Is It Designing?

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This article explores some of the fascinating aspects of designing as a process within CDT. It argues that designing is vital to the development of technological capability.

The views expressed are personal and comment on them through the editorial pages will be welcome.

What is Design?

Useful clarification begins with the dictionary where design is described as 'a plan or scheme, conceived in the mind: the preliminary *conception of an idea* to be carried into effect by action, a project'. The essence of this definition is the phrase in italics. Designing is seen as an intellectual process which brings into being those ideas, which are intended to be put into effect. Of course no one expects that *every* idea will be put into effect but to count as a design this at least must be possible.

Any design must have the pòtential to be realised in practice. Designs must therefore be seen as tangible results of human intentions, of the will to satisfy needs or achieve purposes. It is this that distinguishes designing from speculation or fantasy; design has purpose, direction and its outcomes can be realised through action and making. Designing as a process is directed towards the achievement of human material needs and is quite inextricably linked with a very wide field of application: there is room for great variety.

Discussion over a period of years has established that designing is invariably creative, not an unpredictable, spontaneous act but a disciplined process in which a series of stages can be identified. These have been well described, for example in the Assessment of Performance Unit publication *Understanding Design and Technology.* In brief they involve identification of a need; analysis of its qualities; researching factors that relate to them, the envisaging of various solutions and taking decisions about them; planning then making testing and evaluating the outcomes.

Designing therefore calls into action a number of high order cognitive skills, such as analysis where, for example in a technological setting, scientific or mathematical analysis might be called upon, decision making, application, evaluation and so on.

Is it not really all planning?

Again the dictionary provides limited help with clarification. Plans are there described as 'drawings, schemes for buildings etc'. The implication might be thought to follow that *planning* is the process by which plans (ie drawings of things which are to be made) are brought into being and this, it has been argued is part of designing.

Use of the term 'planning' in common language helps to cement the distinction. Tasks of planning are, to a large extent accomplished by recourse to the application of logic, combined with the evidence recalled from previous and similar situations. For example, if I *plan* a voyage, the decision to venture forth will have been reached, the means of carriage will be in immediate prospect and in all probability an outline of the intended route and expected destination will have been determined. In short, the skills of analysis, the imagining of options and decision making will already have been exercised. It is the skill of planning that leads to a prescribed sequence of events the completion of which will yield the desired result. There are of course different levels of planning activity, for example strategic as in 'Town Planning', but for many cases the distinction remains.

In contrast, if I set out to *design,* say, a new bicycle my activity may be in response to any one, or group, of factors. New materials, the need of a particular group of people, (eg, 10 year-old boys, 3 year-old toddlers, postmen or airborne troops), a style, a means of manufacture etc, may, singly or in combination be relevant. My consideration for such factors that relate to the context of the design will impose constraints upon my thinking.

To elaborate, should one set out to design an ultra-lightweight carbon-fibre collapsible bicycle there is no immediate certainty that *logic* and a knowledge of what has gone before, will yield a satisfactory outcome. At some point in the stream of intellectual activity there is a break or gap and the rules alone, developed from a study of previous cases, will be insufficient to bridge it.

It is here that the mind of the designer *must* shift into an intuitive mode of working. This phase of activity will involve the feelings, hunches and impressions and experience gained at all stages of the process up to that point. It will usually lead the designer to envisage possibilities that may, after refinement, lead to an actual solution. Planning is clearly not like this!

Planning is a skill used by designers, and others, in a number of ways. Almost invariably it is the immediate percursor to action. It is used at various points in the design process, and in preparation for realisation. The activity of planning is preceeded by the exercise of higher order skills.

In that case its really problem solving!

Firstly, there are certainly points of contact between problem solving and designing and an exhaustive detailed list of these could be lengthy. Secondly, there will always be exceptional cases and so description in an article such as this must be couched in fairly broad terms.

Designing applies to a distinctive sphere of action. This relates to the ordering and formation of the *made world.* Problems generally might be quite different, for example, legal, financial or mathematical. The solutions to problems may or may not involve the process of design. For example consider the practical problems of maintaining the quality of milk leaving a pasteurisation plant, or the difficulty of balancing income and expenditure within a service industry. The one might involve biochemistry and or design, the other is likely to require the help of a business analyst.

To solve a problem there must first exist clarity of definition. The search for a solution cannot even commence until the nature of the problem is clearly stated. In design a perceived need is usually addressed. The task therefore begins with analysis, possibly of a *whole set* of interrelated problems that must *all* be solved if that need is to be met. The designer, or team, will have to face the fact that unless the design does solve the entire set of problems with a single, ordered solution that *matches the need,* the enterprise will have been worthless.

There is also the question of emotional involvement. Facing problems under some circumstances may provoke strong emotions, for

example, if the problem is redundancy or bankruptcy. Solutions are likely to be found through dispassionate, often logical, thought. In designing, emotions figure almost continuously and from the outset. The designer must have or develop, an emotional reaction to the need. The feelings of the designer, or design team, toward the need are expressed in a sensitive way, for example through their choice of materials, colours, surfaces, the interplay of light and shade on a completed structure, consideration of the effects on the environment and so on.

Emotional reaction to the need is also essential as it provides a pathway for the expression of attitudes and values possessed by the designer. It helps provoke the hunches, feelings and impressions that form in the mind as imagination works toward a group of ideas which may hold the promise of solving the set of problems and satisfying the need.

It is during this largely intuitive phase of the process that acts of inventiveness are most likely, more will be said later of invention.

Even so brief a comparison as this between designing and problem solving would be flawed if it gave no further attention to attitudes and values.

When problem solving, a solution is sought and both logical and intuitive thought might prove fruitful. Specific disciplines are likely to be directly helpful. The skills of decision making are called upon, planning follows and choice results.

When designing, values and attitudes inform and give direction to almost every stage of the process, they ensure that human purpose remains the paramount concern. They influence designing whenever decisions are taken or evaluation occurs; and clearly both are exercised continuously. There are important exceptions, for example, where objective analysis is needed to secure information or concepts that may prove of service in the design.

An example may clarify this. There are cases where the *form* taken by a design follows the functional requirements expected of it to an exceptionally close degree. A bridge, an air intake for a jet engine and some kinds of bearings may be susceptible to formation that can to an important extent be traced directly to mathematical prescription. In such cases clear, objective criteria for performance dominate considerations. However, our common knowledge of bridges, engines and bearings will reveal that variety yet remains, albeit with strong similarity.

The general debate over designed forms and their functions is well stated elsewhere. Sufficient here to remark the obvious; firstly, that designed forms must invariably satisfy the intended functions and secondly, that the relationship varies according to the kind of design being undertaken.

Designing is an intellectual strategy, more powerful and comprehensive in application than problem solving in enabling people to order and form their made world. Attitudes and values give direction to the process which always involves some intuitive thought and emotional commitment.

Design and invention are different

A designer is often working in an area where it is possible to analyse the perceived need and identify a set of interrelated problems to be solved, sometimes building on what has gone before. Finding solutions will inevitably call upon intuitive thought.

There are cases where there is no known solution, either previous or approximate, to a perceived need. Alternatively a person in possession of a good knowledge of the ways of doing some task may be dissatisfied with all of them and tries to respond by conceiving of a fresh, unconventional method. Such a response, if one is achieved at all, is usually termed an invention.

To illustrate: the protection of London from flood might, among other options, have been achieved by building across the Thames a set of massive vertically-sliding gates, an approach which is known elsewhere. This would have required huge, perhaps unsightly structures to support the gates high enough above the waters to allow clear passage for ships. The intuitive thought, that of using revolving gates which, when out of service could rest neatly on the river bed, is a new solution to the stated need an invention. Our society values inventions and protects them in law by patent legislation.

Inventions must be designed

Even after an invention has been accepted by others it must usually be subjected to the process of design in order to develop and refine it from prototype or concept to working device. It must be possible to make the device, perhaps with various modifications, using techniques already known, or in some cases by developing new ones. It must also be built at an acceptable cost, not merely a fiscal cost, placed in the intended location where it must be tested and evaluated.

Because inventions must be designed, the field of design application is forever a widening one. There are two reasons for this. The first and simpler reason, already described, is that every invention that is put into effect provides a new product or means of achieving a particular result and is placed alongside all previous methods. Each invention therefore extends the area of activity for designing. The second reason concerns the recursive nature of design.

Design is recursive

Design rarely, if ever, yields *final* results but rather, it gives results that are good for the timebeing. Designers have the option of reconsidering a particular system or artefact in order to develop a new revised version. Such redesigns create alternatives to be placed alongside, or perhaps supplant, the earlier versions. The influence of technology, for example through the introduction of new materials and processes has a marked effect on design. Changes in the design and production of children's toys when injection moulding became available, or of aircraft following the development of aluminium alloys are interesting illustrations of this.

There are other reasons for the recursive quality. A newly identified need, perhaps of a group of people who wish to use a form of product that was hitherto unavailable to them is a motive for design. For instance the design of a computer terminal for use by those operating a steel rolling mill will need to be different from one destined for an office or a submarine. In short, the context is a powerful influence on the designer's efforts, it informs the judgement of what constitutes an *appropriate* solution. The context for

most design is some aspect of human life. Since the qualities of life change, so the need for design recurs.

Design is iterative

Accounts of designing as a process often include a graphic model to illustrate the description. A typical representation is that of a loop or spiral along the length of which various stages in the activity are placed.

From such a model the work of the designer is seen to progress from stage to stage until an outcome is achieved which matches the original need. The movement however is neither irreversible nor linear. The designer's thinking may dwell in one part, then revert to an earlier stage in view of changes that are then thought to be desirable. For example, having proposed a design solution, difficulties with production in the preferred materials may be encountered. This new subsidiary problem may be addressed by modifying the design, or perhaps analysing the intended production method, properties of the material and so on, in order to find a way forward. Repeated analysis and modification reaching a solution; by a succession of approximations, each better than the last, is not uncommon. The results of each trial are used to evaluate the outcome of both logical and intuitive thinking and provide valuable information to guide subsequent progress. In short, parts of the design process are undertaken iteratively.

Design and technology share a special relationship

It is an overused phrase but, 'we live in a changing technological society'. The cliché focusses on two interesting issues, firstly that of social significance and secondly, of *change in* technology. Both issues are important since they highlight evidence which leads to conclusions about how technology should be represented for young people, our future citizens.

Technological capability in society

Through its development and application over many years technology has reached a point where it influences almost every aspect of modern life. The satisfaction of basic human needs for warmth, clothing, food and shelter are to an important extent satisfied by technological activity. The aspects of personal and social life that are influenced by technology are continually being augmented by innovations for example in transport, communication, leisure and entertainment. Because technology so thoroughly permeates modern life it influences the citizen who, to an increasing extent, now needs a degree of technological capability. The phrase 'technological capability' indicates those attributes possessed by people which enable them to undertake technological activity.

The activity itself has several levels and these are engaged in according to personal interest, circumstances or occupation. The general importance of capability stems from its role in supporting each citizen in a position of confident mastery over the devices and systems that permeate modern life and in enabling participation in the processes of technological change. In short we *all* need the ability to behave to some extent technologically. Virtually all of us, in our daily lives now engage in some technological behaviour. This is mostly of an elementary character and a hierarchy of such activity, engaged in less, or more frequently, stretches beyond. We do so in at least three ways.

Firstly, virtually all of us act as the *informed users* of a great variety of products and systems. Even within this, considerable variation exists, for example between using the telephone and driving a car, motorcycle or controlling some other complicated machine. As informed users we need only that measure of capability that enables us to achieve our intentions in a safe, socially responsible manner.

A significant proportion of our population exercise the skills and abilities needed to diagnose faults in, maintain and repair the array of devices and systems that ease modern life. As new inventions and redesigns continually add to that array so the importance to society of these particular capabilities increases. Many citizens undertake the role of *repairer/maintainer,* (loosely, the technician) usually in relation to devices or possessions in the home or community.

Of considerable importance is the higher-order activity of the *designer-builder.* Either singly but more often as members of teams people in this role identify, analyse, envisage and decide upon measures leading to the development of technology. It is activity at this level which leads to production, testing and evaluation of products and systems that are needed to improve the quality of daily life. It is often through designing and making that fresh options are presented which influence society at large. Capability which is exercised at this level is a mechanism of social change.

Within the levels of technological capability, of informed user, repairer/maintainer and designer/builder there exists great variety. In some areas of activity one level shades into another, relationships exist between parts of higher and lower level activities. It is also clear that higher level behaviour to a greater or lesser extent often subsumes attributes of the levels beneath it. For example, in learning about the maintenance and repair of a dialysis machine, an individual will encounter some, but by no means all, that is relevant to the role of operator.

The argument over levels of technological capability has boundaries which are pronounced when *skilled performance* is considered. For example, the pilot of a fast aeroplane or the driver of an earth moving machine need a breadth and level of skill that is not incorporated in the activity of either the maintenance technician nor the designer. In such situations the continuous exercise of fine and exacting judgements by the user and upon which much may depend creates special cases of the broader classes of activity.

Other qualifications might be described but the description of levels remains helpful as a means of illustrating the structure of activity.

Change in technology

It has been argued that technology thoroughly permeates modern life. It provides and supports many of the systems and devices upon which human physical wellbeing depend. Technology provides fresh opportunities for social contact, leisure interest and communication and is a powerful force for change. But clearly technology itself is subject to change. How does

technology change? There is not a single cause, rather there are three.

Invention causes technology to change
Invention frequently adds to the sum total of technology. Each invention offers a fresh, possibly a better way of achieving some human purpose. Inventions are surprisingly unusual responses which present fresh approaches to doing things. For example, the air-cushion vehicle in transport, the turbine in shipping and power generation and so on. Quite often inventions occur to people already working in that particular field, but by no means is this invariably so, the pneumatic tyre for example was invented by a vet. Descriptions of the act of inventing, by those who have engaged in it, usually place considerable emphasis upon the intuitive.

It has been argued above that usually, after an invention has occurred it must be designed in order to refine and develop it. It is also clear, perhaps because of the very high level of intuition that may be involved, that people cannot invent 'to order'. The best that can generally be expected is that inventiveness will be welcomed and supported by others. This is consistent with other creative activity where toleration of the surprising and unconventional may from time to time encourage a more than usual degree of originality.

Technology changes through applications
There are numerous examples of systems, devices and processes the development and operation of which owe much to the dispassionate application of knowledge and academic skill. The development of new types of plastics, glass and ceramic may illustrate this area. The application may involve the skill of enquiry appropriate to the discipline or concepts or data derived from it.

What remains likely however, is that any such new development or process will rely upon designing as a means of creating the equipment and systems necessary to embody and support it in practice. Such interrelationships are very important.

Technology changes through design
The recursive and iterative qualities of design were demonstrated above. These apply with equal effect in a technological context. Many existing branches, systems or devices of technology may be developed by designing to meet particular requirements.

This is readily demonstrated by examples. For instance there are helicopters designed for speed and manoeuvrability and others for cargo space and heavy lift. In schools there are examples of pupils designing robotic vehicles that navigate routes marked on the floor and others designed and built to pick up and place separately for storage manufactured components.

Technology includes the techniques of making
If the breadth of technology is to be represented for young people it is important to keep in view the fact that making or production, is also part of technology. The great variety of production techniques has, to a considerable extent resulted from accumulated experience. Production technique includes processes such as casting and drilling, and also fermenting, throwing and weaving. Many of these processes are undergoing rapid revision and development as information technology and computer control is applied to them.

When including production technique as part of education through technology it is essential to recognise that making without first designing, inventing or applying, is activity that may be denuded of much of the human purpose that should confer value and worth upon it.

Does this mean technology has no content, only process?
It should be clear that the importance of technology to society lays in its power to address and possibly satisfy certain types of human or social need; that is as a process. There is however some content.

Most of the concepts of a technological character have wide fields of application. They apply, not universally, but with great frequency whenever inventions, applications or designs are being envisaged, developed or planned in readiness for implementation. These concepts are well described elsewhere. They include structures, systems and control of them, machines, mechanisms; materials and ways of manipulating them in order to develop the properties that are required for a particular purpose.

Technological concepts assume importance when they are utilised during the process of design. It is then that related understanding, of colour and tone of human proportion and movement enables them to be used in pursuit of human purpose. It is also during designing that values and attitudes, as powerful influences guide the progress of applications. Equally it is during designing that knowledge, concepts and skills from many and varied disciplines can be called upon in support of the technological undertaking. This is generally achieved through painstaking assembly of a design team the members of which bring particular skills to it; or else through consultancy and so on. In education this is paralleled by engaging children in interdisciplinary activity.

In concluding
It is reasonable for young people to expect from their education a broad and accurate portrayal of the society they are to enter and in due course, to develop, maintain and shape. Technology is one of the most powerful forces for the maintenance and improvement of society, a distinctive and general feature of it. Technology should therefore be a vital component built into the education of all and at every stage.

The arguments developed in this article lead to an inescapable conclusion. It is that young people need to come to terms with technology, with its power and limitations and acquire the confidence to use, control and develop it for worthwhile purposes. A relationship with technology is essential in which the framework of values and attitudes develops alongside and through a growing capability. This implies learning through experience, through action and through participation.