P. Keenan
Halifax

Evaluating Design Abilities using the APU Approach

For many of those involved in the field of CDT education, the changes in emphasis from traditional craft teaching to design must be bewildering.

There are basically three areas in CDT which together form a cohesive subject. Unless these three areas are treated equally the subject becomes unbalanced and thereby loses some of its worth. The resulting crudity is perhaps one reason why CDT has not enjoyed the status in the eyes of others that some of the purely academic subjects have. These three areas are:

a) Skill — those practical abilities concerned with physical manipulation of materials

b) Knowledge — an understanding of the technology and properties of those materials

c) Design — the ability to solve problems using a) and b) above.

Although too brief to be entirely accurate, the definitions at least outline the areas mentioned.

As far as making an assessment of abilities in these areas is concerned the first two are, *relatively* speaking, fairly easy. The most difficult area is the third for, to put it in simple terms how do we evaluate, assess or mark an idea? Also why should my judgement be any better than the next persons? What might be considered a success by one person may be judged a disaster by the next.

The realisation that I understood the nature of design less than I had previously believed came to a head some two years ago with one of my fourth year 'O' level pupils. His care and attention was such that all of his practical work was of a very high order; his skill then was not in doubt. He learned the theoretical work thoroughly and was able to score high marks in any test which required the reproduction of technical facts. These, then, served to place him high on the list when exam-time came round.

The feeling that I was not perhaps making a satisfactory effort to assess the complete person increased as I became more frustrated with his seeming inability to cope with problem-solving activities. It made me realise that I was not teaching design but merely answers to problems and that my assessment techniques in this area were inadequate. This was rather a sobering discovery for someone who thought that after some seventeen years teaching he had a good grasp of his subject.

I thus looked upon my recent secondment as a golden opportunity to stand back from the problem and try to make some objective analysis rather than, as so often happens in the classroom, a subjective one.

Design, Construction and Description of Research Instrument

Before I could begin any study in this area I had firstly to:

a) find a suitable definition of what CDT teachers call 'Design'.

b) Select from what is a vast subject, the precise area of study and

c) Borrow, adapt or design a research instrument.

Clearly the range of definitions in a) varies as the number of people giving them varies. Some are too specific, others are — at least to me — arguable. I also failed to see why the end result should be useful. Perhaps the best for my purpose was one offerd by Matchett (1968) when he said it was 'The optimism solution to the sum of the true needs of a particular set of circumstances'.

In order to define my area of study I next had to focus on the primary factor of whether a child can initiate the design process. In attempting this I had constantly to ask myself 'What is the single main point that, without which, design would not be design?' This question was asked of many people concerned with design and not surprisingly each had a different answer. I think the best I heard was one given by Barnes Wallis some years ago when he said that solving a problem was easy, the hard part was being able to see the problem. This then was my starting point, namely, can a child see that a design problem exists?

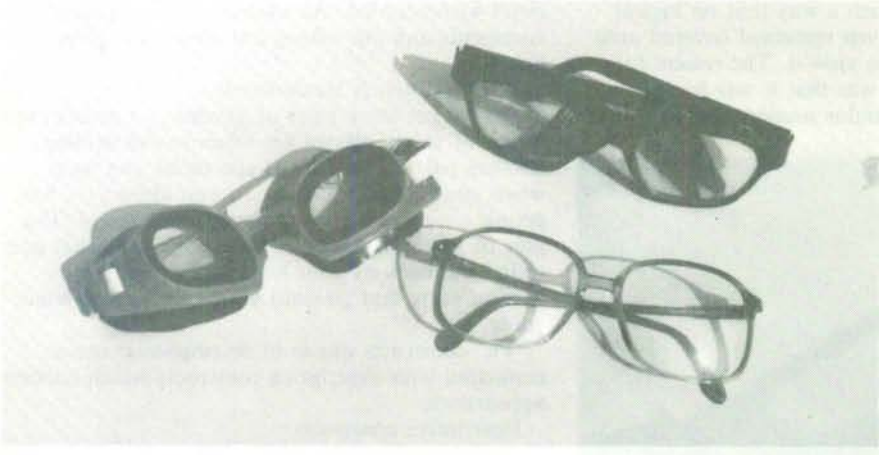
Until quite recently literature dealing with design education confined itself to the design process or design loop showing the stages from problem to artefact. The Assessment of performance Unit (APU) in its booklet 'Understanding Design and Technology' goes one step further and for the first time tells the teacher more than what has been done or is going to be done. It attempts to tell him what the child should achieve or display at each step. It was my intention, then, to use the APUs framework as the basis for formulating a method of assessing the degree of design ability which a pupil possesses. This was, then, why I leaned towards the area described as 'FIT' and even more specifically to the section which stated:

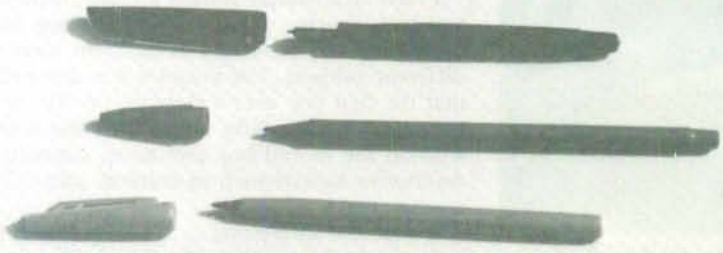
'Can a child *perceive* (describe, discuss or otherwise communicate) or *identify* through investigation a fit or misfit between an artifact or system and set of human requirements (desires, needs)?'

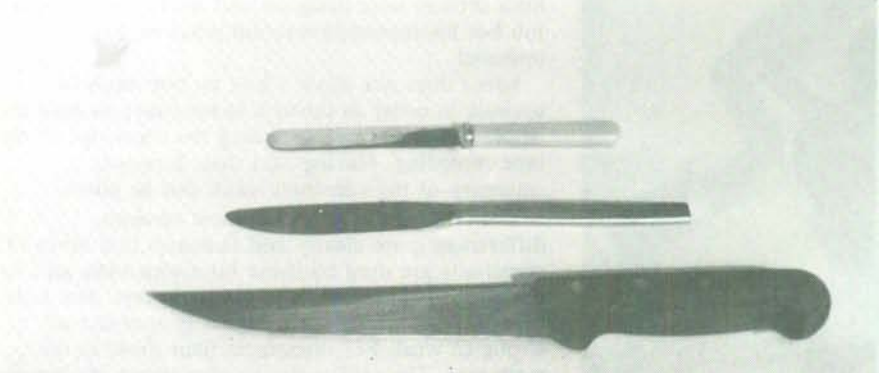
The first step in problem recognition must surely be receiving or attending the problem. The pupil, because of previous experience, is bound to bring to each situation a point of view which may help or hinder him in the recognition of the problem to which the teacher is trying to sensitise him. Unlike knowledge, awareness does not imply attention or assessment of the values, qualities or nature of the stimulus. At its most basic level it is a simple awareness without specific discrimination or even recognition of the characteristics of the problem even though these characteristics may be deemed to have an effect. These characteristics might include

colour, aesthetics, form or even another point of view. During this awareness the problem simply stands out as a rather crude figure against a general background. It holds a peripheral rather than central place.

The main problem in formulating some test which would evaluate a pupil's awareness is to avoid any hint by the examiner that the subject or phenomenon exists. For example, if an examiner asks a pupil to comment on colour he would, by definition, be making him aware of the phenomenon.







Having identified the focus of the research, that is precognition at the level of awareness, it seemed likely that this awareness would be signalled by a verbal response but now could this response be stimulated and recorded? It was at this point that I came across George Kelly's Personal Construct Theory (see Cohen and Manion, *Perspectives on Classrooms and Schools,* pp.57-59, Holt). it is based on the idea that each individual views the significant 'events and people in his life through a series of bi-polar constructs (bi-polar implies opposites e.g. good/bad and a construct may be likened to a brick in a wall i.e. it is a separate, but basic component of the whole). It asks him to make personal statements rather than agree with given suggestions or statements.

Kelly achieved his constructs by giving the subject a series of triads (a group of three), each triad for example may consist of three cards each bearing the name of a different pupil from the same class. He would then ask the subject to pair two of the names because we felt that they were in some way similar and thus dissimilar from the third. They might be paired, for instance, on the basis of intelligence, colour or attitude. After a dozen or so of the subjects *own* constructs had been collected by using a sufficiently large sample of names, the subject was then asked to list the constructs in order of importance. This rank-ordering would then give a clear picture of a person's preferences and prejudices both to the person concerned and to a third party and infer something about the ways generally in which we saw people.

As I was not investigating someone's personality constructs the technique was to be modified. Firstly the notion of bi-polarity was dropped because many of the constructs would not have an opposite. For instance 'This is a brick' does not have an opposite in a way acceptable here. Secondly, I was investigating design which in turn implies an artifact — artifacts do not have human qualities but rather those associated with inanimate objects e.g. shape, size, colour etc.

The components of each triad can be seen from the illustrations and were selected on the basis that some pairings would be obvious (have a strong 'FIT' construct) where others would be weak. For a construct to be strong there had to be a clear, explicit description or explanation of the use to which the objects are, or could be put.

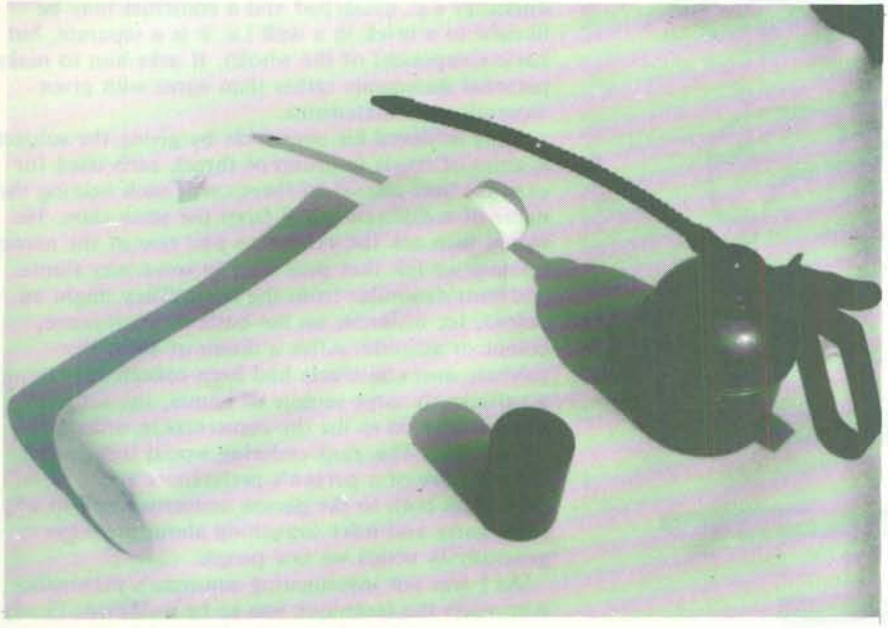
Each pupil was given 45 seconds in the trial run in which to examine the objects, make comments as he did so (which were tape recorded) and finally make a pairing. He was also asked to give a reason for doing so. In the actual testing, the time was shortened to 30 seconds as I felt 45 sconds prompted children to make value judgements which was not the purpose here. When all the pupils had

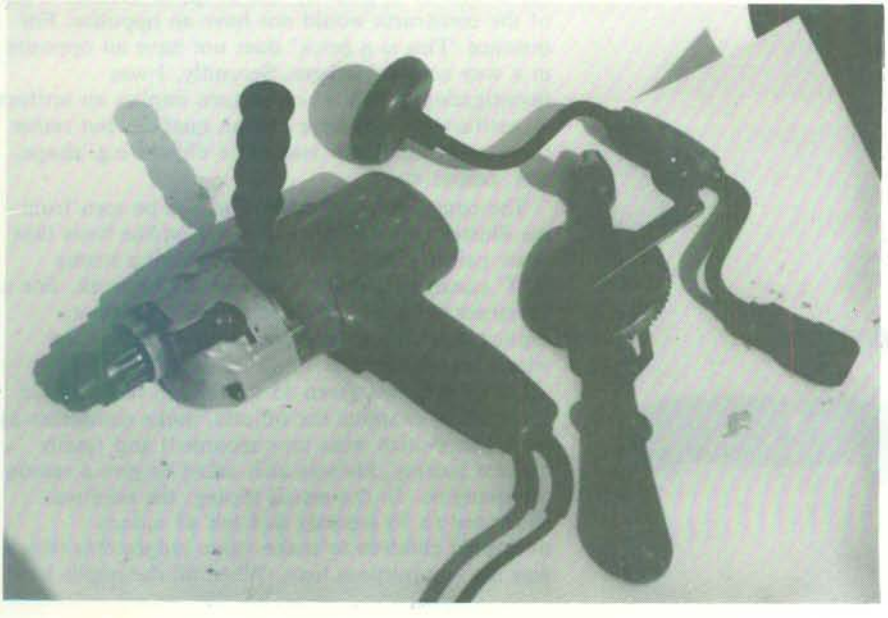
Rank order of Construct Frequency

Pilot run	Main Test
64 FIT (27 strong + 37 weak	35 Shape
29 Colour	39 materials
24 construction	28 FIT (9 strong + 19 weak)
21 other	24 other
19 shape etc.	6 texture
11 texture	8 constructon

completed their comments they were typed up and analysed.

Before I comment further on the analysis, a word of explanation regarding the order of presentation of the triads is necessary. As stated earlier some of the pairings were obvious, others not so. It was felt that if these were presented in rank order of difficulty the purpose for doing the test might become apparent to the pupil. The triads were therefore presented in such a way that no logical sequence emerged and even remained covered until the pupil was required to view it. The reason for giving them in this way was that it was hoped to discover the level of stimulus needed to throw up a construct. This, hopefully would also indicate the level of stimulation needed in a design situation.





A detailed analysis of the transcripts made from the tape recordings was made to discover which constructs were most popularly used. These were (other than 'FIT' — both weak and strong), colour, texture, shape (size or weight), material, construction and other. The frequency with which each of these constructs was mentioned by each pupil was recorded. An example of two pupils' comments and the subsequent analysis is given below.

'FIT' constructs (underlined).

'We've got three pairs of glasses . . . (pause) one a pair of safety glasses for when you're drilling, another pair . . . a pair of spectacles you wear when you're going round . . . you know . . . for people . . . and a pair of swimming goggles. The pair of swimming goggles have got elastic that goes round the back of your head and rubber . . . suction parts that go onto your eyes to stop water going in . . .'

'Fit' constructs allude to or emphasise use as compared with descriptive constructs which concern appearance.

Descriptive constructs:

'Well these all have some kind of plastic on them but goggles are probably harder to make more parts to them . . . goggles are more simply made . . .'

I have deliberately chosen a comparison between two boys viewing the same triad to show how the same triad can be viewed in different ways by different subjects. For instance it is quite obvious that the first boy uses a clear set of 'Fit' constructs (i.e. use) when he talks about the various objects, whereas the second boy uses none, concentrating on descriptive aspects such as material and construction.

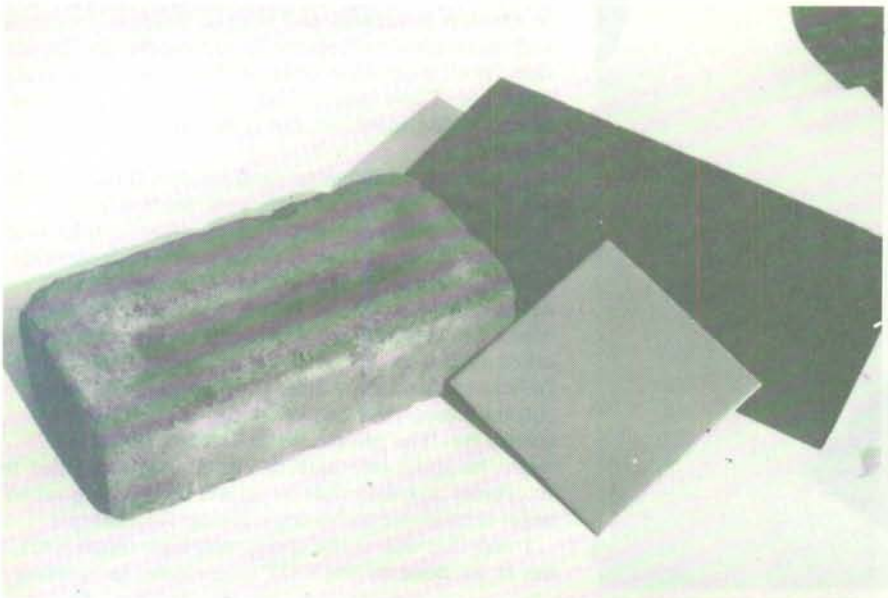
It was also interesting to see how colour affected judgement. One pupil in the initial pilot run stated in his commentary, quite correctly, that white (the handkerchief) was not a colour and paired the red felt and blue paper napkin on the basis of colour. On the basis of 'FIT' his pairing was correct as both articles were designed and made for a specific job but his reasoning was not what we had intended.

Space does not allow a boy by boy analysis because in order to do so it is necessary to read the whole, original study including the transcript of the tape recording. Having said that, however, a summary of the construct totals can be given.

The table above show the most obvious differences quite clearly and indicates that more FIT constructs are used by those boys who took part in the pilot (trial) run than in the main test. Not only that but they also show a higher proportion of strong to weak FIT constructs than those in the main text. The rank ordering also shows the general line of thinking of the group. In the pilot scheme the order seems much more logical and certainly more in keeping with design thinking rather than

purely descriptive. My immediate reaction was to assume that I had been given pupils from a design class rather than woodwork. On checking this with the master-in-charge I found that it was, in fact, a woodwork class as in the main group; the only difference being the syllabuses used. (Pilot = JMB, Main = Oxford Local). Reading the relevant syllabi produced no firm evidence although a slightly greater emphasis is perhaps placed on design work in the JMB syllabus than in the Oxford local. This did not seem to fully answer the question of the difference in results.

Both schools, at least on the surface appeared to be of similar socio-economic class but closer inspection showed that this was not true. The pilot school draws from a catchment area where there is a high proportion of people in the middle classes whereas the school used in the main attempt has a much wider catchment area and also a much more diverse class structure. The latter is a small boys' grammar school and as the local authority has not held the proportion of grammar school entrants constant (as a percentage of the school population) as rolls have fallen, there is a greater number of pupils in the grammar system who would otherwise have gone to a secondary modern school. Another factor is that most parents elect to send their children to the larger co-educational grammar schools leaving the school in question in the position of often having to accept those children 'rejected' by the main grammar schools. The ability range (as measured by the 11+) is thus much lower than is normal for this type of school. In fact results from Richmond Tests which were regularly used in the first three years showed that a number of pupils scored less than average marks (and as everyone knows, these pupils are 'encouraged' into the 'easier' subjects of CDT.



On the surface, then, it appears that it is the type of pupil and his socio-economic background rather than just the education he receives which has an effect on the choice of constructs. Time did not allow me to look into this problem so my comments are necessarily supposition.

I was particularly interested to know whether there was any correlation between a pupil's ability to display 'FIT' constructs and my own opinion of him in the design situation.

The boy who began my search for an answer, the raison d'être for my study, showed a limited response in that not only were there few descriptive constructs but he displayed only four weak 'FIT' constructs. There was also no clear evidence that he had a level of consciousness at which 'FIT' constructs appeared nor did he seem to lean more heavily towards descriptive constructs when the pairings were either obvious or not obvious. In short he produced an analysis which would prompt me to ask 'Where do I start with him?'

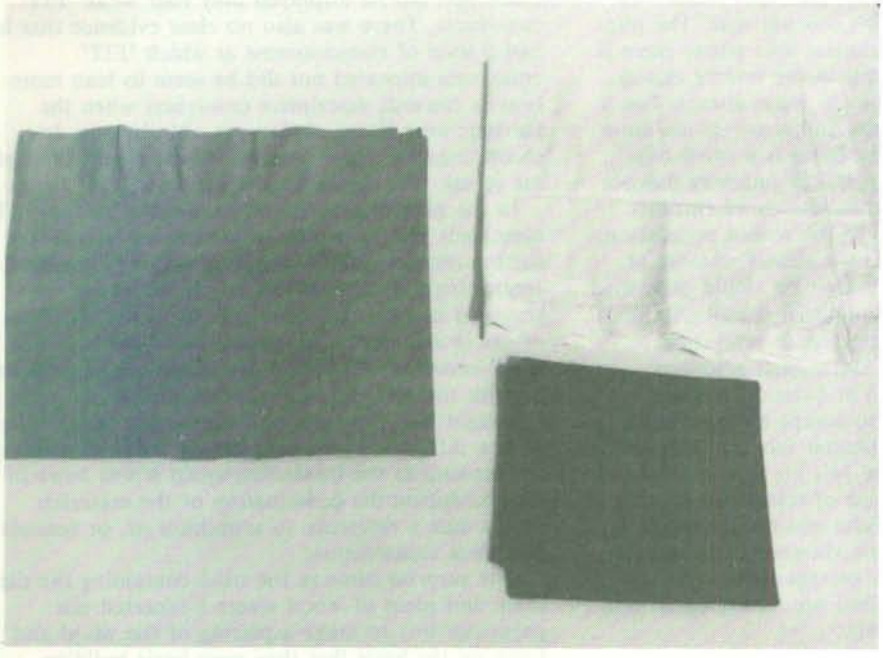
In the pilot test one pupil gave many strong 'FIT' constructs and according to his teacher was picked for the test because he was 'one of his better lads'. Interestingly another of his pupils whom we regarded as being less able seemed almost unaware of use in any of the triads and displayed only one 'FIT' construct. His main preoccupation seemed to be with the material and construction of the items. I thought his references to construction might have been a different way of explaining 'FIT' constructs but looking at the transcripts again it was more of a comment on the combination of the materials rather than a reference to soundness of, or reasons for, their construction.

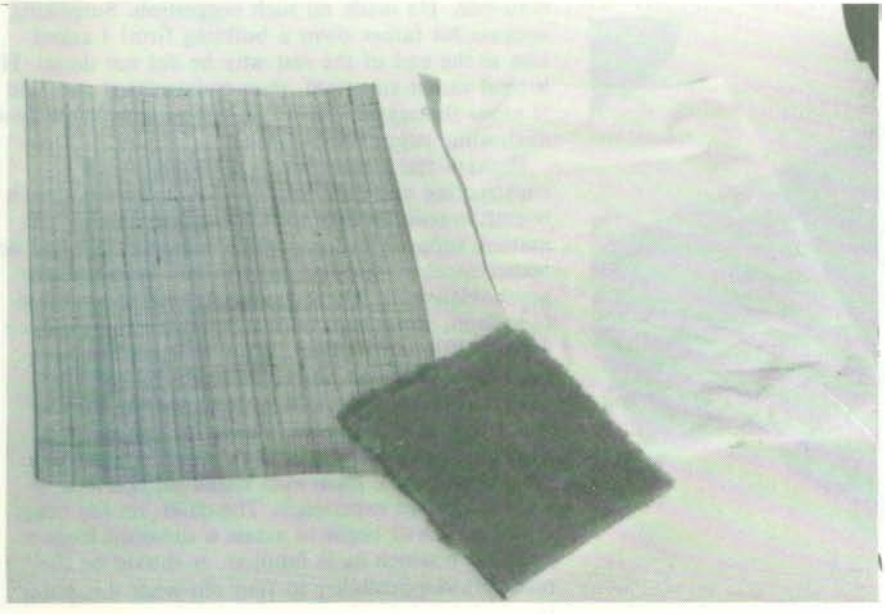
One surprise came in the triad containing the tile, brick and piece of wood where I expected one particular boy to make a pairing of the wood and brick on the basis that they were basic building materials. He made no such suggestion. Surprising because his father owns a building firm! I asked him at the end of the rest why he did not do so. He looked rather surprised, then embarrassed and said 'I never thought about it!' It just goes to show how misleading supposition can be!

Perhaps the biggest lesson I learned from constructing and carrying out this study was that it is embarrassingly easy to fall into the trap of making suppositions and value judgements based on 'experience' or 'gut-feeling'. As any sociologist or psychologist will tell you, expectations transmitted to a child, sometimes unconsciously, often produce a self-fulfilling prophesy. What is needed is a realisation that just maybe it is not the chlid at fault but the teacher. He must remember that he has a high level of mastery over his subject and thus tends to look at it in a relatively logical way. He will also take short cuts based on previous knowledge and experience. The child, on the other hand, may well begin to assess a situation from a point with which he is familiar. It should be the teacher's responsibility to find out what this point is.

In my own case the first boy I used had been selected because I considered that he showed poor design ability and to some extent this seems to have been borne out in the results. In practice he tends to skirt round a problem and produce ideas which are impractical or he fails to see basic errors. He seems to experience difficulty unless the ideas or clues are clear and obvious. This seemed to be reflected in the triads in that his 'FIT' constructs tended towards the obvious and descriptive towards to less obvious.

The 'problem' pupil who began this study showed more or less what I had hoped in that at the basic level of awareness he flits from construct to construct. There is little indication that he appreciates use for the objects and if he is unable to do this how then is he able to make value judgements? I had always tended to look at his problem from the point 'can he identify criteria without appreciating that his problem lay at a more fundamental level than this?' We probably assume that because a pupil can see that something is wrong he must, per se, know why. Ken Baynes made a good point here when he siad 'We give children a lot of practice in absorbing knowledge, little in reasoning or decision making and hardly any in handling problems of appreciation'.





In the final analysis the pairings, as used by Kelly in his repertory grid technique, turned out to be nothing more than a method to give a sense of meaning or relevance to an exercise which must appear rather unusual if not downright peculiar to the subjects. The main value of the exercise was perhaps to enable the researcher to see if a subject could ascribe a use to what is nothing more than a sample or isolated object. Implications from the tests would seem to indicate that we must organise our design briefs, or sets of instructions, so that they are pitched at the level of the pupils' independent design awareness rather than simply ask him to follow rules which we lay down for the solution of design problems. We cannot successfully do this unless we make some effort to find out what that level is. In my own particular case I no longer issue design briefs which outline a problem and possible areas of investigation, rather, I outline an area where a problem may exist and ask for suggestions from the pupils which might indicate what the problem is. Having outlined the problem we then discuss areas of investigation. Each child is then able to write his or her own brief and although similar to others will be more personalised than one devised by me. What I am aiming at is an attempt to develop awareness and then to develop diagnostic and assessment procedures in my pupils. As Brosan said 'With a problem defined there may be several solutions. There may or may not be large amounts of originality involved, but some will always be present'.

It seems reasonable to suppose that those who do not display 'FIT' constructs view the world in a different way from those who do and if design is a sequential process then it is necessary to foster this ability in children. This might be achieved by devising what might be called 'pre-design briefs' where the children are shown unfamiliar objects and asked to deduce use from an analysis of the object. Indicators for use in these objects might include cutting edges, methods of or for holding, gears, levers, etc. The phrase 'form follows function' might be applicable here. It could also be applied to structures and materials as an aid to those about to begin a modular technology course for example.

I feel that this study shows just how much work has to be done by the CDT community in tackling

TABLE I

DESIGNING, PLANNING AND IMPLEMENTATION

1. DESIGNING

1.1 FIT

1.1.1 Can a child *perceive* (describe, discuss or otherwise communicate) or *identify* through investigation a fit or misfit between an artifact or system and set of human requirements (desires, needs)?

1.1.2 Can a child *judge the quality* of the fit or misfit ('How well does it work?) and express this judgement?

1.1.3 Can a child *recognise* that something might be done to improve, rectify or change an artefact, *or* if there is a good fit, to leave things as they are?

1.1.4 Can a child *identify criteria* which are relevant to improving the quality of fit?

1.2 HOLISM

1.2.1 Can a child *analyse* a misfit ('Design problem') in such a way that he *takes into account such factors and considerations as:—*

i. Economic (cost, time, availability of materials).
ii. Social (awareness of others and of the effect of the designed artifact/system upon them).
iii. Ethical (morality of proposed change).

1.2.2 Can a child mould all the aspects of a design problem in a balanced, *interactive way?*

1.2.3 Can a child fit ends to means as well as means to ends?

1.3 FORMULATION

1.3.1 Can a child *state or restate* the design problem? (In order to arrive at its essence.)

1.3.2 Can a child look at a particular solution and *work backwards* to reformulate the original problem?

1.3.3 Can a child *generate a variety* of possible provisions (solutions) to a design problem?

1.4 CONVERGENCY

1.4.1 Can a child *decrease* the variety of possible solutions and show commitment to a specific, practical proposal?

1.4.2 Can a child *explain and justify* the reason for his choice of one in preference to others?

1.5 DATA SEARCH

1.5.1 Can a child *recognise* the need for the collection of information which is appropriate to the problem?

1.5.2 Can a child *search* for, generate, collate and judge the reliability and usefulness of information?

1.5.3 Can a child *apply* the relevant information, which he has obtained, to aid the solution of the problem?

1.6 IMAGING OR COGNITIVE MODELLING

1.6.1 Can the child *conjure up* a description of an artefact, system (or parts of such things) in the mind's eye?

1.6.2 Can he *manipulate the images? (Rotate, assemble, change colour or texture, cause interpenetration or change form.)*

1.6.3 Can the child express these images? (Sketch, model, etc.)

1.7 DESIGN MODELLING

1.7.1 Can a child *demonstrate the purpose* of modelling? (Iconic, symbolic, analogue.)

a. to simplify (by reduction to essentials)
b. to show correspondence (eg by analogy)
c. to give emphasis (eg to salient features)
d. to extrapolate (eg trends)
e. to simulate (eg lighting change)

1.7.2 Can a child *detect the limit of usefulness* of a form of modelling? (eg when scaling down invalidates a model.)

1.7.3 Can a child *translate* one form of model or simulation to another form or to reality? (eg circuit diagram to assembled components.)

2. PLANNING, IMPLEMENTATION AND EVALUATION

2.1 PLANNING

2.1.1 Can a child *cost the production* of an artefact or system? (In terms of use of material resources, time, energy, social effects.)

2.1.2 Can a child *distinguish* between the difference of producing a single artefact or manufacturing for bulk production?

2.1.3 Can a child *plan a sequence of operations in an appropriate order which will lead to the production of an artefact or system?*

2.2 IMPLEMENTATION

2.2.1 Can a child demonstrate that he is alert to the possibility that an *unforeseen difficulty* may arise during making which may indicate an *alternative* means of realisation or production?

2.2.2 Can a child *deal effectively* with such difficulties by *acquiring* new strategies, information or skills?

2.2.3 Can a child *execute a task* with due regard to the need for *safe* practice?

2.2.4 Can a child *choose* and *use* appropriate tools, materials and appliances to achieve his purpose?

2.3 EVALUATION

2.3.1 Can a child *evaluate* and offer a continuing *critique* on the *process* and *progress* of his design?

2.3.2 Can a child *re-evaluate* at the conclusion of realisation (after a suitable interval of time) the quality of the *match between design and need?*

2.3.3 Can a child analyse and evaluate the approach and solution adopted by *other* designers?

the reasons for the assumptions upon which we base so much of our teaching practice. There is perhaps too much reliance placed on empirical knowledge which may devalue the effort we put into our teaching. Part of an educational essay which I read some time ago put my feelings succinctly.

'Education is an investment in mankind. The teacher, therefore has a duty not to waste young peoples' time and if the dignity of our pupils is probably the real argument for teaching well, then the sooner we gain a clear picture of the underlying factors involved, the better.

Instructions and Information for Subjects at the Beginning of the Triad Research Instrument

Hello (Name)

Thank you for helping me with this investigation. I apologise for reading this. I know it's rather impersonal but as I told you earlier, it is important that I say exactly the same thing to each of you.

There are no right or wrong answers so whatever you say will be correct.

Do you understand?

I am going to show you 8 groups of objects in turn. Each group consists of three articles and I want you to pick two in each group which you think are most alike in some important way. You may pick up the objects, handle them, do whatever you feel necessary. You will be given 45 seconds in each case to come to a conclusion. Don't rush but please think out loud so that I can record your thoughts on the tape recorder for later.

Do you understand?

The first group, which is not one of the eight, is just a trial run to make sure you understand what to do.

Do you understand?

Please begin. This is your trial-run.

(At the end of this trial-run I can tell if he understood or was, for example, speaking clearly or giving enough information e.g. naming the objects).

Thank you — this is the first of the real groups. Please begin.

bongos' I said.