h) Electronics in Music - musical applications of Electronics and Microelectronics are well developed in industry and offer new approaches to the teaching of music.

(i) Electronics in Physical Education - this is an area which as yet is relatively untouched by new technology and where a lot of scope exists for new teaching approaches.

(j) An awareness of Microelectronics, its impact in society, potential and limitations should be part of every child's education.

It is obvious that Electronics/Microelectronics, like Computing, Maths., or Language, does not in general "belong" in any one subject area. This obviously has implications for curriculum and staff development. It is important that the Authority tries to avoid the introduction of Electronics into schools and colleges to occur on an ad hoc basis. This also applies to the provison of INSET courses or staff development programmes.

As far as the TRIST programme is concerned, the Authority has tried to ensure that courses are widely advertised in schools by circulating information through head teachers to all teachers in the school. Some courses are really continuation of previous INSET and in these cases a more restricted circulation has been used. However, we would normally circulate all members of staff concerning Electronics courses because it is not believed that Physics or CDT or any other subject area can claim that their teachers are more suited to the teaching of a subject which crosses many boundaries.

It is intended that all TRIST courses will be carefully monitored and this should be the norm for all INSET courses. The approach adopted to monitoring can be expected to vary from course to course depending on the prevailing conditions. For example a different approach may be possible for INSET courses

Cont'd ....

run at the Microtechnology Centre from that possible for courses run either in schools or by another authority on our behalf. In general, it would be considered preferable to monitor and evaluate courses from all relevant viewpoints. We are interested in trying to evaluate courses in terms of effectiveness (eventually in the classroom) and value-for-money. Follow-up to courses is an area which needs to be investigated in some depth. Again the pattern adopted will need to be varied according to circumstance but there are financial as well as educational implications to be taken into consideration. You are welcome to information about monitoring and evaluation but in general it is expected that solid opinions in this area will only emerge over an extended period of time particularly as we are trying to respond to feedback by modifying approaches as we proceed.

Yours sincerely,

Mr. C. N. L. France,
37 Willowtree Avenue,
Gilesgate Moor,
Durham.
DH1 1EA.

DURHAM COUNTY COUNCIL

D. J. W. Sowell, B.A., M.Ed.
Director of Education

Please address any reply to

The Director of Education,
County Hall,
Durham DH1 5UJ.

My reference GRDD/SR   Your reference   Tel: Durham 64411 (STD Code 0385) Ext. 273

21st August, 1979

Dear Mr. France,

Thank you for your enquiry of 20th July, 1979, regarding Schools/Industry links and the response of this Authority to the recent D.E.S. Circular. In Durham County a number of initiatives had already been taken prior to the issue of the D.E.S. Circular, notably the setting up of a network of Careers Associations in the County, attended by teachers, employers and Careers Officers. However the regional conferences chaired by Shirley Williams (styled as the Great Debate), the D.E.S. Green Paper, and subsequent circulars undoubtedly gave impetus to the work of these Associations.

Perhaps the most dramatic evidence of the County's interest in developing schools/industry links was the setting up in 1978 of the Durham Industry Commerce Associations (or D.I.C.E.). I have enclosed some background information on D.I.C.E. and its activities. Since the inaugural meeting in March, 1978 the Association has gone from strength to strength and now has its own Newsletter. In addition to the Mathematics Working Party referred to in the enclosure, D.I.C.E. now has Working Parties on Schools-Based Work Experience, English as a Means of Communication, Common Reference Forms and Audio Visual Aids - all of which are producing tangible results. D.E.S. and the Schools Council have recently shown an interest in D.I.C.E.

For further details about the Association's activities I suggest that you contact Miss J.O. Ritchie, District Careers Officer for Wear Valley and Teesdale at the following address:-

Careers Officer,
Cradock Villas,
Bishop Auckland,
Co. Durham.

I trust that this information is helpful.

Yours sincerely,

G. R. D. Dick

County Careers Officer

Mr. C.N.L. France,
98 Moor Crescent,
High Grange Estate,
Gilesgate Moor,
Durham City.
DH1 1DL

The matter is being dealt with by Mr. G.R.D. Dick

Department of Education and Science
Elizabeth House York Road London SE1 7PH

Telegrams Aristides London Telex 23171
Telephone 01-928 9222 ext

7

Mr Christopher N L France
87 Moor Crescent
Gilesgate Moor
DURHAM CITY
DH1 1DL.

Your reference

Our reference

Date 03 July 1979.

Dear Mr France

Thank you for your letter of 14 May about your research project on the means of keeping the public informed of important aspects of technical innovation. I am sorry you have not had an earlier reply.

The Department employs a number of means of informing the public of important technological developments, but you will appreciate that our primary concern is with the educational implications of such advances.

Information is distributed via a number of means, for example Press releases, Parliamentary Debates and Questions (published in Hansard), in Ministerial speeches (which generally attract Press coverage), through information leaflets published by the DES, circular letters and administrative memoranda (primarily directed to our partners in the education service). The Department also handles a large volume of correspondence from members of the public, and in this way attempts to provide a personalised information service. The DES also maintains close liaison with many other bodies - in particular other Government Departments and representatives of the education service.

In your letter you expressed your concern, which we share, that with the present rapid changes in society and technology many people may not be aware of the industrial basis of our economy. The Department is concerned to help young people and adults alike to develop a better understanding of the crucial role of industry, and has taken steps to encourage better liaison between education and industry and commerce. For example, a circular letter was issued last year to local education officers to stress the importance of forging closer links between schools and local firms. A copy of this letter is enclosed. At the other end of the academic scale, the Science Research Council is actively promoting schemes which bring industry and university departments together to pursue research of mutual interest. There are also many examples of industrial liaison in Higher and Further Education.

One of the most important technological developments is the rapid progress being made in micro-electronics technology. This is clearly an area which will have powerful social and economic repercussions, and the Department is engaged in urgent discussion to assess the implications for the education service. A circular letter was issued in October last year to various educational bodies outlining our attitudes and plans. Since then considerable progress has been made in working out more detailed proposals, but the document is still a good summary of Departmental thinking, and a copy is accordingly enclosed. Earlier this year a consultative document was issued describing plans for a national development programme to help schools and colleges become aware of the potential of micro-electronics. I enclose a copy for your information. However this programme is currently under review in the light of cuts in public expenditure. As soon as any plans have been given Ministerial approval, details will be released to the Press for publication.

The DES recognises that an appropriate response to the new technology must necessarily include the provision of technical courses to train the specialists who will be needed by industry. However, it is also important to develop non-technical education to familiarise adults and children alike with the potential widespread uses of microprocessors, to help them to adjust to the rapid changes society can expect to see in the next few years.

I hope that this is the kind of information which you were seeking. If I can be of any further assistance, please do not hesitate to contact me.

Yours sincerely

M D Goldspink.

37, WILLOWTREE AVE.,
GILESGATE MOOR,
CITY OF DURHAM.
DH1 1EA.
16-11-85

Dear

I am part of a team at the University of Durham Institute of Education, conducting research into the applications of computers in education.

As a teacher my professional interests lie in that area of the curriculum known as Craft, Design and Technology and I am directing my invesigations towards the field of Control Engineering in Secondary and Primary schools.

The Royal Society of Arts, in its manifesto "Education for Capability", (to which you are a signatory), recognises that to be well-balanced, education "must also include the exercise of creative skills, the competence to undertake and complete tasks and the ability to cope with everyday life; and also doing all these things in co-operation with others." (Para 2)

This quotation is a part of its criticism of current educational practise. The assertion being that education is not catering for such requirements. However, curriculum design which encourages the fostering of those qualities was being promulgated in Colleges in 1967 when I was being trained. I am bound to ask, if Colleges of Education were training new teachers to recognise the need for a new direction in the assessment of academic success in 1967, why are you and your co-signatories currently in the position of having to move a "new" initiative?

The third paragraph of the manifesto recognises a culture concerned with "doing, making and organising, and the creative arts." The education of this culture is to be catered for. In the light of the aims of the Society, I interpret this "culture" as the Society's perception of our Nation per se. To what extent then, are we to see the influences of Industry and Commerce in the process of Education, and how will this extent be measured?

Those requirements of education, as identified in the Manifesto, are not new, and have been included in schools curricula. What has changed, I would suggest, has been the use to which they are put by the school leaver. Is there perhaps a lack of appreciation of his/her flexibility both by employers and others, possibly fostered by the relatively "old-fashioned" environments and resources to which the school pupil is exposed?

I would hope that perhaps you might also be prepared to consider the following dilemma. If the preparation of individuals for the world of industry and commerce requires skills which can be developed in ways which do not need the hands-on use of new technology, would sucess be recognised? If not, it would seem to imply that education needs to be newly resourced and I wonder what aspects of industry and commerce you would consider imperative to be included in the hardware resources of schools? Furthermore, the Manifesto separates "education" and "training"; clearly there is good reason for this. If industry and commerce wish to influence the content of curriculum, how else can it be done without appearing to be advocating "training" or without influencing the content of the Public Examination Syllabuses?

And would this second be productive in view of the abysmally low regard with which British Universities recognise the current relevant 'A' levels? (A strange dichotomy since they set and supervise the assessment of the content!)

It is not my wish to divert your attentions from your primary interest, but I hope you will appreciate that I cannot hope to conduct meaningful research without the assistance of those who are currently involved in the "nuts and bolts", so to speak.

Thank-you for your time,

Yours sincerely,

C.N.L.France.

Bishop of Liverpool — Church House 1 Hanover Street Liverpool L1 3DW
Rt Rev David Sheppard — 051 708 9480

13th December 1985

Mr C France
37 Willowtree Avenue
Gilesgate Moor
City of Durham
DH1 1EA

Dear Mr France.

Thank you for your letter of 16th November. Please accept my apology for taking a month to reply, but I have been very busy, not least because of the publication of the Report of the Archbishop of Canterbury's Commission on Urban Priority Areas, called **Faith in the City** Might I suggest you would find this report helpful if you wish to know my mind on issues you raise. (I was Vice Chairman of the Commission). Pages 295 to 300 or so might be specially useful.

Don't you think that it is rather for you, as a researching educationalist, than for me, all things considered, to answer your question, 'if Colleges of Education were training new teachers to recognise the need for a new direction in the assessment of academic success in 1967, why are you and your co-signatories currently in the position of having to move a 'new' initiative?' It might be a point for me to make as a Bishop, to help you, that every generation has to come again and again, with God's grace, to the task of realising God's Kingdom on earth, because it is in the nature of things that things in this world go wrong rather than right!

Many points in the Report I have invited you to read - not least because we regard what we have to say to be of the utmost urgency - have been made before in the course of the last one hundred years and more: we have to say them again and again in relation to present-day circumstances because people do not listen or don't want to listen or fail to give them our priority, or genuinely disagree.

May I suggest that you communicate with John [Burn] - Head teacher of a Community School in North Tyneside - who was intimately involved in the writing of the education section. I [illegible] his address.

Yours sincerely,
+ David Liverpool

Carlton, Bedfordshire. Telephone 720077 (STD 02

ferences .
ase ask for .
. extension .
ase address
r reply to .
e .

Mr C N L France BA(Hons)A dip Ed Cert Ed
37 Willowtree Avenue
Gilesgate Moor
City of Durham DH1 1EA

9 December 1985

Dear Mr France

Thank you for your interesting letter of November 16.

Rather than trying to respond to each part of your letter in detail in writing, I would suggest that you might find it helpful to discuss the issues raised with colleagues within British School of Technology of which I am Chairman.

BST is the national organisation most closely involved in the practical aspects of the points you raise, and I would suggest that you contact their Executive Secretary, Geoff Wainwright, to arrange a discussion with him and his colleagues. His address is British School Technology, Carlton, Bedfordshire MK43 7LF. Telephone: Bedford (0234) 720077.

Without wishing to prejudge the discussion you have with BST, I would however make a number of general comments.

(1) The cultural stereotype of the United Kingdom as being more concerned with the elegant consumption of wealth than with its creation is an interesting study.

(2) Such profound changes in national and international circumstances have occurred since 1967 that the presence of current educational initiatives does not of itself imply an inadequacy in those of an earlier age. As recently as June 1974, for example, unemployment stood at 2.1% of the working population.

G. Wainwright
Executive Secretary

(3) Your questions relating to the role of industry and commerce within the school curriculum, the resourcing of schools for technological studies, and the degree to which examinations could (or should) reflect industrial and commercial consideration are all inter-related. While industry and commerce are too diverse to speak with a single voice, as, in many cases, are local education authorities, BST has nevertheless undertaken a study of LEA requirements and concerns in the broad curriculum area of your own studies and this may be something else for you to discuss with them.

I am sure you will find contacts with BST beneficial and I wish you well in your research.

Yours sincerely

Henry Chilver

Sir Henry Chilver
Chairman

THE OPEN UNIVERSITY

Walton Hall, Walton,
Milton Keynes,
MK7 6AA.
Telephone: Milton Keynes 653214
Telex: 825061

Vice-Chancellor
J H Horlock ScD FEng FRS

Our Ref JHH/SW

Your Ref.

21st November, 1985.

Mr. C. N. L. France,
37 Willowtree Avenue,
Gilesgate Moor,
City of Durham,
DH1 1EA

Dear Mr France,

Thank you for your interesting letter of 16th November. I accept your point that the Royal Society of Arts initiative may not be a new theme, but I am sure you will agree that any movement towards a third culture in this country (like the German TECHNIC in addition to arts and sciences) is to be welcomed.

My own opinion is that discussion about the differences between education and training is somewhat arid, and in my own subject of mechanical engineering I find it difficult to distinguish between the two. I myself have less criticism of industry than I do of British Universities themselves, and the general British establishment. I have much sympathy with you in your views about recognition of current relevant A levels.

All good wishes in your work at Durham.

Yours sincerely,

J. H. Horlock

CITY OF COVENTRY

EDUCATION DEPARTMENT

Robert Aitken,
Director of Education,
New Council Offices, Earl Stre[illegible]
COVENTRY, CV1 5RS
Telephone 0203 25555 Telex

My reference DE
Phone extension 2001
Your reference
Enquiries to
Date 22 November 1985

Mr. C.N.L. France,
37 Willowtree Avenue,
Gilesgate Moor,
City of Durham,
DH1 1EA

Dear Mr. France,

You raise pertinent issues in your letter but which are not capable of simple reply. I suggest you need to read widely about the many initiatives which are taking place and as a contribution I enclose:-

1. C.E.F.L.

2. My RSA Lecture

3. Copy of OCEA draft handbook

4. Outward Bound Report

Underlying all of these is a fundamental change in the teaching/learning process, rather than content.

Yours sincerely,

Robert Aitken

Director of Education

GL

THE ROYAL SOCIETY *for the encouragement*
OF ARTS *Manufactures and Commerce*

JOHN ADAM STREET · ADELPHI · LONDON WC2N 6EZ · TEL 01-930 5115

16 December 1985

Mr C N L France
37 Willowtree Avenue
Gilesgate Moor
City of Durham
DH1 1EA

Dear Mr France

Your letter to my secretary, Shelley Wilson, and that to Professor Ashworth have been passed to me. I will endeavour to answer both letters in this reply.

To take some of the comments that you have made in both letters: first of all, we have nothing specific on the field of control you are asking for but do have some information in our Data Bank concerning Craft Design Technology. This Data Bank is not set up as you might expect but is based on the submissions we have received in the past for our Recognition Scheme. A list of these is enclosed and I include short summaries on those that specifically relate to the CDT area.

You asked for information on our Committee members. The best that I can do, I think, is to refer you to a previous newsletter where the members of the Committee are described together with the changes that have recently taken place. I enclose this edition for you. It would be impractical to provide you with more detail but I can assure you that the Committee has wide experience of different fields of education and, of course, of industry.

In your letter to Professor Ashworth, you make frequent reference to our manifesto and to what you believe is happening in teacher training and in the schools curricula. [illegible]. [illegible]s, the way in which students learn, [illegible] that may facilitate that learning but does not necessarily according to the hands of the teacher in which it rests. Our experience goes widely, as I have mentioned, across education and industry and draws on practice from both those fields. This width of experience is represented in our Signatories, our supporters, our newsletters and in our occasional paper series. I enclose a copy of our publication list in case there are any

.../

that you would particularly wish to see. It is also represented in the conferences we run. Our participants and our speakers and group leaders are invariably drawn from both education and industry. In this way, we make practical use of the expertise of the different areas. I would say that feedback suggests that there is considerable appreciation of the opportunity we afford to share experience across the boundaries.

Can I finally draw your attention to the most recent of our newsletters and to the mention in these of two conferences that may be of interest to you. First of all, we are holding a seminar for those working in North Eastern education authorities. This will take place towards the end of June and will in fact be based at the Durham University Business School. We have a very good friend in Professor Alan Gibb and in Cliff Johnson who are based at the School. Secondly, can I mention the Higher Education Conference which, in one of its aspects, will draw attention to the problem of admissions and to the university impact on the academic scene in secondary schools. You mentioned in your letter to Professor Ashworth the problem of universities and their recognition of particular A-levels. This is certainly an aspect which would be discussed at this conference.

Thank you for your interest. I shall be happy to place you on our future mailing list.

Yours sincerely

Shelley M. Wilson

pp. Janet Jones
Education for Capability Fellow
and Education Adviser to Industry Year

Encs

Nov 21

House of Lords

Dear Mr Frame

Thank you for your letter. I found it interesting but was not entirely clear as to its purpose

The questions up to and including para 6 appear to be rhetorical. Or at least they are ones on which I have no views.

In your para 7, to the first question which concludes 'would success be recognised?' I would answer 'Yes'

To the last question in that para I would answer that to say that it is necessary to distinguish between 'education' + 'training' is by no means to say that there should not be 'training' in the curriculum.

Success would be recognised by the emergence of pupils competent in thought and action anxious to make experiments + accept responsibility. Such pupils would of course be promptly regarded as unemployable by British industry but enough of them might succeed to cause a revolution in our society. In any case, successful or not, they would be more whole people!

Yours

Tim Beaumont

WM

DEPARTMENT OF EMPLOYMENT

Caxton House Tothill Street London SW1H 9NF

Telex 915564

Telephone Direct Line 01-213 - 5815
Switchboard 01-213 3000
GTN Code 213

Mr C N L France BA (Hons) A Dip Ed Cert Ed
37 Willow ee Avenue
Gilesgate Moor
DURHAM
DH1 1EA

Your reference

Our reference

23 December 1985

Dear Mr France,

Thank you for your letter of 16 November 1985 to the Secretary of State, Lord Youn which has been passed to me for reply. I am sorry I have not been able to respond earlier.

I was pleased to read that the qualities called for by the RSA Manifesto 'Educatio for Capability' were already being encouraged in Colleges of Education in 1967. However I think you will agree that the 'attitudinal' changes advocated by the Manifesto can only be achieved gradually, with the full cooperation of Government, education authorities, Schools, Colleges, industry and commerce.

Two main areas of this Department's concern are I think relevant to your research. Firstly, you are no doubt aware that the Technical and Vocational Education Initia (TVEI) introduced in 1982 as a pilot scheme to widen and enrich the curriculum for 14-18 year olds has done much to bring schools, colleges and employers closer toge to produce more relevant curricula, and at the same time has enabled schools and colleges to invest in new equipment and in-service training for teachers. The results of TVEI have been encouraging, including work done in Craft, Design and Technology, and the Government is currently considering how best to apply the less learned more widely.

Secondly, the Review of Vocational Qualifications working group, due to report in April 1986, is attempting to put forward a more relevant and comprehensible struct of vocational qualifications, and one which recognises competence and capability in the application of knowledge and skill. The intention is that the recommendati will have the support of employers, examining and validating bodies and others concerned, thus giving full recognition to an integrated Programme for the certifi of education, training and work experience.

When one takes into account the various other programmes currently in operation to encourage relevant curriculum development, including the Manpower Services Commiss attempts in colleges to make work-related non-advance further education more responsive to employers' needs, I hope that you will agree that the Department of Employment is not holding back in its attempts to foster those qualities outlined in the RSA's Manifesto.

Yours sincerely,

A McLellan

A McLELLAN

Manpower Policy

APPENDIX 3. ADDRESS GIVEN BY K.B.GRIMSHAW.

At the inauguration of the British Schools Technology / Durham LEA Technology Education In-Service scheme.

"It gives me very great pleasure to welcome you here this morning on behalf of the Education Committee. The use of electronic equipment to control machinery to a sophisticated level is one which is assuming an increased significance in Industry and Commerce and it is an area in which we must in Education accept our responsibilities for preparing children for their future employment and in providing them with an insight and understanding of these new developments. We have in this Authority already taken very considerable steps over the past few years to stimulate the use of microcomputers and microelectronics in our schools and to increase understanding and awareness of New Technology.

We feel privileged to be one of a limited number of Authorities to be involved in this particular project and our committment is total. It especially pleases me that a wide range of speakers from different backgrounds have accepted an invitation to be present at today's meeting in order to start the ball rolling. It is important that we should develop and strengthen our links with Industry and Higher Education for the benefit of our students. The activities of out recently established S.A.T.R.O. are already making a contribution and I know, Mr. Chairman, of your work with sixth formers and that is something which I would like to see further encouraged in this Authority.

I am, however, somewhat saddened, looking around the hall this morning, to see so limited representation from women. I think that there is a great danger that in the developments of computers and microtechnology we are moving into a male dominated situation. That, I think, is very wrong because it seems that we are failing to tap the potential and harness the ability which lies in at least half of our school population. This means, therefore, that we are losing a great deal. One of our aims, therefore, must be to encourage more girls to take advantage of courses which are offered in the fields of computer studies and microtechnology. Unfortunately if we do not get this right at the outset it becomes a self-perpetuating situation which we have seen developing in other areas of the curriculum. Once attitudes are established it becomes very difficult to alter them. it would be a tremendous pity if we lost so much.

One of the remarkable and welcome things about the microelectronic revolution which is now affecting our schools is the way in which the availability of this hardware has stimulated interest and enthusism among young people in a way that no other single development has occurred in Education over the past thirty years.

The imagination of youngsters, many of very modest abilities, has been stimulated and led them to develop an expertise and an understanding which sometimes far surpasses those who are teaching them and therein lies one of the problems that we are trying to tackle through conferences and courses of this kind. There is an understandable fear among adults, both parents and teachers alike, that they are getting left behind in this very rapidly moving field or that they will be embarrassed by ignorance when confronted by knowledgeable youngsters. It is the intention of this project, among others, to provide a strong cadre of well informed teachers who will not only provide the expertise needed for their students but who will also spearhead these new developments in encouraging their colleagues over a wide range of curriculum disciplines to avail themselves of New Technology.

As I said earlier, the Authority has already committed itself along this road and we are determined to do what we can to make sure that our young people in this region, and in particular, in this county, have the opportunity to avail themselves of the best that is available. I know from past experience that our schools and teachers will respond to the challenge and we shall do what we can to help them achieve that goal.

Now that Design/Technology at 'A' level is acceptable with mathematics and physics for a Degree course in Engineering the whole range of the curriculum is open. The Graduate Engineer needs the support of Technician Engineers and Engineering Technicians at all levels. I hope, however, that new work in this field will not mean simply being railroaded along the familiar, and for many pupils, barren 'O' and 'A' level avenue thus restricting exciting opportunities for too many pupils. There is a need for teaching skills and for academic rigour, but perhaps these could be tested differently. There is, in my view, a high priority to get the assessment process right in such a way that pupils of a very wide ability range are motivated to work in this developing and exciting area of the curriculum. This project along with other interesting initiatives such as the joint teacher fellowship scheme of the Institution of Mechanical Engineers and Institution of Electrical Engineers and the developing work of the relatively new Engineering Council should aim to build up a very broad approach available to as many young people as possible. I shall listen with very great interest to what will be said today and I look forward to visiting the exhibition. I am sure that we shall have a good and informative day.

19-10-83.

APPENDIX 4. A COLLECTION OF SIGNIFICANT YEARS.

1666. French Academie des Sciences founded.

1675. Royal Observatory founded at Greenwich.

1662. British Royal Society founded.

1700. Berlin Academy of Sciences founded.

1709. -French Academie des Sciences employs 20 research assistants.

1777. Beckmann coins the word 'Technology'.

1789. French Revolution. Academie des Sciences degenerates - is transformed after the revolution.

1791. Priestleys home, and those of other Birmingham non-conformists, attacked by mob encouraged by government agent. His laboratory and library burned out.

1791. The Lunar Society of Birmingham inaugurated. Members: James Watt, Mattew Boulton, Dr. Small, Erasmus Darwin, Josiah Wedgewood, Richard Lovell, Edgeworth, Samuel Galton. Expressed support for the French revolution.

1830. Babbage. C., Professor of Mathematics at Cambridge University, wrote 'Reflections on the Decline of Science in England and Some of its Causes'.

1835. Joseph Henry demonstrates the Electro-magnetic relay.

1835. The Geological Society inaugurated. It was a government scientific agency.

1842. Laboratory of the Government Chemist inaugurated by the government.

1844. The first telegraph line, from Baltimore to Washington, demonstrated.

1851. The Great Exhibition.

1856. Coal derived dyes demonstrated by William Perkin.

1864. Dam burst, Dale Dyke, Sheffield.

1867. The Paris Exhibition.

1870. The Devonshire Commission set-up to look into research facilities. It proposed i) a Ministry to deal with Science and Education as a public service, ii) A Science Council to advise the Ministry, iii) the establishment of State Science Laboratories, iv) the encouragement of increased productivity amongst the British Societies.

1879. Tay bridge disaster.

1907. Parliament votes £150,000 to be added to the £186,000 profit from the Royal Exhibition, to buy a site in South Kensington and to build three 'Royal Technical Schools'. They were eventually incorporated as the Imperial College of Science and Technology.

1910. National Physical Laboratory set-up.

1914. Board of Inventions and Research set-up by the Admiralty. J.J.Thompson and C.Parsons to serve on the Board.

1916. Department of Scientific and Industrial Research established.

1916. The Chemical Defence Experimental Establisment at Porton Down.

1917. The Imperial Trust for the Encouragement of Scientific and Industrial Research to administer a £1M fund. Industrial and scientific initiatives to be backed, pound for pound.

1917. National total of 24 student research grants.

1918. Explosives factory disaster, Chilwell Notts.

1919. Four Co-ordinating Boards to collate developments spurred by the First World War. The Radio Board being the most successful with the development of Radar.

1920. National total of 56 student research grants.

1932. The £1M fund exhausted but the need for continued assistance reluctantly recognised.

1933. 'Anyone who looks for a source of power in the transformation of atoms is talking moonshine'.- Rutherford.

1938. National total of 81 student research grants.

1939. Self-sustaining nuclear fission reaction possibility recognised in Britain, U.S.A. and Germany.

1941 I.C.I. agrees to build a reactor in return for helping to produce a nuclear bomb.

1942. Asimov. I. Postulates three laws of Robotics.

1946. Williams. F.C., at Manchester, demonstrates the electronic storage of one binary digit.

1948. The Royal Society accepts Newman's description of a computer as being Automatic, Digital and General purpose.

1948. Williams. F.C. demonstrates the electronic storage of 340K digits.

1948. The demonstation, at Manchester, of a machine which performs according to Newman's definition of a computer.

1948. American demonstration of current amplification by p and n-type semiconductors.

1949. The Manchester computer able to access 5120 digits immediately from a Cathode ray tube store and 40,960 digits from a back-up magnetic drum.

1949. The EDSAC computer at Cambridge demonstrated.

1950. Shockley. W. The first demonstration of a uni-junction transistor. U.S.A.

1961. The Robbins Committee on Higher Education set up.

1964. The Schools Council set up.

1966. Schools Council commissions a pilot study to find out how help could be afforded to schools showing an interest in the targetting of technology in their curriculum.

1967. Schools Council 'Project Technology' set up.

1968. 'Technology and the Schools'. A pilot study report from the Schools Council.

1969. Professor J.Black. Working paper No.1, on interactive video, for NCET.

1969. The University of the Air. (Open University) granted Royal Charter.

1970. G.Hubbard appointed Director of the National Council for Educational Technology (NCET).

1970. Modular Technology approach started in

Hertfordshire.

1973. Schools Technology Forum curriculum and examinations working party survey publishes 'The Essence of School Technology'. Examines all examinations which included the word 'Technology' in their title.

1973. The Council for Educational Technology replaces the NCET. G.Hubbard is the Director. A charitable trust jointly funded by the Departments of Education and Science England & Wales, Scotland and Northern Ireland.

1974. Bath & Avon Education Authority start to develop 'Modular Technology'.

1975. Schools Council 'Control Technology' at Danum Trent Grammar School.

1975. Oxford ordinary level 'Applied Science for Technology'.

1976. Schools Council 'Modular Technology' courses start.

1976. NCST discussion paper on qualities needed by teachers of Technology.

1976. Durham Industry and Commerce into Education (DICE) set up.

1977. Working party set up for an Honours Degree in Design & Technology.

1977. The Industry Project. Schools Council / Confederation of British industry / Trades Union Congress.

1977. 'Education in Schools' DES.

1977. Circular 14/77 asking for LEA review and report on curricular arrangements.

1978. 'School Technology - a position paper'. B.S. Nicholson, Hillingdon ILEA

1979. First East Anglian CSE 'Technology'.

1978. Letter from DES to CEO's ref 'Schools Industry Links'.

1979. Conference at Brunel University 'CDT as an essential part of a balanced curriculum'.

1979. Cambridge ordinary level 'Technology'.

1979. First 'ITEC' set up in London.

1979. 'Education for Capability' campaign launched by the RSA.

1979. G.Shillito speaks on Technology. (Trends).

1980. 'Craft, Design & Technology' first used as a title.

1980. The, so called, 'black and brown' report published.

1980. Microelectronics Education Programme (MEP) set up.

1980. 'Mindstorms' by S. Pappert, published.

1980. 'Chips in Control'. Conference of the SCSST held at National Centre for Schools Technology, Trent Polytechnic.

1980. Kieth-Lucas report on Design Education.

1980. Sinclair ZX80 ready built personal computer £99.95. (Kit - £79.95) 4K ROM, 1K RAM.

1981. CET telesoftware format published.

1981. 'Foundation Studies in CDT' published by the Association of CDT Advisers.

1981. Secondary Science Curriculum Review (SSCR) set up.

1981. 'CDT - A review of A Levels'. Durham LEA report.

1981. K.Baker. Under Secretary of State for Industry, announces 20 ITEC's in London.

1982. BBC Micro launched by Acorn Computers.

1982. Information Technology year.

1982. K. Baker Minister of Information Technology.

1982. Manpower Services Commission (MSC) invited to launch Technical Vocational & Educational Initiative (TVEI)

1983. Durham SATRO established.

1983. MEP allowed to run for two years more.

1983. British Schools Technology (BST) set up. G.Shillito to be director.

1983. Letter from G.Shillito to D.Sowell, Director of Durham LEA., reference rolling programme of in-service education for teachers of Technology.

1983. Curriculum 11-16. 'Towards a statement of entitlement, curricular re-appraisal in action'. DES

1983. One day conference in Durham with reference to BST INSET programme.

1983. SSCR planning & consultation phase to finish. Development phase to start.

1983. Durham ITEC started.

1983. 14 TVEI schemes in England & Wales.

1984. Chemical disaster, Bhopal, India.

1984. Schools Curriculum Development Committee announced.

1984. Schools Council scrapped.

1984. Conference on the secondment of teachers to industry.

1984. 48 more TVEI schemes start.

1984. Certificate in Pre-Vocational Education discussion document. City & Guilds.

1984. Electronics and Control Technology Domain Information File published by MEP.

1985. 'Curriculum from 5 to 16'. HMI

1985. MEP finished.

1985. Women into Science and Engineering (WISE) bus project.

1985. 12 more TVEI schemes start.

1985. £4.5M for Higher Education to increase the number of under-graduates in engineering and technology.

1986. Industry Year.

1986. Space disaster, US Challenger.

1986. Nuclear disaster, Chernobyl, USSR.

1986. K. Baker, Minister for Education & Science, announces TVEI extension.

1986. SSCR development phase to end. Dissemination, implementation and aftercare to run until 1989.

1986. G. Hubbard retires as director of CET.

1987. The last GCE 'O' and CSE examinations sat.

1987. BBC/Acorn Archimedes launched.

APPENDIX 5. THE AUTOMATIC FACTORY.

Please Note.

This is a curriculum package which was conceived during my research for this thesis. It was written and developed with the aid of second year pupils at Belmont Comprehensive School in County Durham, who took an active part in its trialling.
The documentation for pupil use was written with them in mind - boys and girls in mixed ability groups. The documentation for teachers use was originally much shorter, being written for the benefit of my colleagues in the department who were interested in this curriculum development.

As a result of a request from Sunderland Polytechnic Education Faculty, I prepared a formal version of the project which has formed a part of an MSC funded initiative.

This appendix is a copy of that version.

THE AUTOMATIC FACTORY.

C.N.L. FRANCE BA(Hons), A.Dip.Ed., Cert.Ed.

Sunderland Polytechnic.

Manpower Services Commission.

JULY

NINETEEN HUNDRED AND EIGHTY SEVEN.

TEACHERS NOTES.

....the impossible we do in seven weeks.

You are going to put a class of children into a Design, Make and Test situation.

The Design Brief establishes a Knowledge Gap.

The necessary Research is undertaken.

The Results are considered.

Inventiveness is required.

A Product is manufactured.

Evaluation is inevitable.

Co-operation is evident.

THE AUTOMATIC FACTORY - THE REAL WORLD IN MODEL SIZE.

This is a one hour per week, seven week package to introduce 12 year-old pupils to "Technology".

It has been assumed that the class will be of mixed ability and that teachers will recognise this when they divide the class into smaller groups.

The package is intended to be used 'Hands-on' by the pupils, and assumes that the teacher will act as advisor and organiser, rather than as a knowledge base. The role of the teacher is not seen as 'The Expert'.

It would be unreasonable to assume that a group size greater than 18 will not have a detrimental effect upon the efficiency of the package.

The package assumes that the teacher can provide three physically remote areas within the classroom:

THE COMPUTER CONTROL AREA.

THE TECHNICAL LEGO AREA.

THE PROCESS RESEARCH AREA.

THE AUTOMATIC FACTORY - THE REAL WORLD IN MODEL SIZE.

1. HYPOTHESIS.

Technology is already seen to be a broad area of experience. It is manifestly difficult to define, but can non-the-less be seen to encapsulate strategies and processes which are used in the pursuance of assistance to man. It should be possible to design a learning environment which can model a real life activity.

Appropriate technologies.

As in all systems, technology can be described in terms of its constituent parts. However technology does not always use these parts to the best advantage. Rather it utilises those features from the spectrum which are considered appropriate. "Appropriateness" has to be seen in the light of the real world. For those of us in education, we find ourselves now as in the past, subject to a world where the needs of pupils are seen to be changing and widening. Perhaps our situation is more complex because there seem to be so many "New Technologies" and not only are we unable to master them all, we are often unable to call upon appropriate classroom equipment.

This is surely a reflection of a human condition and as such is not only confined to education. Real-world considerations are the very stuff of which 'design' is made, and taking as my maxim the words of a thoughtful if sometimes obscure colleague, "If you do nothing, nothing gets done", I decided to look at what was already available, cost what extra could be afforded and produce what was appropriate.

The Technological experience into which it is proposed to put pupils, can be seen to incorporate the following areas:

a) Control
b) Structures
c) Manipulation of Mechanisms
d) Management
e) Design
f) Communication
g) Systems
h) Industrial Fabrication

The practical learning experience may well show other areas which can then be developed according to the interests, expertise and equipment available.

2. EQUIPMENT NECESSARY.

Experience has shown that the provision of adequate resources is vital to the smooth running of this project. The following are absolutely necessary and must be available at the beginning of each of the seven sessions.

Hardware:-

BBC Computer.

40 Track disc drive.

Monitor/VDU/TV.

1 User Port Interface board for Output control.

The Disc with the Software. PROG1/5.

Pupils in small groups are capable of assembling the Computer system from scratch without any help.

Lego Kit No. 1032.

Assuming a class of eighteen pupils, during the first three weeks there should be available three kits, with Lego Workcards. In the last four weeks it will be necessary for the pupils to have access to another Lego Motor.

Power Supplies. 4.5 volt for Lego, 9 volt for the Input/Output and the Relay boards.

Scissors

Glue

Drawing Pins

A display board.

Stationary:-

6 copies each: a) The Computer Activity booklet.

b) The Lego Activity booklet.

c) The Research Activity booklet.

18 copies: d)The Last Four Weeks booklet.

Photo copies of the Computer System map, sufficient for 'one each'.

3 Foolscap wallets for the "Research and Data Banks".

A4 paper for writing.

A4 paper for sketching.

Display paper.

Assorted coloured pens and pencils for graphics.

Research base for Process Machinery:-

Assorted reference books: woodwork, metalwork, textiles etc.

A collection of old text books with pictures of people doing jobs, using machines or tools, in the past as well as the present.

The pupils must have access to sources of information on PROCESS, MATERIALS and MACHINES in their widest sense.

Dictionary

Photographs

Video?

Slides?

Catalogues

Holiday Brochures

Newspapers

Industrial Liason?

Personal contributions by the pupils?

It is important that the pupils be encouraged to assemble their own collection of information and for this reason they must be allowed to cut out, make posters and record ideas. A plentiful supply of expendable materials must be provided.

3. TEACHING STRATEGIES.

The evaluation session in week 7 can be ruined if the Contract time is over-run.

WEEKS 1,2 & 3.

The teacher should have read the three Activity booklets.

Week 1.

It defeats the object of fostering inventiveness and personal responsibility to give too many instructions. The class will need to be divided into the three areas, the control area, the Lego area and the research area.

Pupils should be given their Activity Booklets and be:-

a) made aware of the Design Brief which is included with all Pupil Activity Booklets,

b) made aware that words printed in capital letters are most significant and that pupils will be responsible for recording their meanings,

c) told how to use their Research and Data Banks for the storage of each groups work,

d) allowed to start work, by reading the activity booklets, without further delay.

Weeks 1,2 & 3.

From now on until the end of the lesson the role of the teacher will not vary much during these first three weeks.

The COMPUTER group will need to be watched to make sure that they do exactly what the activity booklet requires them to do.

The teacher should expect to be asked for a) a system map b) an interface board d) a research disc and finally e) a little house board.

These requests should be treated as flags which signal to the teacher the rate of progress of the group. If the order of these requests is changed, the group will have skipped something.

Be prepared to listen to an interesting discussion on what to call the other two OUTPUT devices!

Check the connection of the interface board shortly after being asked for it.

Do not offer to give pupils equipment unless they ask for it. It is, however, sensible to offer advice if the 'flow' is being lost.

The LEGO people will need to be encouraged to make notes and pictures of their own. It might seem sensible for the groups to agree to make different models. Models which are driven by motor or are modified to do so, would be more appropriate.

Experience has shown that in a 1 hour lesson, it is usual for one pair of pupils to make, test and document only one model.

The RESEARCH group will probably not share the workload amongst its members without intervention from the teacher.

A notice board divided into three areas serves several purposes for this group. It allows work to dry undisturbed, it demonstrates to the rest what has already been covered and gives experience in assembling a display. This last is a skill to be developed in the final four weeks.

The teacher should bear in mind that during the last four weeks, all work stored in the Research and Data Banks will be made available for a public display to be assembled by members of this class. The pupils need not be told in case it encourages them to change their attitude to their current task from one of 'doing research' to 'making quality products'.

At the end of the lesson unfinished paperwork can be taken home for home work, and the display left until their next session or stored in the Bank.
Pupils should also be made aware of their next activity.
Homework topics are included at the end of each of the Activity booklets used in the first three weeks.

Week 3.

By the end of this session the class must be made aware of the need to identify a simple product which their model factory will 'make'. Week 4 allows for class discussion and a corporate decision.

WEEKS 4,5,6 & 7.

Read the 'Last Four Weeks' booklet before Week 4.

The information in the booklet has not been split into descretely separate 'weeks' or 'Engineers' booklets so that all pupils have access to the total work load of the group as a whole. (It also reduces the teachers storage problems.)

The teacher should have given some thought to the demonstration and display facilities which will be needed in week 7. Are there wall surfaces available? Should the display be public? Is there sufficient security for a long term display?What power points are available? Is there a large enough table or similar surface?

This second part of the course aims to provide each pupil with the opportunity to be creative. The three areas of experience are still available and pupils can be allowed a limited degree of choice in respect of the materials and techniques they prefer to work with by being involved in the composition of the 'Engineers' groups. This is seen as a further dimension to the project, allowing a form of overlaid management structure to be used by pupils recognising the opportunity.

The management structure is formed by splitting the class into the three new groups, which, for the remainder of the project they will associate with the computer, Lego building and the production of graphics.

Each group will then delegate two of its members to cope with inter-group communications and the display. This Liason group is to be responsible for the following things:

a) representing the views and needs of the group that they 'belong' to,

b) taking questions from one group to another and returning with the answers,

c) helping out with other groups when the workload becomes unbalanced.

The management structure also helps to alleviate the very real problem of classroom disorganisation resulting from quantities of bodies wandering around the room duplicating the search for answers!

The teacher continues to assume the role of adviser and provider, although now it is necessary to overview the management structure. The pupils will adapt to the structure providing there is no alternative! The teacher can foster its use by 'playing the game' and only discussing information with the target group. Other users of the information will then only be able to access it from within the structure.

It is also possible to maintain the impetus necessary to keep to the timetable by utilising the structure and choosing the persons to advise with care.

Week 4.

The class must first meet as a single entity to define the agreed 'product'. Although this is not absolutely vital, the establishment of a product, described by the pupils and perhaps sketched on the board by the teacher, will focus the mind when the next step is taken.

The Brief asks for four machines, one of which has to handle materials. The remaining three ought to be for cutting, fitting and finishing. However this may not seem appropriate to the pupils and anyway, if there are sufficient interfaces and Lego sets, it is possible to control a maximum of eight items with the software provided.

When the production outline has been agreed and understood by all, the pupils assume their Engineer status and sufficient quantities of the "Final Four Weeks" booklet can be distributed.
The sooner that the pupils can be allowed to consider their new responsibilities and consult their booklets, the more time the teacher will have to deal with the requests from them for materials and equipment.

The Liason group needs to be identified and their responsibility for handling inter-group questions understood by all.
The resource base should contain the same materials and equipment as were available in the first three weeks, with the addition of the three Research and Data Bank

files assembled by the pupil groups in the first three weeks.

The Control Engineers will need powered Relay Switches for use with PROGS.

Week 5.

The Production Engineers must plan, and publicise, the Display layout before the end of the lesson.

Weeks 5 & 6.

When considering what to write here, I was reminded of the reply given to the man who asked the way from Manchester to Durham. After some thought he was told, "If it was me, I wouldn't start fom Manchester."
From the point of view of the teacher, these two weeks ought to have been provided at the beginning when all the preparation had to be done because if the project is going well the teacher will be feeling relatively unwanted and with littleto contribute it is time to take the opportunity to stand back and reflect upon the aims of the work, the attitudes of the pupils and the effectiveness of the course. All vital if the course is to be repeated.
Apart from that, remedial work can be done with individuals and there will be the ever present need for the resource situation to be monitored.

Display material should be made to 'finished quality' and will need to be stored. Lego models may need to be taken apart if the school is using the Project with more than one class of pupils.

It might be worthwhile to invite an 'outsider' to the demonstration in week 7. The teachers decision on this matter will no doubt be influenced by the progress the class is making!

Week 6.

The pupils will need to be reminded of their Contract Time which expires half an hour before the end of the next session.

Week 7.

The construction of the display will depend upon the facilities available but there will be a finite time needed for the job. An early meeting of the Production Engineers is required to make this assessment. The class will need to be given the cut-off time will allow the display to be erected and tested before the Contract time.

This first half of the lesson is usually hectic. The responsibilies for actions and inactions are discovered and often firmly levelled at those pupils who have defaulted.

The evaluation session can be ruined if the Contract time is allowed to over-run.

Pupils do appreciate the sense of occasion and even though visitors cannot be expected to fully appreciate the work done, the automatic operation of the project will capture their attention.

THE AUTOMATIC FACTORY.

THE FIRST THREE WEEKS.

THE COMPUTER ACTIVITY.

ASPECTS OF COMPUTER CONTROL.

input.....process.....output

You are going to need to find out about computer control.

You may have used a Computer to play games, but Industry takes Computer Systems a lot more seriously!

INDUSTRIAL DESIGN IN MINIATURE.
THE DESIGN BRIEF.

Your class is going to learn how to become an Industrial Design Team. Its task is to design, make and display an Automatic Factory. The factory should have three process machines and one machine which moves the materials from one process machine to another.

The finished factory will only be a model, so even though all your little machines will work, we just have to pretend that the product is being made!

CONTRACT TIME:

7 weeks. The Demonstration is to take place 30 minutes before the end of the seventh lesson. It is possible that visitors will arrive at that time to assess your product. They must not be kept waiting.

MATERIALS AVAILABLE:

A BBC Computer System with interfaces.
Technical Lego Construction Kits.
Display materials.
Resource base.

NOTE:

Every member of the class can be thinking of what the factory might make, but a final decision does not have to be made until the end of week 3. By this time all the members of the class will have learned about three things.

1. Manufacturing Machinery.

You will have collected information on many different types of machines and the jobs they can do in industry.

2. The use of Model Kits.

You will have learned to use TECHNICAL LEGO to make models of things which work.

3. Computer Control.

You will have used a computer to turn electrical things on and off.

Be sure to keep looking for help in the lesson booklet and if you are in doubt about anything, talk it out in your team before asking your teacher.

PUPIL LESSON NOTES.

COMPUTER CONTROL.

You have read through the DESIGN BRIEF and you know that you are going to have to find out how a COMPUTER SYSTEM can help you.

In this RESOURCE FILE you will find information that you will need, but you will have to make your own collection of information in your DATA and RESEARCH BANK. Make sure that your teacher has explained what this is, and that you have materials handy.

When you come to a word in capital letters, you must write down its meaning.

Whenever you reach a row of stars in these notes, it means that you have just read about something which needs to be doneand now is the time to do it.

At this time, for example, you have to make sure that your teacher has explained the use of the bank.

When your team is sure that all the members are ready, you can all read on.

****

Now ask for a copy of the COMPUTER SYSTEM MAP each.

****

A SYSTEM is a collection of things which do something. Some parts are for INPUTting, some are for

OUTPUTting and others are for PROCESSing. On the SYSTEM MAP you will see the parts of the COMPUTER SYSTEM drawn as boxes, which should be linked together with arrows.

When Engineers want to explain things to each other, they often draw boxes and join them together like this. If they don't say how the thing in the box works, then the box is known as a BLACK BOX. (It has nothing to do with colour.) Perhaps you have heard about 'Black Boxes' on the television news? Find out about them, possibly from your parents, as soon as possible.

On your copy of the map the lines which join the boxes should be arrows When you have worked out what the arrows are trying to tell you, you will be able to add the arrow heads. You will also be able to label each box as an input, process or output devise.

Do this now.

****

If the computer system is switched ON, switch it OFF now.

****

Listen carefully, and watch the KEYBOARD, when the computer system is next switched ON. You should be aware of two other OUTPUT devices. Decide what to call them and print their names inside the two empty boxes on the map.

One of your team should switch the system ON at the wall socket, whilst the rest of the team observes the system. If you cannot agree about these two other OUTPUTs, then switch the system OFF and try again.

You MUST find these outputs before you pass the next row of stars!

****

SWITCH THE COMPUTER SYSTEM OFF AT THE WALL SOCKET NOW!

****

It is now time to add another item to the COMPUTER SYSTEM. It is called an INTERFACE BOARD, and its job is to allow the computer to be connected to lots more OUTPUT and INPUT things.

When you get it, you will find that it has two RIBBON CABLES. One has to be plugged into a PRINTER PORT, and the other goes into a USER PORT. These ports (some people call them Sockets), which are underneath the KEYBOARD, are fixed onto the edge of the MICROPROCESSOR BOARD.

Since the INTERFACE BOARD will be using the PRINTER PORT, it will not be possible to have the PRINTER connected today. If the printer ribbon cable is already plugged in, someone will have to remove it.

When you reach the next row of stars, ask for the INTERFACE BOARD and carefully connect it.

Find a place on your system map, and add the input/output interface board.

****

Your teacher will be interested to check your assembly before switching ON at the wall socket for you. You will also be given the RESEARCH DISC, on which todays PROGRAMs have been STORED.

****

Someone will need to type LOAD"PROG1", press the RETURN key, then type the word RUN and then press the RETURN key again.

The team should work out why you have to press the RETURN key before the computer system does what was typed.

Make a note of your decision.

The computer will now give you help, but don't forget to keep putting information in the BANK!

HOMEWORK.

1) Add colour to your systems map.

2) Make a collection of pictures and notes about a computer different from the one you used in class.

3) Make a mini display from your collection, show

it to your parents and ask for their signature.

Hand this in at the beginning of the next lesson.

THE AUTOMATIC FACTORY.

THE FIRST THREE WEEKS.

THE RESEARCH ACTIVITY.

ASPECTS OF MAKING BY MACHINE.

cutting..assembling..handling

The Design Brief does not tell you what product the factory will be making. You need to know about lots of Process Machines!

INDUSTRIAL DESIGN IN MINIATURE.
THE DESIGN BRIEF.

Your class is going to learn how to become an Industrial Design Team. Its task is to design, make and display an Automatic Factory. The factory should have three process machines and one machine which moves the materials from one process machine to another.

The finished factory will only be a model, so even though all your little machines will work, we just have to pretend that the product is being made!

CONTRACT TIME:

7 weeks. The Demonstration is to take place 30 minutes before the end of the seventh lesson. It is possible that visitors will arrive at that time to assess your product. They must not be kept waiting.

MATERIALS AVAILABLE:

A BBC Computer System with interfaces.
Technical Lego Construction Kits.
Display materials.
Resource base.

NOTE:

Every member of the class can be thinking of what the factory might make, but a final decision does not have to be made until the end of week 3. By this time all the members of the class will have learned about three things.

1. Manufacturing Machinery.

You will have collected information on many different types of machines and the jobs they can do in industry.

2. The use of Model Kits.

You will have learned to use TECHNICAL LEGO to make models of things which work.

3. Computer Control.

You will have used a computer to turn electrical things on and off.

Be sure to keep looking for help in the lesson booklet and if you are in doubt about anything, talk it out in your team before asking your teacher.

PUPIL LESSON NOTES.

MACHINING.

Read right through this booklet before doing anything else.

You have read through the DESIGN BRIEF and you know that you are going to have to find out about the way things are made, or PRODUCED, in modern factories.

This RESOURCE FILE gives you some pointers to the task of RESEARCHING the subject of MATERIALS HANDLING machinery. You will have to make a collection of notes for your DATA and RESEARCH BANK. Make sure that your teacher has explained what this is, and that you have the materials handy.

Whenever you reach a row of stars in these notes, it means that you have just read about something which needs to be done. Now is the time to do it and not before. At this time, for example, you have to make sure that your teacher has explained.

When your team is sure that all the members are ready, you can all read on.

When you come to a word in capital letters, you must write down its meaning.

****

No one has yet decided what the Factory is going to pretend to make, but when a PRODUCT has been decided upon, this is what must happen.

1) Decisions will have to be made about what MATERIAL the product could be made from.

2) When the material has been chosen, decisions about how it is going to be worked into its final shape will have to be taken.

3) When this has been done, someone will need to know which machines would do the job or jobs.

So there are three things to be done, and your group will spend this lesson finding information about all three.

One of your team should collect all the research RESOURCE materials and equipment from the teacher now.

****

You have to make a collection of pictures and notes. You should use writing, cut-outs, drawings and colours.

These are your three areas. Divide them between the members of your team, and find evidence to answer the questions in this booklet.

1) MATERIALS.

a) What are MATERIALS?

b) How many different materials can you find that are used to make products?

c) How do the materials behave? (What are their main PROPERTIES?)

d) What else have you found out?

2) PROCESSES.

a) What are PROCESSES?

b) How many different processes can you find?

c) Are some processes always linked with others?

d) Are there any processes which always have to be used when making a product?

e) If you look at your list of processes, you should find that they fall into groups. Can you name the groups?

f) What else have you found out?

3) MACHINES.

THE AUTOMATIC FACTORY - THE REAL WORLD IN MODEL SIZE.

a) What is a MACHINE?

b) Find as many examples of machines as you can. Draw up a table and fill it with the answers to the following questions for each machine.

i. What POWERS it?

ii. Is it FREE-STANDING or HAND-HELD?

iii. Is it AUTOMATIC?

iv. How is it CONTROLLED?

v. What does it do?

vi. What material is it DESIGNED to PROCESS?

c) What else have you found out?

HOMEWORK.

1) Find someone who works with any kind of machinery, tell them about your lesson and find out from them what their machine does and how they operate it.

2) With writing and sketching, describe for your teacher what you have found out.

3) Ask your parents to read and sign it.

Hand this in at the beginning of the next lesson.

THE AUTOMATIC FACTORY.

THE FIRST THREE WEEKS.

THE LEGO ACTIVITY.

ASPECTS OF MACHINERY AND DRIVES.

drive........power.........gearing

You are going to find out about Technical Lego.

You may be used to playing with it, but now you have to use it as Process Designers would!

INDUSTRIAL DESIGN IN MINIATURE.
THE DESIGN BRIEF.

Your class is going to learn how to become an Industrial Design Team. Its task is to design, make and display an Automatic Factory. The factory should have three process machines and one machine which moves the materials from one process machine to another.

The finished factory will only be a model, so even though all your little machines will work, we just have to pretend that the product is being made!

CONTRACT TIME:

7 weeks. The Demonstration is to take place 30 minutes before the end of the seventh lesson. It is possible that visitors will arrive at that time to assess your product. They must not be kept waiting.

MATERIALS AVAILABLE:

A BBC Computer System with interfaces.
Technical Lego Construction Kits.
Display materials.
Resource base.

NOTE:

Every member of the class can be thinking of what the factory might make, but a final decision does not have to be made until the end of week 3. By this time all the members of the class will have learned about three things.

1. Manufacturing Machinery.

You will have collected information on many different types of machines and the jobs they can do in industry.

2. The use of Model Kits.

You will have learned to use TECHNICAL LEGO to make models of things which work.

3. Computer Control.

You will have used a computer to turn electrical things on and off.

Be sure to keep looking for help in the lesson booklet and if you are in doubt about anything, talk it out in your team before asking your teacher.

THE AUTOMATIC FACTORY - THE REAL WORLD IN MODEL SIZE.

PUPIL LESSON NOTES.

MODELLING.

Read right through this booklet before doing anything else.

You have read through the DESIGN BRIEF and you know that you are going to have to find a way of building machines.

This RESOURCE FILE tells you how to go about preparing for the job of MODELLING MACHINERY.

As you will see, you will have to make a collection of notes for your DATA and RESEARCH BANK. Make sure that your teacher has explained what this is, and that you have the materials handy.

Whenever you reach a row of stars in these notes, it means that you have just read about something which needs to be done. Now is the time to do it and not before. At this time, for example, you have to make sure that your teacher has explained.

When your team is sure that all the members are ready, you can all read on. When you come to a word in capital letters, you must write down its meaning.

****

In order to make a Factory, you need to be able to construct MODEL machinery. (This is because it would take too much time and money for you to build the real things!)

In the Lego Kit you will find a file of things to make, and it will show you how to put the parts together. Some of the things could be described as models of real machines. You could also MODIFY the Lego designs to make models of other machines.

Two things have to be done, and both are very important.

1) No one has decided yet what sort of Factory the class is going to make, or what PRODUCT the factory will pretend to make, so no one knows yet what machines are going to be needed.

It would seem sensible to make as many different machines as possible in this lesson. It might also be a good idea to find out what other people have made, and make something different.

2) The second thing to do is to keep a record of what you are doing. If no one does, then when it comes to deciding what machines can be modelled for the factory, we won't have any evidence of how <u>difficult</u> they are to make, or how much <u>time</u> they take to build, or how <u>well</u> they work, or what they <u>look like</u>.

Each machine you make must have a short PRODUCT REPORT which goes into the BANK. The report needs to have NOTES and SKETCHES which describe the MAKING and TESTING of the model, together with COMMENTS on whether it is any good, or not, and why.

Make sure that you leave 10 minutes for packing and checking, at the end of the lesson.

The bits in the Kits are fiddly and small. It is easy to drop them on the floor. At the end of the lesson all the models have to be taken apart and the kit must be checked. This is done by comparing the kit with the plan on Lego file card No.1. If any bits are not in their correct place THEY MUST BE FOUND.

If you need a power supply to make the electric motor work, you should ask your teacher. Lego motors need 4.5 volts. They should not be given more than this, so check the Power Supply befote you switch it on.

HOMEWORK.

1) Using materials which are normally thrown away; card, plastic, paper etc., make a simple model of a machine. It should have a moving part.

2) Show it to your parents, ask them if they like it and ask them to sign it somewhere.

Hand this in at the beginning of the next lesson.

THE AUTOMATIC FACTORY.

THE LAST FOUR WEEKS.

THE DESIGN ACTIVITY.

THE ENGINEERING STAGE.

ideas......make......test

......and now for the factory!

And only four weeks left to do it in!

INDUSTRIAL DESIGN IN MINIATURE.
THE DESIGN BRIEF.

Your class is going to learn how to become an Industrial Design Team. Its task is to design, make and display an Automatic Factory. The factory should have three process machines and one machine which moves the materials from one process machine to another.

The finished factory will only be a model, so even though all your little machines will work, we just have to pretend that the product is being made!

CONTRACT TIME:

7 weeks. The Demonstration is to take place 30 minutes before the end of the seventh lesson. It is possible that visitors will arrive at that time to assess your product. They must not be kept waiting.

MATERIALS AVAILABLE:

A BBC Computer System with interfaces.
Technical Lego Construction Kits.
Display materials.
Resource base.

NOTE:

Every member of the class can be thinking of what the factory might make, but a final decision does not have to be made until the end of week 3. By this time all the members of the class will have learned about three things.

1. Manufacturing Machinery.

You will have collected information on many different types of machines and the jobs they can do in industry.

2. The use of Model Kits.

You will have learned to use TECHNICAL LEGO to make models of things which work.

3. Computer Control.

You will have used a computer to turn electrical things on and off.

Be sure to keep looking for help in the lesson booklet and if you are in doubt about anything, talk it out in your team <u>before</u> asking your teacher.

PUPIL LESSON NOTES.

THE LAST FOUR WEEKS.

This is week 4. You have four weeks, including this one, to finish the Project and win the contract.

The time-table is as follows:-

PROJECT WEEK 4. "MANAGEMENT STRUCTURE WEEK."

A Product has to be decided upon, and the material(s) from which it is to be made need to be stated.

The maximum number of Processes has to be agreed, and each has to be described so that it can be modelled.

When the product and the processes have been decided upon, the class has to be divided into another three groups. This is because there are three major tasks which need to be done.

There is another task, communications, which will need two people from each engineers group. They will form the Liason Group.

1) The Mechanical Engineers.

a) To be responsible for the Design, Construction, EVALUATION and COMMISSIONING of all Process machinery.

b) To produce Product Reports and OPERATING INSTRUCTIONS for each one.

c) Two members, to be named, to liaise with the Control and Production Engineers.

2) The Control Engineers.

a) To be responsible for the SEQUENCING and TIMING of the factory.

b) To liaise with the Production Engineers and input the timing and sequence DATA into the Control Program.

c) To test its operation, and to produce a CONTROL FLOWCHART.

d) Two members, to be named, to liaise with the Mechanical and Production Engineers.

3) The Production Engineers.

a) To be responsible for the PROCESS SEQUENCE and TIMING DATA and to discuss this with the Control Engineers. b) To produce all manner of descriptive materials which are to do with the Factory.

c) To design and assemble a display of the work neccessary to design the Factory.

d) Two members, to be named, to liaise with the

Control and Mechanical Engineers.

For the rest of the lesson:-

The Mechanical Engineers should research the required machinery.

Half of the Control Engineers and half of the Production Engineers should get together to sort out the SEQUENCE in which the machines work and their TIMING.

The remainder of the Control Engineers should look at the Control Program (PROG4) on the computer system.

The remainder of the Production Engineers should start REVIEWING all the information collected by the class in the Research and Data Banks.

PROJECT WEEK 5. "DEVELOPMENT WEEK 1."

All groups to experiment in their area, working towards their aims as set out above in Week 4.

A drawing of the DISPLAY LAYOUT PLAN has to be posted on a wall board, by the Production Engineers, before the end of the lesson.

Note: ALL LEGO MODELS ARE TO BE TAKEN APART BEFORE THE END OF THE LESSON AND THE KITS CHECKED.

Graphics work done by the Production Engineers can be permanently manufactured.

PROJECT WEEK 6. "DEVELOPMENT WEEK 2."

This is another opportunity to build test and illustrate. All class members must have looked at, and understood, the display layout plan.

Note: ALL LEGO MODELS ARE TO BE TAKEN APART BEFORE THE END OF THE LESSON AND THE KITS CHECKED.

Graphics work done by the Production Engineers can be permanently manufactured.

PROJECT WEEK 7. "GETTING IT ALL TOGETHER WEEK."

This is the last session allowed.

The Production Engineers must meet for 10 min. at the start of the lesson, and agree the time when building has to stop and the working Display starts to be assembled. They must inform the class.

The Display is to be ready for demonstration at Contract Time.

****

CONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRAC
TTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECO
NTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTT
IMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONT
RACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIM
ECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRA

Half an hour before the end of the lesson, there is to be a working model factory surrounded by a display of explanations and graphics.

CONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRAC
TTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECO
NTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTT
IMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONT
RACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIM
ECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRACTTIMECONTRA
****

If any Technologists wish to photograph the finished display, this will be the time. Remember that you are entirely responsible for your camera, and that flash will give you better pictures.

THE AUTOMATIC FACTORY.

COMPUTER PROGRAMS.

"Anything that can go wrong, will ... and does."

(Murphy.)

The Software presented with this Project has been written and run on a standard BBC microcomputer with 40 track disc drive.
The programs are written in BASIC and are not supposed to represent the 'State Of The Art' when it comes to programming. There are no fancy bits: no machine code or obscure *FX commands. (More like my mothers meat & potatoe pie rather than the cordon bleu at the Savoy.)
They are not intended to form part of the pupils education; as with the rest of the package they exist as an example of Black-Box technology.

If the pupils report that the program no longer does what it 'did before' or has 'stopped' or some other catastrophe has become manifest, don't bother with an inquest - press <ESCAPE> and RUN the program again.

```
LIST
   10 REM PROG1
   20 REM THE AUTOMATIC FACTORY.
   30 REM C.N.L. FRANCE. DH1 1EA. 1987.
   40 REM OUTPUTS GO HIGH ONE AT A TIME
   50 ?&FE61=0
   60 MODE6
   70 VDU19,0,4;0;0;
   80 PRINTTAB(12,3)"CONTROL PROG 1"
   90 PRINTTAB(4,5)"You will each need a PLAN of the "
  100 PRINTTAB(4,7)"INTERFACE BOARD. When you have RUN"
  110 PRINTTAB(4,9)"this program a few times, you"
  120 PRINTTAB(4,11)"should be able to add to the"
  130 PRINTTAB(4,13)"PLAN so that it describes"
  140 PRINTTAB(4,15)"what the program does."
  150 PRINTTAB(4,20)"Sketch your plans now."
  160 PRINTTAB(4,22)"Press the <SPACE BAR> to continue."
  170 G=GET
  180 CLS
  190 PRINTTAB(4,4)"CONTROL NUMBERS."
  200 wait = 2000
  210 PRINT''
  220 A = 1
  230 ?&FE61=A
  240 PRINT A
  250 FOR x = 1 TO wait:NEXT
  260 FOR B =0 TO 6
  270  A = 2^(B+1)
  280 PRINTA
  290 ?&FE61=A
  300 FOR x = 1 TO wait
  310 NEXT
  320 NEXT
  330 PRINTTAB(4,18)"What might the numbers be for?"
  340  PRINTTAB(4,22)"Press the <SPACE BAR> to repeat."
  350 PRINTTAB(4,23)"ESCAPE and load PROG2 to continue."
  360 G=GET
  370 GOTO180
>
```

```
LIST
   10 REM PROG2
   20 REM THE AUTOMATIC FACTORY.
   30 REM C.N.L. FRANCE. DH1 1EA. 1987.
   40 REM INPUT NUMBER, LED LIGHTS UP.
   50 MODE6
   60 VDU19,0,4;0;0;0;
   70 ?&FE61=0
   80 DIM list%(20)
   90 CLS
  100 z%=6
  110 PRINTTAB(12,3)"CONTROL PROG 2."
  120 PRINTTAB(4,6)"This is the first part."
  130 PRINTTAB(4,9) "Type in one of the CONTROL numbers"
  140 PRINTTAB(4,11)"you were given by PROG1."
  150 PRINTTAB(4,13)"and keep your eye on the LED's!"
  160 INPUTTAB(4,21)N%
  170 PROCtest
  180 IF flag=0 GOTO160
  190 ?&FE61=N%
  200 z%=z%-1
  210 IF z%=0 PROCnext
  220 CLS
  230 PRINTTAB(4,5) "(You have ";z%;" goes left.)"
  240 PRINTTAB(4,9) "You typed in ";N%
  250 PRINTTAB(4,11) "An LED has lit up."
  260 PRINTTAB(4,13) "Type in another number."
  270 GOTO 160
  280 DEFPROCnext
  290 CLS
  300 ?&FE61=0
  310 PRINTTAB(4,5)"Now for a bit of fun."
  320 PRINTTAB(4,7)"In a moment, I want someone"
  330 PRINTTAB(4,9)"to type in a list of numbers."
  340 PRINTTAB(4,11)"Use the numbers you were given"
  350 PRINTTAB(4,13)"by PROG1. The numbers which you"
  360 PRINTTAB(4,15)"choose, and the order they are"
  370 PRINTTAB(4,17)"given to me, I leave up to you."
  380 PRINTTAB(4,19)"I need TWENTY numbers!"
  390 PRINTTAB(4,22)"Press <SPACE BAR> to continue."
  400 G=GET
  410 CLS
  420 FOR in%=1 TO 20
  430 PRINTTAB(4,15)"Give me a number. ";in%;:INPUT")"N%
  440 CLS
  450 PROCtest
  460 IF flag=0 GOTO430
  470 list%(in%)=N%
  480 NEXT
  490 CLS
  500 PRINTTAB(4,5)"Now watch the LED's."
  510 ?&FE61=0
  520 FOR wait%=1 TO 10000:NEXT
  530 FOR out%=1 TO in%-1
  540 ?&FE61=list%(out%)
  550 FOR wait%=1 TO 8000:NEXT
  560 NEXT out%
  570 ?&FE61=0
  580 PRINTTAB(4,5)"Although someone typed in the"
  590 PRINTTAB(4,6)"numbers, the computer did many"
```

```
600 PRINTTAB(4,7)"very different things."
610 PRINTTAB(4,8)"Talk about this and then you can"
620 PRINTTAB(4,9)"write down what they were."
630 PRINTTAB(4,13)"Perhaps you would like to try out"
640 PRINTTAB(4,14)"some Flash Patterns before you"
650 PRINTTAB(4,15)"finish with this program?"
660 PRINTTAB(4,16)"(Keep a note of your best one.)"
670 PRINTTAB(4,17)"To do this, all you do is just"
680 PRINTTAB(4,18)"press the <SPACE BAR>."
690 PRINTTAB(4,22)"ESCAPE and load PROG3 to continue."
700 G=GET
710 CLS
720 PRINTTAB(4,8)"PLEASE CHANGE THE ORDER."
730 GOTO340
740DEFPROCtest
750 RESTORE
760 flag=0
770 FOR test%=1 TO 8
780 READ data
790 IF N%=data flag=1
800 NEXT test%
810 IF flag=0 CLS:PRINTTAB(8,7)N%;"?":PRINTTAB(4,9)"Look at the
list of numbers again."
820 ENDPROC
830 DATA 1,2,4,8,16,32,64,128
>
```

```
LIST
   10 REM PROG3
   20 REM THE AUTOMATIC FACTORY.
   30 REM C.N.L. FRANCE. DH1 1EA. 1987.
   40 REM TO ALLOW THE HOUSE GAME
   50 MODE6
   60 ?&FE61=0
   70 VDU19,0,4;0;0;
   80 PRINTTAB(12,3)"CONTROL PROG 3"
   90 DIM list%(20)
  100 PRINTTAB(4,5)"You will now need to connect"
  110 PRINTTAB(4,6)"the little House Board to the"
  120 PRINTTAB(4,7)"INTERFACE BOARD."
  130 PRINTTAB(4,9)"To do this you need to connect the"
  140 PRINTTAB(4,10)"black WIRE/PLUG to the black Ovolt"
  150 PRINTTAB(4,11)"socket on the INTERFACE BOARD."
  160 PRINTTAB(4,12)"Then the other plugs go to"
  170 PRINTTAB(4,13)"the green sockets."
  180 PRINTTAB(4,19)"Connect them up now."
  190  PRINTTAB(4,23)"Press <SPACE BAR> after connecting."
  200 G=GET
  210 CLS
  220 PRINTTAB(4,5)"The purpose of the INTERFACE BOARD"
  230 PRINTTAB(4,6)"is to connect the Computer System "
  240 PRINTTAB(4,7)"to the outside world. It becomes a"
  250 PRINTTAB(4,8)"clever set of light switches."
  260 PRINTTAB(4,10)"Your first job will be to find"
  270 PRINTTAB(4,11)"the Control Number for each lamp."
  280 PRINTTAB(4,13)"You will have to design a chart"
  290 PRINTTAB(4,14)"to show the Control number for "
  300 PRINTTAB(4,15)"each lamp. The chart has to be "
  310 PRINTTAB(4,16)"filled in, and put in the BANK."
  320 PRINTTAB(4,23)"Press <SPACE BAR> to find numbers."
  330 G=GET
  340 CLS
  350 PRINTTAB(4,5)"There are 8 lights, you must find"
  360 PRINTTAB(4,6)"the 8 control numbers."
  370 INPUTTAB(4,15)"Input a Control number; "N%
  380 CLS
  390 IF N%=0 GOTO440
  400 PRINTTAB(4,23)"Press < 0 > when you have finished."
  410 PROCtest
  420 ?&FE61=N%
  430 GOTO 370
  440 CLS:?&FE61=0
  450 PRINTTAB(4,5)"Now I want you to work out an old"
  460 PRINTTAB(4,6)"persons journey, as they finish"
  470 PRINTTAB(4,7)"watching the t.v., and go to bed."
  480 PRINTTAB(4,9)"I want to turn their lights ON/OFF!"
  490 PRINTTAB(4,11)"Remember; a 0 turns all lights OFF"
  500 in%=0
  510 REPEAT
  520 INPUTTAB(4,15)"Give me a number. "N%
  530 out=0
  540 CLS
  550 IF N%=999 out=1 :GOTO610
  560 in%=in%+1
  570 REM PROCtest
  580 PRINTTAB(4,23)"Input 999 to test your idea."
  590 REM IF flag=0 in%=in%-1:GOTO530
```

```
600 list%(in%)=N%
610 UNTIL out
620 PRINTTAB(4,5)"Now watch the House lights."
630 ?&FE61=0
640 FOR wait%=1 TO 10000:NEXT
650 FOR on%=1 TO in%-1
660 ?&FE61=list%(on%)
670 FOR wait%=1 TO 8000:NEXT
680 NEXTon%
690 ?&FE61=0
700 PRINTTAB(4,5)"O.K. Perhaps that was good, but"
710 PRINTTAB(4,6)"is that really what people do?"
720 PRINTTAB(4,7)"If you add the Control numbers, you"
730 PRINTTAB(4,8)"should find that more than one light"
740 PRINTTAB(4,9)"goes ON at once. Would this help?"
750 PRINTTAB(4,11)"You can try again."
760 PRINTTAB(4,20)"Work on a CONTROL LIST until"
770 PRINTTAB(4,21)"the end of the lesson."
780 PRINTTAB(4,23)"Press <SPACE BAR> to repeat."
790 G=GET
800 GOTO440
810 DEFPROCtest
820 RESTORE
830 flag=0
840 FOR test%=0 TO 8
850 READ data
860 IF N%=data flag=1
870 NEXT test%
880 IF flag=0 CLS:PRINTTAB(8,7)N%;"?":PRINTTAB(4,9)"Look at you
r Control numbers again."
890 ENDPROC
900 DATA 0,1,2,4,8,16,32,64,128
>
```

```
LIST
   10 REM PROG4
   20 REM THE AUTOMATIC FACTORY.
   30 REM C.N.L.France. DH1 1EA. 1987.
   40 REM TO CONTROL THE FACTORY.
   50 MODE6
   60 ?&FE61=0
   70 VDU19,0,4;0;0;0;
   80 CLS
   90 PRINTTAB(12,3)"CONTROL PROG 4"
  100 PRINTTAB(4,5)"You will need to connect the"
  110 PRINTTAB(4,7)"INTERFACE BOARD. When you have done"
  120 PRINTTAB(4,9)"so you will be able to see"
  130 PRINTTAB(4,11)"the L.E.D.'s light up."
  140 PRINTTAB(4,13)"This lets you test your planning."
  150 PRINTTAB(4,15)"Connect the Board to the Ports now."
  160 PROCgoon
  170 PRINTTAB(4,4)"CONTROL LINES."
  180 PRINTTAB(4,6)"You should remember, from the House"
  190 PRINTTAB(4,7)"task, that it is possible to switch"
  200 PRINTTAB(4,8)"On and Off a number of different"
  210 PRINTTAB(4,9)"things. You must not plan to"
  220 PRINTTAB(4,10)"control more than this number of"
  230 PRINTTAB(4,11)"machines."
  240 PRINTTAB(4,12)"After naming it, each machine has"
  250 PRINTTAB(4,13)"to be given a CONTROL NUMBER."
  260 PRINTTAB(4,15)"I shall need to be told this"
  270 PRINTTAB(4,16)"Number followed by the time in"
  280 PRINTTAB(4,17)"SECONDS that you want the machine"
  290 PRINTTAB(4,18)"to RUN for."
  300 PRINTTAB(4,20)"Make a note of what I need, now."
  310 PROCgoon
  320 PRINTTAB(4,4)"PLANNING THE CONTROL DATA."
  330 PRINTTAB(4,7)"You might find it useful to make"
  340 PRINTTAB(4,8)"out a list of the order, or"
  350 PRINTTAB(4,9)"SEQUENCE, in which the machines"
  360 PRINTTAB(4,10)"RUN."
  370 PRINTTAB(4,11)"Beside each you could jot down"
  380 PRINTTAB(4,12)"the proposed RUNning time."
  390 PRINTTAB(4,14)"DON'T FORGET THE TIMES WHEN "
  400 PRINTTAB(4,15)"NO MACHINES ARE RUNNING AT ALL!"
  410 PRINTTAB(4,17)"When you have finished, count"
  420 PRINTTAB(4,18)"the number of steps in your list."
  430 PRINTTAB(4,20)"Afterwards, press the Space Bar."
  440 PROCgoon
  450 PRINTTAB(4,5)"DATA INPUT PROCEDURE."
  460 PRINTTAB(4,7)"How many steps in the Sequence?"
  470 INPUTTAB(4,9)steps%
  480 PROCwait
  490 PRINTTAB(4,11)"Thank-you"
  500 PROCwait
  510 IF steps%<2 PRINTTAB(4,13)"Don't be silly!":PROCwait:CLS:GO
TO450
  520 DIMdata(2,steps%)
  530 PRINTTAB(4,13)"How many machines are to be used?"
  540 INPUTTAB(4,15)number%
  550 PROCwait
  560 PRINTTAB(4,17)"Thank-you."
  570 PROCwait
  580 IF number%>8 OR number%<1PRINTTAB(4,19)"I am not able to ha
```

```
ndle ";number%:PROCwait:CLS:GOTO450
  590 PRINTTAB(4,19)"I confirm that I can handle ";number%;"."
  600 DIMcontnum(number%)
  610 PROCwait
  620 PROCwait
  630 CLS
  640 PRINTTAB(4,5)"PLEASE NOTE:-"
  650 PRINTTAB(4,7)"You should use CONTROL NUMBERS:-"
  660 PRINT
  670 RESTORE
  680 FOR cn%=1 TO number%
  690 READ XXXX
  700 contnum(cn%)=XXXX
  710 PRINT contnum(cn%)
  720 NEXTcn%
  730 PRINTTAB(4)"to switch the machines ON,"
  740 PRINT
  750 PRINTTAB(4)"and remember, 'O' stops the lot!"
  760 PROCgoon
  770 PRINTTAB(4,5)"INPUT DATA."
  780 PRINT
  790 FOR row%=1 TO steps%
  800 PRINTTAB(4)"Step No ";row%
  810 INPUTTAB(4)"CONTROL NUMBER is  - "data(1,row%)
  820 PROCcheck
  830 IF flag%=0 PRINTTAB(4)"NOT A VALID CONTROL NUMBER.":PRINT:P
ROCwait:GOTO800
  840 INPUTTAB(4)"TIME in SECONDS is - "data(2,row%)
  850 PRINT
  860 NEXT row%
  870 PROCwait
  880 PRINT:PRINT:PRINT:
  890 PRINTTAB(4)"That concludes your Sequence Data."
  900 PROCwait
  910 PROCdisplay
  920 INPUTTAB(4)"Is alteration necessary? Y/N "choice$
  930 IF choice$="Y"PROCalter:GOTO900
  940 PROCwait
  950 PRINTTAB(4)"I shall now RUN your sequence."
  960 PRINTTAB(4)"Check it against your notes."
  970 PRINTTAB(4)"If it is still not exact you will"
  980 PRINTTAB(4)"be able to alter it when I finish."
  990 PROCgoon
 1000 CLS
 1010 PRINTTAB(4,4)"Here I go!"''
 1020 FOR output%=1 TO steps%
 1030 ?&FE61=data(1,output%)
 1040 time=TIME
 1050 REPEAT:UNTIL TIME=time+(data(2,output%)*100)
 1060 NEXT output%
 1070 PRINT
 1080 INPUTTAB(4)"There! Was that O.K.? Y/N "choice$
 1090 IF choice$="N" CLS:PROCdisplay:PROCalter:GOTO900
 1100 CLS
 1110 PRINTTAB(4,4)"RECORD THE DATA!"
 1120 PRINTTAB(4,6)"Make sure that you have a copy"
 1130 PRINTTAB(4,7)"of the final Sequence Data."
 1140 PROCgoon
 1150 PROCdisplay
 1160 PROCwait
```

```
1170 PRINT''
1180 PRINTTAB(4)"You have now finished."
1190 END
1200 DEFPROCdisplay
1210 CLS
1220 PRINTTAB(4,4)"INPUT DATA"
1230 PRINTTAB(4,6)"STEP.        CONTROL No.      TIME."
1240 FOR list%= 1 TO steps%
1250 PRINT "       ";list%;"                    ";data(1,list%);"
    ";data(2,list%)
1260 NEXT list%
1270 ENDPROC
1280
1290 DEFPROCalter
1300 INPUTTAB(4)"Which step number needs alteration?"row%
1310 PROCwait
1320 PRINTTAB(4) "STEP No. ";row%
1330 PRINT"    CONTROL NUMBER = ";data(1,row%)
1340 PRINT"    TIME           = ";data(2,row%)
1350 PRINT:PRINT:
1360 INPUTTAB(4)"What should the CONTROL No. be? "data(1,row%)
1370 PROCcheck
1380 INPUTTAB(4)"What should the TIME be?          "data(2,row%)
1390 ENDPROC
1400
1410 DEFPROCcheck
1420 flag%=0
1430 FOR check%=1 TO number%
1440 IF data(1,row%)=contnum(check%)THEN flag%=1
1450 IF data(1,row%)=0 THEN flag%=1
1460 NEXT check%
1470 ENDPROC
1480
1490 DEFPROCgoon
1500 PRINTTAB(4,23)"Press the <SPACE BAR> to continue."
1510 G=GET
1520 CLS
1530 ENDPROC
1540
1550 DEFPROCwait
1560 FOR wait=1TO2000
1570 NEXTwait
1580 ENDPROC
1590
1600 DATA 1,2,4,8,16,32,64,128
>
```

```
LIST
   10 REM PROGS
   20 REM THE AUTOMATIC FACTORY.
   30 REM C.N.L.France. DH1 1EA. 1987.
   40 REM To Run the Factory.
   50 *TV255
   60 MODE6
   70 ?&FE61=0
   80 VDU19,0,4;0;0;0;
   90 CLS
  100 PRINTTAB(12,3)"CONTROL PROGS"
  110 PRINTTAB(4,5)"Use this to run the Factory."
  120 PRINTTAB(4,7)"You will need to connect the"
  130 PRINTTAB(4,9)"INTERFACE BOARD. When you have done"
  140 PRINTTAB(4,11)"so you will be able to see"
  150 PRINTTAB(4,13)"the L.E.D.'s light up."
  160 PRINTTAB(4,15)"Connect the Board to the Ports now."
  170 PROCgoon
  180 PRINTTAB(4,4)"CONTROL RELAYS."
  190 PRINTTAB(4,6)"You know how many things need to be"
  200 PRINTTAB(4,7)"controlled. You will need to use the"
  210 PRINTTAB(4,8)"same number of RELAY SWITCHES."
  220 PRINTTAB(4,9)"Connect the inputs on the CONTROL"
  230 PRINTTAB(4,10)"RELAYS BOX to the output posts on"
  240 PRINTTAB(4,11)"the Interface board."
  250 PRINTTAB(4,12)"Now connect the Black Interface post"
  260 PRINTTAB(4,13)"to the Black Control Relay Box post."
  270 PRINTTAB(4,15)" "
  280 PRINTTAB(4,16)" "
  290 PRINTTAB(4,17)" "
  300 PRINTTAB(4,18)" "
  310 PRINTTAB(4,20)" "
  320 PROCgoon
  330 PRINTTAB(4,4)"RELAY SWITCHING THINGS."
  340 PRINTTAB(4,7)"Each Relay Switch has a pair of 4mm"
  350 PRINTTAB(4,8)"sockets. Find them now."
  360 PRINTTAB(4,9)"You will need as many power packs"
  370 PRINTTAB(4,10)"as there are LEGO motors."
  380 PRINTTAB(4,11)"Your teacher will show you how to"
  390 PRINTTAB(4,12)"connect a power pack and motor"
  400 PRINTTAB(4,13)"to the Relay Switch sockets."
  410 PRINTTAB(4,15)"You can connect the others!"
  420 PRINTTAB(4,17)"(Then ask for it to be checked.)"
  430 PRINTTAB(4,18)" "
  440 PRINTTAB(4,20)"Afterwards, press the Space Bar."
  450 PROCgoon
  460 PRINTTAB(4,5)"DATA INPUT PROCEDURE."
  470 PRINTTAB(4,7)"How many steps in the Sequence?"
  480 INPUTTAB(4,9)steps%
  490 PROCwait
  500 PRINTTAB(4,11)"Thank-you"
  510 PROCwait
  520 IF steps%<2 PRINTTAB(4,13)"Don't be silly!":PROCwait:CLS:GO
TO460
  530 PRINTTAB(4,13)"How many things are controlled?"
  540 INPUTTAB(4,15)number%
  550 PROCwait
  560 PRINTTAB(4,17)"Thank-you."
  570 PROCwait
  580 IF number%>steps% PRINTTAB(4,19)"You have more THINGS than
```

```
STEPS!":PROCwait:PROCwait:CLS:GOTO460
  590 IF number%>8 OR number%<1PRINTTAB(4,19)"I am not able to ha
ndle ";number%:PROCwait:CLS:GOTO460
  600 PRINTTAB(4,19)"I confirm that I can handle ";number%;"."
  610 DIMdata(2,steps%)
  620 DIMcontnum(number%)
  630 PROCwait
  640 PROCwait
  650 CLS
  660 PRINTTAB(4,5)"PLEASE NOTE:-"
  670 PRINTTAB(4,7)"I now need the CONTROL DATA which"
  680 PRINTTAB(4,8)"you designed with PROG4."
  690 RESTORE
  700 FOR cn%=1 TO number%
  710 READ XXXX
  720 contnum(cn%)=XXXX
  730 NEXTcn%
  740 PROCgoon
  750 PRINTTAB(4,5)"INPUT DATA."
  760 PRINT
  770 FOR row%=1 TO steps%
  780 PRINTTAB(4)"Step No ";row%
  790 INPUTTAB(4)"CONTROL NUMBER is  - "data(1,row%)
  800 PROCcheck
  810 IF flag%=0 PRINTTAB(4)"NOT A VALID CONTROL NUMBER.":PRINT:P
ROCwait:GOTO780
  820 INPUTTAB(4)"TIME in SECONDS is - "data(2,row%)
  830 PRINT
  840 NEXT row%
  850 PROCwait
  860 PRINT:PRINT:PRINT:
  870 PRINTTAB(4)"That concludes your Sequence Data."
  880 PROCwait
  890 PROCdisplay
  900 PROCtime
  910 INPUTTAB(4)"Is alteration necessary? Y/N "choice$
  920 IF choice$="Y"PROCalter:GOTO880
  930 PROCwait
  940 PRINT
  950 PRINTTAB(4)"I shall now RUN your sequence."
  960 PRINTTAB(4)"Check it against your notes."
  970 PRINTTAB(4)"If it is still not exact you will"
  980 PRINTTAB(4)"be able to alter it when I finish."
  990 PROCgoon
 1000 PRINTTAB(4,4)"Health & Safety At Work Act."
 1010 PRINTTAB(4,6)"Machinery is dangerous."
 1020 PRINTTAB(4,7)"Will your machines be safe when"
 1030 PRINTTAB(4,8)"you press the Space Bar and I"
 1040 PRINTTAB(4,9)"start the Control Sequence?"
 1050 PRINTTAB(4,12)"Make a safety check NOW!"
 1060 PROCgoon
 1070 CLS
 1080 PRINTTAB(4,4)"Here I go!"''
 1090 FOR output%=1 TO steps%
 1100 ?&FE61=data(1,output%)
 1110 time=TIME
 1120 REPEAT:UNTIL TIME=time+(data(2,output%)*100)
 1130 NEXT output%
 1140 PRINT
 1150 INPUTTAB(4)"There! Was that O.K.? Y/N "choice$
```

```
1160 IF choice$="N" CLS:PROCdisplay:PROCalter:GOTO880
1170 CLS
1180 PRINTTAB(4,4)"RECORD THE DATA!"
1190 PRINTTAB(4,6)"Make sure that you have a copy"
1200 PRINTTAB(4,7)"of the final Sequence Data."
1210 PROCgoon
1220 PROCdisplay
1230 PROCwait
1240 PRINT''
1250 PRINTTAB(4)"You have now finished."
1260 PRINTTAB(4,23)"Press <SPACE BAR> & repeat cycle."
1270 G=GET
1280 GOTO 1070
1290 END
1300 DEFPROCdisplay
1310 CLS
1320 PRINTTAB(4,4)"INPUT DATA"
1330 PRINTTAB(4,6)"STEP.        CONTROL No.      TIME."
1340 FOR list%= 1 TO steps%
1350 PRINT "       ";list%;"                      ";data(1,list%);"
    ";data(2,list%)
1360 NEXT list%
1370 ENDPROC
1380
1390 DEFPROCalter
1400 INPUTTAB(4)"Which step number needs alteration?"row%
1410 PROCwait
1420 PRINTTAB(4) "STEP No. ";row%
1430 PRINT"   CONTROL NUMBER = ";data(1,row%)
1440 PRINT"   TIME           = ";data(2,row%)
1450 PRINT:PRINT:
1460 INPUTTAB(4)"What should the CONTROL No. be? "data(1,row%)
1470 PROCcheck
1480 INPUTTAB(4)"What should the TIME be?        "data(2,row%)
1490 ENDPROC
1500
1510 DEFPROCcheck
1520 flag%=0
1530 FOR check%=1 TO number%
1540 IF data(1,row%)=contnum(check%)THEN flag%=1
1550 IF data(1,row%)=0 THEN flag%=1
1560 NEXT check%
1570 ENDPROC
1580
1590 DEFPROCgoon
1600 PRINTTAB(4,23)"Press the <SPACE BAR> to continue."
1610 G=GET
1620 CLS
1630 ENDPROC
1640
1650 DEFPROCwait
1660 FOR wait=1TO2000
1670 NEXTwait
1680 ENDPROC
1690
1700 DEFPROCtime
1710 time%=0
1720 FOR add%=1 TO steps%
1730 time%=time%+data(2,add%)
1740 NEXT add%
```

```
 1750 PRINT
 1760 PRINTTAB(6)"Total  TIME for 1 CYCLE = ";time%;"sec."
 1770 ENDPROC
 1780
 1790 DATA 1,2,4,8,16,32,64,128
 1800STOP
 1810 IF flag%=0 PRINTTAB(4)"NOT A VALID CONTROL NUMBER.":PRINT:P
ROCwait:GOTO780
>
```