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This article is extracted from a longer piece of work commissioned by QCA during the National Curriculum Review to consider the place of ICT in design and technology 2000.

Abstract

Children growing up in a society which is comprehensively dependent on technology and technologically developed products, will be profoundly adrift and alienated from the nature of that society unless they have some insights into where products, on which their life depend, come from, why and how they come into being.

This short article considers the influence of information and communication technology on three aspects of design and technology – modelling, manufacture and control and communications and provides a rationale for the inclusion of ICT (information and communication technology) in the design and technology curriculum.

“Everything we eat, wear, use and touch is produced and delivered by machines and ICT. Without technology ... the UK land mass would only support a population of less than 10 million and not the 60 million of today. Today the fastest rate of change is most visible in ICT. Can you imagine travelling back a mere 20 years and trying to explain how an internet business called YAHOO would grow from nothing to \$8 billion in four years. Or going back only 50 years with stories of mobile phones?”

“Technology now totally underpins and supports human society, and our existence. So joining the ranks of thousands of technologists world-wide means assuming a role of responsibility.” Cochrane (1999) Head of Research, BT Laboratories

Design and technology in the English schools curriculum has gone some considerable way towards ‘assuming this role of responsibility’ with respect to the development of a technologically appropriate curriculum. This curriculum has developed a complex and very special learning style, focusing on the development of products in response to human needs and aspirations. This complexity subsumes a range of component learning styles including analysis of needs, creating and developing ideas, planning and managing the use of time, a wide range of making activities and as information and communication technology (ICT) becomes increasingly ubiquitous it is coming to support almost all these aspects of design and technology in schools.

Reflecting industrial practice

Much of the practice of designing that can now commonly be seen in schools has been drawn from industrial approaches in the adult world. Similarly, as industrial manufacturing methods are drawn into schools (accelerated

by changes in the National Curriculum and national examinations including GCSE, GCE and GNVQ) we can see children’s activities more and more closely following the changes that have been seen in industrial design and manufacture. It must though be borne in mind that this does not deny the fundamental differences of purpose between education and industrial product development.

The justification for reflecting changes in industrial practices in schools is founded in the notion that children growing up in a society which is comprehensively dependent for its lifestyle on technology and technologically developed products, will be profoundly adrift and alienated from the nature of that society unless they have some insights into where the products on which their life depends come from, why and how they come into being.

Industrial design and manufacture has become highly dependent on information and communication technology, though the degree to which this has happened depends somewhat on the manufacturing sector being examined. In all sectors ICT can be seen to support a number of aspects of the designing and making process, including:

- acquisition, computation and analysis of quantitative data
- visualisation and presentation of information
- planning and control of production and distribution.

Computer aided design (CAD) emerged in industry in the 1960s and 1970s as did computer aided manufacturing (CAM) and the two subsequently were connected into computer-integrated manufacture with digital design information directly controlling production machinery. It is a credit to innovative teachers that these two, separately or together, can be seen commonly in use in English secondary schools and elements of them in primaries.

In the 1990s leading edge companies also developed the use of ICT for communications with, for example, designers working collaboratively across national boundaries on a single, shared design file, which might then be sent to yet other countries for manufacture. Most recently, the communications capabilities of the Internet have brought world-wide sourcing of parts and control of supply chains which together with other emerging technologies such as three-dimensional scanning and smart-card information storage opportunities give opportunities for some remarkable developments. These largely seek to secure company advantage by dramatically

shortening the time taken to develop new products to match evolving market requirements (lead time).

Astonishingly, before this selling procedure reached the marketplace almost every component technology it requires could be seen in use in an English school – such is the creativity and innovativeness of some teachers, helped by a responsive educational supply industry and charitably funded curriculum development projects. However, the majority of schools had no such capability but schemes are developing which circumvent some of the established blocks to development, including funding.

For example, remote manufacturing, whereby a CAD file prepared in a school on a standard personal computer can be sent through the Internet and used to control the machining of a part at a remote centre such as a local FE college, is established in a number of areas of the country. This requires significant training of staff and some targeted investment of National Grid for Learning funding but is widely feasible.

Meanwhile, teachers and educational managers need to know what the basics are, the core capabilities which at least introduce students to the fundamentals of designing and manufacturing in the ICT age.

The then National Council for Educational Technology (NCET) in 1993 identified for the Department for Education two major focuses for ICT development in design and technology: control and manufacture; and modelling. NCET was subsequently commissioned to produce resources for each. Since then, the communications component has leapt forward to the point where it merits consideration in its own right.

Modelling

Creating ideas and representing them to yourself and to others so that they may be developed is the very core of the design and technology process and it requires a range of modelling techniques from the purely conceptual to the physical. Physical models include sketches and notes and three-dimensional mock-ups which are partly dependent on the materials to be used for the product, and on a range of other factors. ICT in the form of computer aided design has brought a supplementary range of on-screen modelling facilities which go much further in their nearness to 'real' models, some also automating the rapid production of complex engineering forms. Car design, for example, as befits a highly complex product requiring massive investment in dedicated plant before going into production, usually involves a very

Commercial snap-shot

A leading high street retailer had this capability before the new millennium:

The customer walks into a local store, undresses down to underwear only and enters a scanning booth. His measurements are embedded on the 'chip' on his smart card and he goes home. From then on when wanting to purchase new clothes he can do this from home over the Internet. Bringing up the knit design for a new sweater he chooses a stitch pattern, changes various thread colours and then, satisfied by what he sees in a whole-screen view of the knit, he selects a pattern and views it made-up, knitted in the colour and stitch he chose. He then drapes this garment on a mannequin to his own body measurements and watches it walk down a catwalk towards him. Satisfied with the design he swipes his smart card and confirms the order and his custom-made sweater arrives three days later by express delivery.

wide range of both ICT and conventional modelling techniques:

- sketching
- CAD representations
- full size print-outs of drawings
- full size clay models
- stereo-lithography produced plastics models of engineering parts from which production moulds are created
- sophisticated engineering analysis through CAD software (e.g. testing the concentrations of stress on individual parts, weighing them and finding their centre of gravity, on-screen)
- virtual reality models allowing such as the revolving of a jack to test that it fits into its location in the car boot
- machining tests to ensure that manufacturing tool paths do not clash
- etc.

By contrast, a piece of ceramic holloware such as a vase might be modelled as a real object produced rapidly by hand with no waste of materials, to make a prototype which is recorded in a technical drawing for production. Scanning the prototype to create a CAD record might see ICT introduced only at a late stage in the process.

Software has been produced for schools, constrained in its range of functions to accommodate the limited power of the computers available. Commercial software with an enormous range of functions, some of which are mentioned above, has been made available at special educational prices and through projects such as the CBI's 'Manufacturing by Design' scheme and the DfEE design and technology CAD/CAM project. Gradually we might expect more ideal applications to emerge which shorten the learning curve required by industrial CAD

References

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through user-friendly interfaces whilst still retaining the remarkable advantages of CAD. Realistically this is likely to emerge in the form of modular software which builds up from 'layers' of cut-down industrial packages.

Manufacturing and control

Much of the use of information and communication technology in design and technology is for controlling devices – both incorporated in the products we use and in controlling the means of manufacture. A greenhouse window opener controlled by temperature sensors is an example of the former, CAM represents the latter.

Innovations in control technologies in schools have included data-logging, pneumatic, hydraulic and electronic circuit design, using both on-screen CAD simulations and easy to assemble kits. Control software has been built in to dedicated educational robots ('turtles') and into highly flexible learning kits such as 'Lego'. Electronic circuits are commonly made 'from scratch' and with recent dedicated design software available at low cost and production equipment such as bubble-etch baths 'near-real' industrial design and manufacturing experiences are achievable. More recent developments allow the incorporation of programmable control 'chips' in the end product without undue cost.

Thanks to industrial progress in standardising data file types and a responsive educational supply sector, schools now have compatible computer aided design and computer aided manufacture in a variety of forms from milling machines and sheet material cutters to embroiderers outputting from CAD software running on standard PC networks. Software is also available to simulate processes used in food production including sophisticated hazard control.

Communications

Almost all design and manufacture in industry is carried out by teams of people and the importance of this ability has been recognised by including working with others as a nominated Key Skill. Until recently industrial teams worked in close physical proximity. As more companies work globally, with branches in many different countries, and materials and component supplies come from yet more, the use of e-mail to send information point-to-point and web publishing to make information available world-wide becomes ever more central. Pressure is coming from industry for students to work in teams more often, in the later stages of their education and ICT plays a part in supporting and encouraging this. Some schools have worked on a series of successful projects with educational institutions in foreign countries pursuing joint design and

make exercises communicating through phone, fax, e-mail and web sites.

A number of schemes (e.g. the Nortel/Ultralab and Artist-in-Non-residence projects) have shown the potential of linking school children and professional engineers, artists and others on collaborative activities or activities supported remotely by outside experts.

ICT brings many new demands and new dimensions to collaborative learning. Much recent thinking has referred to the potential in contexts such as 'lifelong learning' for education to become less place dependent though continuing to involve communication and collaboration with others. Design and technology can play its part in this though many of its activities require specialist equipment, safety supervision and regular tutorial guidance that in part militate against remote learning.

ICT permeating design and technology

In summary, much experimental work has been undertaken in design and technology in English schools exploiting the learning potential of ICT and whilst not every teacher can be at the cutting-edge, every student has the right to benefit from ICT support in their design and technology work for a number of reasons:

- ICT capability within design and technology empowers pupils to produce high quality outcomes in a range of materials, often comparable with commercial products;
- ICT techniques provide pupils with the means to work with repeated accuracy, fit and finish in a wide range of media;
- ICT in conjunction with appropriate peripherals enables pupils to participate in batch production of high quality items in 'Enterprise' type activities;
- using ICT can provide pupils with a personal experience of automatic control of systems and basic robotics;
- most employment opportunities will bring pupils into contact with ICT in the workplace;
- ICT can enable pupils to simulate a manufacturing process and anticipate what would happen if certain design decisions are taken;
- ICT enables pupils to explore contexts beyond their immediate designing and making experience;
- ICT can provide pupils with fast access to information to support their designing and making;
- ICT can provide a vehicle for supported self-study;
- ICT is highly motivating for many children.