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Knowledge and CDT: Some Questions Posed

It is not at all easy, within the traditions of educational knowledge, to set out the distinctiveness of CDT. Part of the difficulty lies in the fact that within the intellectualist liberal tradition there is a tendency to see knowledge primarily as the uttering of true and justifiable statements. On this basis the higher the status a school subject possesses the more likely it is to be firmly grounded in the academic disciplines, which set the measure of human truth. Sometimes it seems as if all knowledge resides solely within the arts and the sciences. In reaction to this, writers have attempted to find some unique intellectual asset in a practical activity such as human movement or to discover parallels between the so-called two cultures of the arts and the sciences and a third culture of practical activities or design or engineering.

Mr. G. Hicks the staff HMI chiefly responsible for the development of CDT, recently pointed out — 'The knowledge base of our work has proved difficult to define in past years as, unlike some other subjects, we do not stand easily on a recognised body of knowledge'.[1] He went on, however, to suggest it is the categories of control, energy and materials which, while relating to other practical areas of the curriculum, provide the content specific to CDT. The statement of the 16+ criteria for CDT shares some of these general doubts, in so far as the aim specifically concerned with the development of knowledge, described its content in general terms as 'a body of knowledge applicable to solving practical/technology problems'. In some schools, perhaps more on organizational than epistemological grounds, CDT is placed in a faculty with the arts, in others it is put with the sciences, in yet others it is classified with domestic science and art as a design area.

Another reason for the difficulty in classifying CDT lies in the variations of models that exist within the subject, all based on different interpretations and emphases given to the three elements of craft, design and technology and their interrelationships. The differences are greater because various institutions — policy-makers, training bodies, examination groups etc., not all applying the same model of CDT, — are in the process of trying to create a curriculum reform in this area. Yet school staff may lack facilities, training and commitment to the particular projected model. One aspect of this difficulty of interpretation may be seen in the potential competition that could exist between the physics and CDT teacher for the area of technology. Of course it all depends upon what you mean by technology, how much theory or practical work you emphasize, and who seems to be more interested in it and capable of teaching it.

One attempt to cope with the issues raised by the intellectual tradition of knowledge is to emphasize that of 'knowing how' rather than 'knowing that'. This dynamic view of knowledge, though it cannot be totally disassociated from the propositional account, was given a renewal of interest in writings of Gilbert Ryle, though, the idea is much older. In educational circles, John Dewey, belonging to the school of American Pragamatist philosophy, strongly emphasized the need for knowledge to be usable, applicable and effective. 'The knowledge which comes first to persons and that remains most deeply ingrained is knowledge of how to do. Only in education, never in the life of farmer, sailor, merchant, physician, or laboratory experimenter, does knowledge mean primarily a store of information aloof from doing'.[2] In this context within modern American writings we often find technology, described as 'knowing how', as a way of distinguishing it from science, described as 'knowing that' or 'knowing why'.

In what follows I want to consider three strands of the intellectualist tradition and to suggest ways in which the concept of 'knowing how' presents a different view of the relationship of theory and practice, and therefore of theorizing and practical activity. There are many details and issues that I must, however, by-pass in order to try to get a synoptic view.

1. Greek and Modern Views of Scientific Theory and Technological Practice

In order to understand the roots of the intellectualist model of man, it is necessary to look at some of its sources in ancient Greece. Built into the Greek conception of human knowledge is the view that the highest activity of man is the contemplation of truth — which is abstract, universal and unchanging. Thus knowledge receives its status in relation to such criteria. For Plato technical knowledge either proceeds by conjecture and intiution based on practice and experience (e.g. agriculture) or as with carpentry involves the application of mathematics.[3] Activities such as cooking are characterized as knacks, pure techniques or routine ways of acting, based on experience, in which one is unconscious of the true nature of things.[4] Altogether such knowledge and activities are regarded as of lower status than the speculative sciences.

Aristotle held a similar general position to Plato, arguing that the speculative sciences are intrinsically valuable, whereas the practical sciences are only instrumentally valuable. Thus the geometer is a spectator of the truth, while the carpenter, although he may employ geometry does so only in so far as it is useful for the task in hand.[5] The life of reason is best because it enables man to transcend the purely human and to know the unchanging and eternal.[6] Next in importance is the life of action — exemplified by politics and ethics — which is intrinsically related to human nature and human affairs[7] There can be no science of politics and ethics, since the knowledge of how, when, where and to whom to apply their truths cannot itself be

reduced to principles. 'For the things we have to learn before we can do them, we learn by doing them e.g. men become builders by building and lyre-players by playing the lyre; so too we become just by doing just acts, temperate by doing temperate acts, brave by doing brave acts'.[8] The life of action, in short, is a matter of 'knowing how', learned by demonstration or imitation and practice. It is based upon experience and is concerned with planned changes. At a lower level but necessary for human existence is the life of production[9] While the ability to make something involves a knowledge of universals rather than of individuals like any other kinds of knowledge, its objects are transformed by some extrinsically imparted form and its products are solely concerned with use. Thus technology is neutral in itself, being instrumental to chosen ends and therefore deriving its meaning and value from the use to which it is put and the human purpose which it serves. Central to the Greek notion of science and technology is the view of nature as something of primordial unchanging character, formed and given as a totality of individual things, whose truth is known through pure contemplation. On this account, theory is concerned with the contemplation of an unchanging nature, while the practical operates at a lower level being limited to particular insights and rules of thumb or being based on experience.[10]

But for some modern writers many of the Aristotelian theses are untenable. Theory is not radically separated from practice. Neither is the practical necessarily of lower status than the theoretical. The distinction between means and ends has lost its clarity. Scientific knowledge is seen as provisional and experimental instead of providing the key to an unchanging state of nature.

The Aristotelian theses I have considered have connections with the intellectualist tradition attacked by Ryle, in its stress on man's rational uniqueness and superiority. Given that such rationality is best illustrated by man's capacity to use language, to think abstractly and to theorize, it could be expected that dualists would argue that intelligent action must be preceded or steered by some ulterior act of theorizing. Of the carpenter Aristotle says 'It is his hands that move his tools, his tools that move the material, it is his knowledge of his art, and his soul, in which is the form, that moves his hands or any other part of him with a motion of some definite kind, a motion varying with the nature of the object made.[11] The higher status of the theoretical sciences, judged by such criteria as that of intrinsic value, can be seen in Aristotle's analysis of liberal education[12] in which he makes it clear that while it is acceptable to teach such useful things as reading, writing and drawing, 'to be always seeking after the useful does not become free and exalted souls'.[13] Such an educational ideal historically, stood for a non-specialisit, non-vocational and non-technlogical education. From such criteria emerged the view that such practical subjects as craft were to be regarded as of low status and thus more suited for the less intelligent.

However we have noted the rejection of some of the Aristotelian theses. These need to be elaborated in order to grasp a new conception of technology and with it a higher status for CDT.

a) *Theory and Practice.* While scientific theory may still be regarded primarily as the search for truth, it cannot be regarded as detached from the practical. For Aristotle the truths of science were absolute and unchanging and grasped in contemplative leisure; for modern man, science is more hypothetical, and therefore answers to old problems can give rise to new problems which are pursued by experimental approaches. Heidegger even finds revelation through self-transcendence in modern technology.[14] The various technologies give rise to their own theorizing, and the practitioners, while their inventions can go beyond existing theories, cannot be entirely devoid of technological knowledge.[15]

b) *Means and Ends.* In some senses the distinction between means and ends; so central to Aristotle's assertions about the lower status of the practical areas is undeniable. We may regard many things as merely instrumental to some other desired end. But we also recognise that means may become ends and ends means. Whether something is to count as a tool or a product is decided within a whole set of contextual relationships, and meanings are conferred upon entities for the sake of executing tasks.

c) *Nature.* In a sense nature has become a 'know-how' rather than the know-what of ancient Greece — it is not just a given or formed character. It is a dynamic set of potentialities and a storehouse of energy and materials known through man's interactions with it. It becomes formed and recognised by human action.

2. The Intellectualist Tradition and Ryle

While the Greeks distinguished between knowledge that is acquired by experience — in the case of practical politics and morality this involved knowing how to deal with particular situations or individual cases, in the case of carpentry this knowledge also involved the application of universal principles of mathematics, in the case of cooking it involved knack or technique — and knowledge that is more abstract, universal, unchanging and intrinsically valuable, Ryle argues that a man may have a knowledge of theory, principles, tactics and strategies but be unable to apply these in a practical situation. On the other hand, the man who knows how to do certain things may not be consciously aware of these principles or be thinking of them when he is engaged on a complex task in which such principles could be said to be implicit. In saying this Ryle does not want to lower the status of practical actions — as did the Greeks — but to point out the limitations of body-mind dualism in

its stress on propositional knowledge and rationality.

Ryle's own emphasis on 'knowing how' arises out of his rebuttal of a particular Rationalist view of man, expressed in the writings of the seventeenth century French Philosopher, Rene Descartes, and dubbed by Ryle as 'the intellectualist dogma'. As Ryle interprets this doctrine, man 'lives through two collateral histories, one consisting of what happens in and to his body, the other consisting of what happens in and to his mind. The first is public, the second private.[7] On this view, the mind is regarded as an entity like the body, though an invisible, inaudible and immaterial entity. Bodily action arises out of such mental causes. An action, therefore, is intelligent only to the extent that it is introduced and steered by some ulterior act of theorizing. Theorizing is intrinsically a private, silent or internal operation, the goal of which is the knowledge of true propositions (knowing that). That being the case, acting intelligently is doing two things: thinking what I am doing and doing it, and the thinking operation itself involves the consideration of appropriate rules, maxims, prescriptions or propositions (i.e. knowing that).

Ryle denies the dualist model embedded in these theses. He suggests that intelligence does not consist of two acts — thinking and doing, but of behaviour that is evaluated as constituting achievements, by being set against other acts of the agent and against other people's performances. The dualist model is unduly intellectualist in character: it stresses the primacy of theorizing over practice, and yet it runs into the difficulty of appealing to unobservable mental content. In its place Ryle offers a behavioural model by which mental concepts can only be applied through public criteria, so that we see understanding not as private insight but as a particular ability or disposition that is open to public checks. Ryle uses the phrase 'knowing how' to cover cases of intelligence and understanding, which he distinguishes from 'knowing that' which implies the holding of true propositions. The test of someone knowing how to do something is not the priory mastery of theory or the consideration of such theory as a condition of acting, but achievements in performance and dispositions.

Logically and historically practice precedes theory and indeed many skills and activities lack a supporting explanatory theory. Comedians may tell jokes without knowing any theory of jokes — if there is such a theory. The writing of recipes occurs after the making of cakes. Theory is often a reflection upon practice and may be best understood by someone acquainted with the practice. In arguing this Ryle does not want to deny that acquiring theory and being conscious of the appropriate rules, tactics and strategies, may not be useful for the beginner or someone experiencing problems (as might be the case in learning to drive, to teach or to perform surgical operations). However the competent practitioner need not and indeed ought not to consider such principles during his performance. To appeal to mental activity to judge the quality of a performance gets us into an infinite regress, according to Ryle, for the mental act which precedes the action has itself to be judge by some preceding act, which in turn has to be judged by some prior act and so on. At some point then, we must look at the act itself to evaluate it as intelligent — and not judge it by some prior theorizing and theory.

The philosopher Kant indicated some of the difficulties involved in 'teaching how' two hundred years ago when he argued that even if we could giv the individual rules for making logical inferences or conceptual distinctions, we could not teach him to apply the rules correctly; that depends upon not only what theory he has mastered and what training he has received but also on his native wit. 'A physician, a judge, or a ruler may have at command many excellent pathological, legal or political rules, even to the degree that he may become a profound teacher of them, and yet, none the less, may easily stumble in their application. Fo although admirable in understanding, he may be wanting in natural powers of judgement'.[18] As Ryle puts it, a chess player may be taught all the known rules, tactical maxims and wrinkles of the game. H may be able to recite all of these, and yet fail to know the right moment at which to apply the right tactic. A man may be an expert in citing rules and hypothetical propositions so that he becomes a gooc teacher of them, yet he still may be stupid in his own performance. Knowing how to act is realised i performances which conform to the rule, not in theoretical citations of it.[19]

There are clearly different levels of 'knowing how', from a performance that requires no theory, is difficult to verbalize but can be easily demonstrated (e.g. performing complicated skipping movements) to one that clearly requires some mastery of theory (e.g. surgery). Theory related to practice may be of least two types — 1) practical theory — rules which tell you what to do 2) scientific type theory — accounts which set cause-effect relations in a wider explanatory framework. In the case of the surgeon or someone driving a car, the appropriate type of theory is learned by the beginner and may be consciously considered when one encounters a problem. The skilled practitioner, however, does not normally resort to theorizing when engaged in his activities.

Ryle's model, which has certain parallels to Dewey's accounts of mind and knowledge, offers some support for such educational policies as learning by doing and non-verbalized activities such as are experienced with CDT. Craft skills are learned by practice after a master's demonstration, design ability which is not just a matter of following or applying rules, and technology which involves the shaping of the environment, with or without knowledge of relevant scientific principles — all these involve 'know how' in some senses. Those who possess verbal knowledge may lack practical ability. Oakeshott argues that this is true

of political know-how.[20] Kant argues that this is true of medical knowledge or legal judgement. Hirst suggests that there is a tacit element involved in initiation into all forms of knowledge.[21] We commonly recognize that we learn how to tie shoe laces or ride a bicycle or plaster a ceiling by demonstration, trial and error and practice; and that we exhibit such knowledge by our achievements rather than by our statements.

However, the linguistic distinction between 'knowing how' and 'knowing that' is not so clear as it may seem. First of all we often distinguish 'knowing how' from being able. A man may be able to withstand brainwashing without knowing how to, and someone else may know how to do so without 'being able'. In this sense, 'knowing how' is almost synonomous with 'knowing that' (understanding the principles of theory). There are other senses in which 'knowing how' is similar to 'knowing that'. (In 'he knows how cherry trees look in spring time' the knowledge is conceptual rather than performative. Indeed one might put it more strongly and argue that all 'knowing that' involves 'knowing how' (i.e. the man who 'knows that p' knows how to answer the question related to p). Furthermore if we return to the case of the comedian, while it is true that he may lack knowledge of a theory of jokes he must possess hypothetical knowledge (if you do x then y) and conceptual distinctions of some sort (between good and bad jokes). In a similar way a doctor may know how to use medical technology (in the sense that he can employ electro-therapy and knows its consequences in general) without the scientific knowledge that explains what is going on. In these senses 'knowing how' implies some degree of 'knowing that'. The more complex the skill the more the degree of supportive theory that might be implied (as in the surgeon's or the architect's 'know how'). In such cases we could not expect a repetition of the application of appropriate principles without an awareness of them. Now while Ryle would not deny this, the distinction between 'knowing how' and 'knowing that' becomes less clear in these cases than it would in the case of non-verbalized or tacit knowledge such as implied by the ability to perform practical tasks which might only have been recognized by the actual performance of the task (riding a horse, carving a wooden figure, playing a musical instrument). Ryle is right in maintaining that the competent performer does not need to keep either the theory he learned or the principles of performance in mind (except when he has no problems). But it is more dubious to maintain that there is no mental effort, no concentration or other forms of mental activity going on and accompanying the public performance. As H.D. Lewis maintains[22] 'Ryle is wrong in arguing "Nor does the surgeon's skill function in his tongue uttering medical truths but only in his hands making the correct movements"[23] for what accompanies the physical movement is the elimination of unnecessary stimuli and a constantly changing consciousness focussing on a variety of objects — not, an inner theorizing'. Look at the concentration on the face of a young child making something.

In conclusion, I have argued that Ryle's distinction cannot be completely justified by reference to ordinary language, nor can we entirely separate 'knowing how' and 'knowing that' in practice. It may, however, be that with cases of tacit knowledge or non-verbalized activity as in skilled performance, intelligent action or practical demonstration, 'know how' has a clearer and more valid meaning, involving the ability to do something (except when prevented by circumstances, such as a broken arm) and to be aware of the principles involved — without necessarily being able to state them explicitly.

3. CDT and Know How

a) *Design and Know How*

We have seen that the initiation into a discipline involves far more than the acquisition of propositional knowledge. We learn the practice, within a social context, by demonstrations, models and our own practical activity. Polyani, who coined the phrase 'tacit knowledge', argues that since the aim of a skilful performance is achieved by the observation of a set of rules which are not known to the person following them, an art for which there are no appropriate detailed prescriptions can only be passed on by example from master to apprentice. Practical knowledge can be shown but not formulated. It can only be acquiried by continuous contact with one who is perpetually practising it.[24] The point is made by C. Abel, in the context of an examination of tacit knowing and design, that much architectural education is best achieved by exemplars rather than the stating of explicit rules, and that architectural creativity is best developed by analogies.[25]

Cross, Naughton and Walker conclude an examination of the limitations of scientific methods of design by making three points. 1) Much design is 'know how' and does not require 'knowing that'. Thus 'tacit knowledge embodied in craft seems quite capable of producing objects which are well made, fitting to their context, appropriate to the users, and rich in significance, in short "good designs" '. 2) Non-verbal acts of skill lie at the heart of design. Historically design has arisen from craft, which contains embodiments of 'know how'. Thus invention comes before theory. 3) Knowledge of the explicit 'rules' of design can inhibit practice by concentrating on explicit procedures rather than the subtle details of performance.[26] The authors see knowledge of many practical activities as embodied and embedded in the tiny inter-related details of performance. It is a knowledge which is intrinsically non-verbal and acquired largely by trial and error. The traditions of craftsmanship and architecture involve such knowledge. The rules that can be taught are negative in character, related to mistakes that can be avoided. But in itself design involves

creativity, standards of performance that go beyond mere competence and the avoidance of mistakes. One cannot become creative by learning rules; indeed the acquisition of rules of procedure based on successful traditional models may inhibit originality and the production of what is appropriate for the specific occasion.

Part of the argument draws on the conceptual truth that creativity cannot be entirely rule-governed. In so far as the designer is not repeating existing solutions, design must involve some element of creativity, from a modification of present design to designing for a new situation. Just as Ryle argued that the capacity to know how, when or where to apply principles, rules or strategies cannot itself be taught, since at some point the individual has to display intelligent judgment for himself, so Cross, Naughton and Walker are arguing that design involves intelligent know-how. 'Knowing that' is an insufficient condition for being a good designer; indeed one only draws on the theory when one encounters a particular problem. The good designer like the artist has to display initiative and to achieve a certain quality of performance that goes beyond the mere possession of information. As Kant wrote 'A work of art is dependent on some rules which can be taught and learned; but beautiful things cannot be produced merely by acting according to definite rules'.

Two comments seem appropriate at this point 1) Knowledge in design must be at least partially non-verbal. Skills of graphicacy, involving the ability both to plan visually by drawing or by modelling and to visualise situations suggested by either verbal instructions or graphic representations, are a necessity. It is important to point out that such graphic communication does not just occur at a concrete form of development on the Piagetian scheme, it involves thinking at the hypothetical level. Thus design may occur at the very highest level of thinking, even though it may be iconic in form 2) There is a difference between invention and creativity which Cross, Walker and Naughton pass over. The creative person may be uncertain about both his goals and his means of achieving them, whereas the inventor is often clear about his ends but unclear about how he will achieve them. In this sense the inventor is involved in problem-solving, whereas the creative artist is involved in a more open-ended activity and may feel a greater reluctance to integrate other artists' ideas in his own work since it would infringe his personal integrity. Like the inventor, the designer of a new car draws on all sorts of existing conventional design solutions — involving sub-systems and components, in the way that could not be acceptable to the same degree for the creator of a new poem or painting.

b) *Craft, Technology and Know How*

The Greek distinction between intellectual and manual tasks was reflected in the industrial system of production which involved such a division of labour — with intellectual tasks — represented by management, research and design — and the operation of machines and handling of material and maintenance constituting the manual tasks. With the development of industry both intellectual and manual areas have tended to become more fragmented and specialized as the product and its method of production become more technically sophisticated.[27] But prior to this, when the craftsman was pre-eminent, there was no such division. The crafts were made up of systems of conventional rules originally discovered by trial and error and embodied in cultural traditions. These rules were unformulated though they were of great complexity. Sturt, a nineteenth century English craftsman, showed how the traditions were passed on for a largely non-literate group of craftsmen through apprenticeship and stories, myths, songs and rituals. Such form of tradition constituted a conservative pressure to preserve existing designs and craft forms. They also offered precise details of size and shape, so that the wheelwright, for example, came to accept the height and dish shape of the farm wagon wheels and to know how to produce them, long before he might understand the reasons for them. Thus the craft process was unselfconscious and not wholly rational. The craftsmen could not give adequate reasons for the decisions they took. Although the form of the design might be modified in the light of countless experiences, should the situation totally change, because the rationale of the designs were not recorded, then the form as a whole could not be investigated and altered.[28]

It is in contrast with this that modern design and technology can be regarded as rational, with graphic and, where appropriate, verbal forms of communication and final models emerging from experimental analyses and research. The effect of such rationalization, historically, was to separate the thinking from the making and the design from the production. This led, with the development of machinery, to the two-fold division of labour in the factory and the resulting problems of work-disatisfaction and the feeling of alienation. The validity of the craftsman's knowledge was judged by its effectiveness in the variety of contexts in which it was required. Modern technology must be judged by similar criteria, although the rules undr-writing it are more explicit and its rationale is grounded in experimentation. In this respect, then, it differs from science with its concern for truth.[29] We may not be a hundred per cent sure of the natural laws governing the structure of the world but technology has to operate on the basis of what works and what is effective in the world. Its know how may not be grounded in truth or knowing that. Thus Newtonian celestial mechanics may have been superseded by Einteinian relativistic mechanics but it remains an effective navigating tool, and while we may not know exactly what is happening or we may not be able to explain the detailed changes or processes that are occurring with electro-shock therapy or with the taking of particular drugs, since

we have to make decisions and we cannot wait for certitude, technology has to concern itself with probability and effectiveness, with kowing how to do things, in a small part of the world, with a precision as high as possible.[30]

Within this context technology is equated with 'know how' and science with 'knowing that', on the grounds that 'know how' is something for which there is not necessarily a total explanation or an explicit rationale. In this sense the technologist is like the comedian who cannot set out a universal set of principles concerning why people laugh; both may lack an explanatory theory. Of course it may be the case that if one possesses such a theory one's technology or humour becomes less of a hit-and-miss affair. This might be illustrated by considering the discipline of logic. Although people could operate logically before the rules of logic were formulated, people today may correct mistakes of logic in a way that would have been difficult before Aristotle and others did their work. Though such rules do not tell us what to say or do, they do, however, help us to focus on and correct mistakes. Similarly scientific knowledge may enable us to correct the operations of technology, though technology can exist without scientific explanation. In this sense technology is, like design, political action or moral judgment, partially creative, and as we have seen creativity is not rule-governed. Scientific laws may set the boundaries of what is possible and scientific knowledge can act as a corrective to technological prescriptions.

There are two moves that can be made in opposition to this distinction between scientific 'knowing that' and technological 'knowing how' — 1) to reduce all 'knowing that' to 'knowing how' 2) to see knowing how' as involving 'knowing that'.

Pragmatism employs the former move. William James, for example, argued that the truth of something as its cash value, its effectiveness, its workability; therefore all 'knowing that' is 'knowing how'. But this encounters two main difficulties a) The truth of statements within the various forms of knowledge are judged on different criteria; for all knowledge is not scientific in character. Thus the truth of a religious or moral statement cannot be judged solely by empirical consequences b) As we have already seen, a technology may be effective but based on false premisses.

2) It is also possible to make the opposite move and to argue that technological 'know how' involves a limited form of 'knowing that' — for it tells us what things work in what specific ways in the world. Here the knowledge is not universal but context-specific, and it is hypothetical and prescriptive in character rather than certain and explanatory. The response of writers like Ryle and Kant, however, on this issue has already been made clear. Even knowledge of specific rules and effects is not sufficient to make one intelligent and competent in their appliciation. 'Knowing how' is not reducible to 'knowing that'.

One other point needs noting. In respect of propositional knowledge, the term 'knowledge' can imply mental states marked by claims that are judged as achievements through the fulfilment of objective criteria, as well as the embodiment of such claims in social traditions, books or computer programmes independent of the individual. 'Know-how' similarly can be regarded individualistically, as Ryle regards it, or socially as writers on technology regard it.

4. CDT as a Form of Knowledge

In its stress on the development of mind through the acquisition of propositional knowledge, Hirst's theory of forms of knowledge belongs within the Greek concept of liberal eduacation. But in its relationship to Wittgenstein's theory of language-games, it belongs within a tradition that is opposed to the individualism and dualism of Cartesianism. From the latter position it is possible to argue that in itself 'knowing how' is an ambiguous concept, since it needs to be placed within a social and epistemological context. What kind of knowledge is represented by CDT in its various aspects of craft, design and technology, and in its wholeness as a subject? Hirst has suggested that there are three criteria for distinguishing the categories of question we pose about nature, society, human activities and the human situation: each form of knowledge has its own unique irreducible concepts, peculiar logic, and its particular tests of truth. Thus the logic and tests of truth in mathematics and science are distinctive, and render the areas autonomous and logically independent, although mathematics may be applied to scientific matters. Other forms of knowledge include religion, aesthetics, morals, interpersonal knowledge and philosophy. Some subjects represent a 'field' of knowledge in which several forms are related around some theme or problem, organized as a discipline, and possessing the appropriate literature, researchers and teachers by which such a discipline is proclaimed. Clearly on this account CDT cannot be regarded as a form of knowledge, whether action-based or not.[31] But neither is it sufficient to say that it is concerned with 'knowing how'. The specificity and object of the 'knowing how' must be set out and the form of thought implicit in it or underpinning it must be categorized. It is not enough to talk of 'understanding', one must specify the object of understanding. What is necessary for understanding science is not the same as for understanding religion. Similarly knowing how to make a table, knowing how to design a car and knowing how to solve a technological problem are all different activities. Indeed design and problem-solving[32] are themselves ambiguous in that people design a wide range of things (e.g. electronic circuits, houses, machines, symbols, clothing, book covers, cutlery) and that there are no end of different types of technological problems. For each kind of design or technological problem one requires different kinds of appropriate knowledge.

There are at least two different ways in which propositional knowledge can be approached educationally. a) One might begin by looking at a subject and asking what forms of knowledge, types of thinking and content of knowledge does it represent b) On the other hand, one might ask what knowledge can be experienced through the particular activities. a) Approaching CDT from the former position we might ask whether, on the Hirst analysis, scientific thinking, mathematics and aesthetics are being taught or applied within the subject. The distinction between teaching and application is important, for it is one thing to draw on ideas, skills, formulae and theories that are being taught in other subjects, and another thing to teach them as such. The former position requires a greater element of team-teaching. In relation to the question of what the CDT teacher is responsible for, one must recognize that the relationship between design in art and design in CDT as well as technology in science and technology in CDT needs to be settled. b) Educating children through CDT may be a more chancy business, in that it will depend upon the teacher and the problem being tackled. Not all teachers, for example, will have or use the opportunity to raise moral and social issues concerned with the impact of technology. Not all teachers will go beyond the particular designs being tackled to consider the why's and wherefore's of good design in society.

The problem with Hirst's approach is that it is not easy to classify the type of thinking involved in craftsmanship, design work or technological invention along the lines of the forms of knowledge. To call a craftsman a scientist because he produces work that can be given a scientific explanation would misrepresent what he is doing. The mixture of 'art' and 'science' in craftsmanship (terms used in a general rather than Hirst sense) is difficult to disentangle.

5. **Design as a Third Culture**

One other approach is to look to the area of the practical subjects for features that distinguish it from the other two cultures of the humanities and the sciences. This is the approach of Professor B. Archer of the Royal College of Art. He sees parallels between notation as the language of science, the natural language as the language of the humanities and the language of design as modelling. Just as literacy and numeracy are basic to the grasp of the humanities and sciences respectively, so design awareness, 'the ability to understand and handle those ideas which are expressed through the medium of doing and making',[33] is basic to design. Design constitutes a third culture and deserves to be placed alongside the sciences and humanities.

The scientist is concerned with theory, i.e. generalizable knowledge, rather than knowledge which is practical and applicable to specific concrete situations or in which social, economic, aesthetic etc., considerations are relevant. Thus the sciences exclude technology and the useful arts. Archer finds it difficult to characterize the essence of the humanities but suggests that there is a fair consensus that they are concerned with human values and the expression of the spirit of man. Thus they seem to exclude the making and doing aspects of the fine, performing and useful arts, although their historical, critical and philosophicial aspects would still come under their humanities' purview. A third area of education could therefore legitimately claim technology, and the fine, performing and useful arts. This area he designates design education, offering three criteria for the subjects contained in it 1) They must be *anthropocentric*, being concerned in particular with man's material culture, i.e. 'the ideas which govern the nature of every sort of artefact used and valued by man'. 2) They must be *aspirational* in character i.e. they must strive to achieve human values, and the expression of the human spirit. 3) They must be *operational* i.e. concerned with doing and making. Depending upon how they are taught, musical performance, dance, drama and movement studies may be reckoned as falling under this heading from the performing arts with ceramics and textiles, sculpture and painting from the fine arts; and woodwork, metalwork, technical studies and even environmental studies. Such studies would be distinguishable in terms of their approach to knowledge and the language they employ. Thus whereas science employs notational language and involves theoretical knowledge based upon observation, measurement, hypothesis and testing, and the humanities uses natural language and is based upon contemplation, criticism, evaluation, and discourse, the third area is the collected body of practical knowledge based upon sensibility, invention, validation and implementation, and uses the language of modelling, drawing, diagrams, physical representation, gestures as well as scientific notation and natural language.

One major problem here is that the criteria are unclear. All human knowledge and activities are, by their origins, anthropocentric. The humanities are almost defined in this way; they both originate in man and express his uniqueness; but so also do the sciences, even though they strive for impartiality rather than for emotional objectification. All knowledge is, in this sense, an expression of human aspirations. What then is built into the notion of 'operational'? Is this ultimately the distinctive feature? Here again there are difficulties. The word implies that something is working and has practical or behavioural outcomes. In a sense scientific experimentation and aesthetic creativity are operational processes — and indeed both may be presupposed by technological designs. Gymnastics and drama involve technical and aesthetic considerations as well as physical movements, but neither involves the conception of a functional object — a building, a piece of clothing, a tool etc. — in the way that design seems to. Archer's definition is too general — thus failing to rule out

extraneous content — and insufficiently detailed — failing to rule in the specific features of design.

A.V. Cannon in his analysis of design describes it as unique in its 'world changing' aspects, in that it both prescribes a change and actually changes something to meet the proposal. Of course more needs to be said than this about the material context in which CDT operates, for one can point to other areas being 'world changing' in the sense described. Ethics, in philosophy, has always been regarded as a practical knowledge in that it involves prescriptions which hopefully bring about changes of behaviour. However, there are similarities between Cannon's notion of 'world changing', Archer's criterion of operationalism and this paper's stress on the knowing how element of craft, design and technology.

6. Conclusion

in bringing together material from a wide variety of literature, I have attempted to draw attention to the essential dynamic aspect of CDT knowledge. In considering what part 'knowing how' plays in the subject, I have suggested that learning within CDT can never be encompassed by the notion of replicating information. The student must do more than he is ever told. In applying Hirst's theory to this area I have suggested that the various models of CDT, make it difficult to appraise its boundary lines, though it certainly is not a form of knowledge nor probably even a field of knowledge in the disciplinary sense that Hirst implies. Ultimately CDT is not concerned with contemplation or reflections about the world, as in the Greek ideal of liberal education, though reflections about the impact of design and technology upon society may arise witihin the subject. Archer, in suggesting that Design constitutes a third culture, tries to offer an alternative view of educational knowledge, which has parallels to the concept of 'knowing how'. His account, however, lacks a distinct and clear theory of the knowledge implicit in design. There is a need for research into CDT practice and for an analysis of the body of knowledge and skills of which it is constituted.

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