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Electronics - Why and in what Form it should appear in the Curriculum

Few educationalists would now question the statement 'All pupils should learn something of the principles of New Technology and become aware of its implications as part of the basic education process'.

There is currently however no clear consensus or understanding of what topics such a study should include? How much curriculum time it should take? Where it should be fitted into the curriculum? Who should teach it? What format the teaching programme should have? How much it will cost and who will pay for it?

It is implied by the statements above that a knowledge of electronics is fundamental to a basis for 'New technology awareness'. To justify this implication it is necessary to define what the basic facts and knowledge required for this are. A very simple definition of 'technology awareness' is; 'An appreciation of the fundamental principles of the technology, how the application of the technology relates to human needs and complements human abilities and how the continued development and application of the technology will influence future patterns of living'. In this context the word 'technology', which literally means 'ways of doing things', refers to 'Information Technology' or 'New Technology'.

The first significant fact to be appreciated is that the power of New Technology is not due to some highly complicated new discovery. In fact the rapid advance is due to a coming together of many separate fields of human achievement united by the common medium of semiconductor technology utilising digital techniques. The elements of even sophisticated digital systems depend on the use of many simple principles. The cleverness arises from the way these principles have been brought together. There is no great mystery or complication, a sensible appreciation of New Technology is not reserved for a super intelligent elite. On the contrary teachers are finding that the younger pupils assimilate new ideas very efficiently.

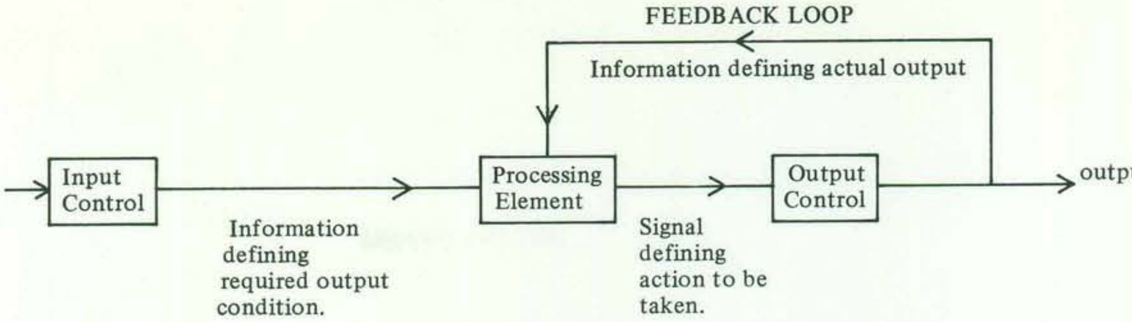
Because the underlying principles of New Technology are simple and common, an appreciation of these enables an understanding of a very wide range of products and systems embodying their application. The fields of human knowledge and enterprise which have been brought together are those of information storage (previously largely paper based), information processing (previously inhibited by the limited accessibility of paper based information) and information communication (previously limited by the low volume flow rate enabled by old technologies). Most significantly these capabilities are brought together in 'Control Technology' which so much extends the capabilities created by the technology of the industrial revolution to control large forces and large power.

From the very onset of human development, defined in terms of our ability to control our environment and our activity in it, our rate of advancement has been determined by the base of information available to us and our ability to use that information effectively. A consideration of some milestones in this development will serve to emphasise this point. Early man was preoccupied by the struggle for day to day survival. The simple skills of life were communicated generation to generation by example and a very limited language. Lack of travel and ability to store and communicate information meant that each individual tribal group's experience and skills were stored in the brains of its individuals and locked up with the group. With the development of writing and eventually printing it was possible to record and so exchange information. Each individual's potential for development was then enhanced by the knowledge and experience of others and was not simply dependent on direct personal interaction.

Early processing systems were largely concerned with numerical data, but with the development of high speed, high capacity digital computers and progress in information representation techniques it became possible to use digital systems to access and process large amounts of information quickly. Paper systems requiring human access simply do not compare in speed, volume, capability, accuracy and sophistication of processing.

Early communication systems were confined to simple message transfer, ie. low information content, or in technical terms, low bandwidth. Transmitted information was sensed and decoded only by a human receiver, had a limited range and very limited message handling capability. With the advent of wire and radio systems various techniques of stacking different messages to increase the system capacity were invented but the significant change in communication came with the advent of digital coding and the ability to switch bits of information very rapidly with all that implies.

The significant developments in all of these fields have occurred largely in the past two decades. Advances in techniques, material technology, manufacturing technology, all interdependent on



one another, have brought us not to the end point of a story or to a revolution but to the point which is only the beginning of potential further development. To coin a well known phrase, 'we have the technology', we now have to discover and decide how to use it. Education must prepare all pupils to be able to accept and live with the huge changes which are about to beset us. All citizens should have an appreciation of the factors which will change their lives so markedly, to appreciate its benefits, to understand the consequences of its misuse. This awareness can only come from an understanding of basic principles which provide perspective and oversight to interpret the wider application of digital technology.

To emphasise the all pervasive nature of Information Technology on our day to day existence and therefore to add one more justification to its study in the basic curriculum, consider the following table of changes in our world and our day to day activity in it.

Exponential Technology:

Timekeeping	Sundial – Digital Systems
Entertainment	Stones – Video Chess Percussion – Synthesisers
Washing	Stones/Rivers – Programmed Washer
Food	Charcoal – Microwave
Communication	Signal Fires – Satellite Links Town Crier – Ceefax, Oracle, Prestel, System X
Calculation	Tally Sticks – Napiers Bones – Microcomputer
Medicine	Thermometers – EEG – Scanners
Transport	Walking – Space
Warfare	Tooth & Claw – Computerised Overkill
Education	Mothers knee – Computer Assisted Learning, Databases
Weather Forecasting	Folk Lore – Satellites & Computers
Information Storage	Cave Walls – Microfilm – Video Disk – Graphics
Farming	Hand & Hoe – Computerised Milking Parlour & Digital Tractors

The table is headed 'exponential technology' because each advance utilises the skills of Information Technology which are increased as a result of this advance. Our ability to control our environment and our activity in it depends on the base of information available to us and our ability to use that information effectively. Both the information base and the skills advance at each step forward and so increase the potential for the next step. An example of his positive feedback is no where more marked than where the previous generation of microchips is used to design, manufacture and test the next generation.

Underlying the application of Information Technology is the concept of a 'system' which may be represented by the block diagram above.

The state of the output of the system is governed by a decision which is taken by the processing element of the system. The concept is quite general but for a digital system the processing element could be programmable. The program might accept information about what the system is required to do, what state it is currently in and to process this information with further possible data stored within the system in order to arrive at the control decision, ie. to generate information (a control signal) defining the consequent state of the output.

In the industrial revolution we became able to make machines whose output power and precision was greater than the capabilities of the human. The systems in which these machines were used contained the ultimate information gatherer and processing element, a human being. The machine operator monitored the process, gathered information through human senses, processed this information and decided the action of the machine. We can now use a digital processor to replace the human operator if we arrange to provide it with the right information in the right form and on condition that we are able to predict and therefore program every circumstance for which the system will be required to operate. In some cases the circumstances will be limited, the task highly repetitive and invariable. In this case the digital processor has to be configured for a limited range of possibilities which can be achieved by a fixed program system. This could use a micro-processor with firmware or at its simplest it could be a hard wired electronic logic block. In a system for which a degree of continuous human intervention would be appropriate we would need to be able to change the processing sequence either because the external circumstances had changed or the required action or product had changed. In which case a software controlled or programmable system is required where the program may be changed.

To summarise the point

Communication technology has grown hand in hand with Digital and Control Technology to bring man to the point where we can now devise and operate systems of huge scale (eg. space) and huge power capability (eg. automatic blast furnace) and with extreme precision (eg. chip manufacture).

We are now in a position where the science of information gathering is a developed art. We can detect and represent variable quantities mathematically and can code them (binary systems etc). We can modulate the signals onto some sort of 'carrier' and can move this information anywhere precisely and rapidly. We also have the ability to produce the intelligent controller, not a 'thinking' device but one which can accept information about processes and which can make process control decisions on the basis of preset programs of instructions.

Education must make clear the relationship of this Technology to man himself. The technology enables 'anything' within the limits of a defined 'program'. Microtechnology systems, sense, calculate, control definable processes faster, more reliably, more accurately than man. This power provides a complement to mans' capabilities to think, to judge, to infer and to reason.

The comments outlined above are illuminated by consideration of the following comparisons:

Cut glass of any complexity may now be produced exactly by digitally controlled systems.

There is no way within the foreseeable future that cars will be driven automatically.

Education must take account of this huge change in mans' potential and provide all pupils with some appreciation of the factors causing our world to change.

They may then not feel threatened by these events and can contribute to a Society which determines confidently and wisely the shape of things to come.

So, what are the basic facts and concepts about New Technology which need to be known and appreciated by properly educated people. How can they be presented in an interesting and meaningful way? Although binary processes are the language of the subject a theoretical approach is obviously quite useless. But as has been demonstrated when pupils are put into a lively open ended situation where they can ask themselves questions and initiate their own investigations practically, then learning and true understanding develops at a rate and to a level quite unparalleled by a purely academic approach.

Information Technology for all. A syllabus Concept — what is it?

The idea that all information is represented, processed and conveyed as a pattern capable of variation. That to be useful the patterns must be well recognised and interpretable. The ideas of codes and decoding, distinction between analogue (human) information and digital information. Need for interface between the technological system and ourselves. Discussion of available means, sound, light (day to day sensing of our surroundings), pictures, print, simple codes, beacons, smoke signals, semaphore leading to digital coding.

Teaching Medium

Lesson with discussion, case studies, videotapes and slide tapes.

New Technology Techniques. Storage, processing and use of information:

Idea of logically processed binary information. That a binary bit string can be used as data or as a control signal. Introduction to simple logic systems without memory, giving unique output information according to the input data. This approach extended to simple systems with memory where data stored in memory may be used in a set predetermined manner to govern the system behaviour. Then to the central concept of a programmable system, where a sequence of operations stored in memory defines the output of an electronic system according to the program and any external data accessed by the system on demand from the program. In simple terms the concept of a programmable electronic device which controls the behaviour of a system.

Teaching Medium

Largely practical 'hands on' experience of digital electronics moving from simple logic demonstrated fixed control systems such as central heating control, leading to simple fixed programme systems' such as traffic lights and then onto programmable systems such as lift systems, pelican crossings, washing machine routines implemented using a simple programmable electronic system designed for use to demonstrate simple principles and therefore technically uncomplicated in use.

This experience of the basic concepts may then be extended by the use of audiovisual aids to relate these principles to their application in manufacturing industry, commerce and banking, administration, agriculture, the home.

Communication of Information

Introduction to the way digital representation enables new powerful communications techniques improving the availability of information and its consequent use. The central database, Oracle, Ceefax, Prestel, banking and commerce, broadcasting with feedback.

Teaching Medium

Lessons backed up by videotapes illustrative of use of new communications techniques. Use of database, Ceefax and Oracle and Prestel.

Applications and Implications

Comparison of human capabilities and needs with the capabilities of the programmable digital information processor and its use in manufacturing processes; its impact on day to day existence, the cashless society, central information storage and privacy.

Teaching Medium

Discussion following the presentation of case studies, demonstrated by visits, videotapes or well illustrated scripts of pertinent examples.

A practical experience of digital processes in action albeit in quite simple systems is the best way to an appreciation of the technique and processes and their capabilities. This leads to an understanding of the vocabulary of the subject whic.., since it embodies common widely applied principles, enables an interpretation of digital technology in its many guises and applications.