Cognitive Styles in Learning and Designing

Nigel Cross and Michael Nathenson
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(Revised version of a paper presented as 'Design Methods and Learning Methods' at the Design Research Society Conference, Portsmouth, December 1980)

Nigel Cross  
Design Discipline  
Faculty of Technology  
The Open University

Michael Nathenson  
Institute of Educational Technology  
The Open University

February 1981
INTRODUCTION

The design process is often likened to a learning process. This is because a designer is quite clearly learning about the design problem as he attempts to solve it. Much of his activity is concerned with attempting to clarify the problem as given, with seeking information, and with attempts to come up with an acceptable 'answer'. As he goes through the design process he is learning more and more about the problem, its constraints, and its potential solutions. At the end of the process he usually regards himself as appreciably both older and wiser than when he began it. Jones (1980) says: 'I think of (the design process) as a specially designed "education" or "course" which one devises, and undertakes, in order to complete the design.'

That the design process is a learning process has also been demonstrated by various observational studies of designers over the last twenty years. These studies have included engineering designers (Marples, 1960), urban planners (Levin, 1966) and architects (Eastman, 1970). Summarising the findings of such studies, Lawson (1980) concludes that 'The essence of (the designer's) approach is that it is simultaneously educational and solution seeking.' In other words, the designer learns about the problem by posing tentative solutions to it.

If we accept that the design process is a learning process then there should be something worthwhile to be gained by relating design theory and learning theory. Learners have been studied more comprehensively than have designers, and learning theory is correspondingly more rigorous, exhaustive (and exhausting) than design theory. In this paper we want to try to relate to design theory one particular area of learning theory; that concerned with cognitive styles.

No two individuals approach a learning task in exactly the same way, and there are few educators who would disagree with the importance of recognising these individual differences in learners. Such differences apply equally to students of law, to 16 year-olds preparing for O-level examinations in mathematics, and to primary school children learning to read. These differences in the ways in which people learn are referred to in psychology as 'cognitive styles'.

To illustrate the existence of individual learning differences consider, for example, your approach to this paper. You might have started at the beginning and plan to read through the sections of the paper in the sequence that we present them, until you reach the end. Or you might have glanced over the paper quickly to gain a general impression of what it is saying and then read the content, all or part of it, in more detail. Or you might read first the sections on design theory because they are intrinsically more interesting to you and then, if you had time, returned to the boring sections on learning theory. In any case, it is unlikely that all readers will approach this paper in exactly the same way.

The paper is structured in four principal sections, concerned with four different categorizations of cognitive style: (i) convergent/divergent, (ii) impulsive/reflective, (iii) field-dependent/independent, and (iv) serialist/holist. Each section presents first a summary of the experimental evidence for the existence of the cognitive categories, and then a discussion of the relevance of this evidence for design and design education.
CONVERGENT AND DIVERGENT STYLES

(a) in learning

Guilford (1967) first distinguished between convergent and divergent types of thinking, suggesting that both are present in different degrees in any give individual. An individual may be better at one than the other or equally good or bad at both. Convergent thinking is primarily concerned with taking in information and producing, or 'converging' on, the single right answer (or a limited number of right answers). In contrast, divergent thinking is not concerned with the one correct answer. Instead, the emphasis is on a person's ability to generate a wide range of answers; the response is a divergence or an expansion rather than one single answer. Questions requiring convergent thinking are usually closed-ended in that students are asked to regurgitate facts. Questions requiring divergent thinking are more 'open-ended', in that students are asked to offer several possible answers to a question.

Within the broad range of abilities known as divergent thinking, Guilford claims that four major aspects have been identified both by himself and other researchers:

Fluency. Guilford described fluency of thinking as the ease with which we use stored information when we need it.

Example 1. Write down as many words as you can which are similar in meaning to the word 'high'. Allow yourself one minute for this.

Flexibility. This concerns the degree to which a person alters his mental set or his approach to a problem. An illustration of this is the match problem.

Example 2. Remove four matches from the arrangement below and leave three squares.

Originality. This is identified as the unusual or rare response. 'Consequences' is one way of assessing this.

Example 3. List as many consequences as you can think of if the volume of water in the sea were to decrease by ten per cent.

Elaboration. This refers to the number of additions that can be made to some simple stimulus.

Example 4. Make a drawing on the basis of these lines:
Torrance (1962) developed and adapted many of Guilford's tests for use with younger subjects. Goldman (1964) provided an overview of these tests, together with the technical data then available on their reliability and validity. As Goldman noted, the provision of norms and the timing of the tests make for difficulties. Time limits do not allow for a warming-up period nor for any unconscious turning-over of the problem which, by some writers at least, has been claimed as necessary for creative thinking. The norms available are based on some American mid-western school-populations, so they are not widely representative. In any case, cultural variations may make the generalization of creativity test norms very difficult. The scoring of the tests is time-consuming and complex and requires at least some training in procedures if acceptably reliable scores are to be gained.

Guilford and Torrance are, in effect, the 'fathers' of tests of divergent thinking, or, as these tests are often claimed to be, of creative thinking. Various selections and adaptations of these tests have been used in a variety of empirical studies. A careful and critical eye, however, is required to evaluate the conclusions drawn.

Meeker (1969), in a survey of the work done by Guilford and his colleagues, suggests that although divergent thinking may have a close relationship to creativity, it is possible to equate divergent thinking and creativity. Others might say that divergent production is a necessary but not sufficient condition for creative activity: that is, you can have good divergent production without creativity, but you cannot have creativity without good divergent production.

Many problems, however, have only one correct answer, and the problem solver needs the mental ability to 'converge' onto this solution, rather than diverging in flights of creativity. Most of the classic intelligence test problems, for example, are designed to have a unique, correct answer. Figure 1 shows examples of this kind of problem; the task is to select which of the six diagrams on the right correctly fits the incomplete pairs on the left. Another test of convergent thinking is illustrated in Figure 2, where the task is to select which of the six lower figures is exactly like the upper figure.

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Fig. 1 Which diagram fits in the space?

Fig. 2 Which lower drawing exactly matches the upper one?
Any given individual can be considered to have both divergent and convergent thinking abilities, although there is some suggestion that many people have distinct preferences towards one or the other cognitive style. There has been some research into whether people can meaningfully be categorised as convergent or divergent types because they are better at, or more interested in, one kind of mental activity than the other.

Hudson (1966), for example, made an extensive investigation of these issues. His particular interest was in finding out whether students were more suited to 'arts' or 'science' courses. He found that 'arts' students tended to be divergent thinkers, whilst 'science' students were convergers. In interpreting this result, Hudson suggests that the arts students tended to be freer to use their imaginations about the different uses for a given object because they are not committed to being practical; the science students were more likely to think about the 'right' use for the object.

The educational implications stemming from Guilford's and Hudson's research are far reaching. Certain teaching strategies commonly found in mathematics, science, and technology are characterised by logical, structured presentations and consequently encourage convergent thinking and discourage divergent thinking. In contrast, certain teaching strategies in the arts, which provide students with an area of interest and ask them to generate a project based upon their study of the area, encourage divergent thinking.

Hudson investigated the effects of matched and mismatched teaching strategies. He identified students at a London teaching hospital as either convergent or divergent thinkers. Then their teachers were identified as convergers or divergers by Hudson, the teachers' students, and fellow teachers (there was unanimous agreement). The results indicated that the convergent students learned best from the convergent teachers, while the divergent students did best with the divergent teachers. The implications of this and similar 'matching' experiments will be discussed later in the paper.

(b) in designing

The cognitive styles labelled as 'convergent' and 'divergent' will already sound very familiar to designers, since the concepts of convergent and divergent thinking are well-established in design theory. The design process is often described in terms of moving between these two styles of thinking, as the designer first widens his search for possible solutions (divergence) and then narrows down to evaluate and develop one preferred alternative (convergence).

Jones (1966) drew attention to these two styles when he classified design methods as aids for one or another style of thinking in design. He suggested that most of the then-new 'so-called systematic methods of designing' were methods of diverging in that 'they permit a widening of the area of search for interpretations of the problems and for solutions to it'. Typical methods of this type include aids to information searching and problem exploration, and the 'creativity' techniques such as Brainstorming and Synectics.
Another type of design method that aids divergence is that in which the whole solution space of the design problem is established and explored systematically. The Morphological Chart is a well-known example of this type. Work on developing methods of this type continues, particularly with the aid of computing techniques for establishing the complete range of possible solutions to a defined design problem. (Mitchell et al., 1976).

Interestingly, these rational methods, although aiding divergent search, are quite different from the 'uninhibited', 'creative' style of thinking normally associated with 'divergence'. This suggests that the concept of 'divergence' can have more than one interpretation in the design field.

Methods of convergence, on the other hand, are more readily associated with the concept of 'convergent' thought as used in psychology. This involves focusing on the 'right' answer to a problem; although in design it is usually assumed that there is never an absolutely 'correct' answer, but a number of 'satisfactory' ones from which a preferred one may be selected.

Jones (1970) suggested that the convergent stage of design 'is that which, traditionally, is nearly the whole of designing, but which, under the impact of design automation, may eventually become the bit that people do not do'. Ten years later, we may feel that this judgement was rather hasty. While it is true that computer-aided design tends to reduce the amount of human effort in many of the traditional, detail-design stages, it is also evident that evaluation of alternatives remains a complex task at which humans are better than machines. Instead, perhaps it is the generation of alternatives (i.e. divergence) that is more likely to be automated?

Jones also added a third stage of 'transformation' in the design process, coming between divergence and convergence. 'This is the stage', he said, 'of pattern making, fun, high-level creativity, flashes of insight, changes of set, inspired guesswork, everything that makes designing a delight'. This sounds more like the psychologists' version of 'divergence'. However, the most important aspect of 'transformation' is in its 'pattern-making' function, in which the 'real' problem is perceived from its background. We will have more to say about transformation later.

Perhaps the most important observation to draw from this discussion of the 'learning styles' and the 'designing styles' of divergence and convergence is that both cognitive styles are necessary in design. It would therefore be wrong, for instance, to attempt to select students for design courses on the basis of whether they were strongly divergent or convergent thinkers. Whilst this may have some value for sorting science students from arts students, design obviously does not fall neatly into either of these categories.

However, the psychological evidence suggests that people do tend to prefer one or another of the divergent/convergent cognitive styles. So design students should be helped to realise and understand their own personal preference, and they should be helped to realise where they need to develop competence in order to become an all-round designer. There are design methods that can assist in each of the cognitive styles. Part of the function of design education should be to ensure that students are aware of the relevance of the two different cognitive styles, and when and how to switch from one to the other.
A more general point seems to be that it is wrong to assume that divergence is the 'fun' and 'creative' part of designing, and that convergence is the 'boring' and 'systematic' part. Some aspects of divergence (establishing the solution space, as mentioned earlier) can be approached rationally and systematically, and some aspects of convergence (evaluating and choosing between alternatives) are essentially a humanistic rather than a mechanistic task.

**IMPULSIVE AND REFLECTIVE STYLES**

(a) **in learning**

Kagan and his associates have investigated differences in how children approach problem solving activities. He identified two distinct cognitive styles: 'reflectivity' at one extreme and 'impulsivity' at the other. 'Impulsive' children tend to report the first answer that occurs to them and this response is often incorrect. In contrast, 'reflective' children delay a rather long time before offering a solution to a problem and this solution is often correct. Kagan found that the reflective child tends to consider the relative correctness of alternative answers, persists longer with difficult tasks, wants to avoid making mistakes, and suppresses potentially incorrect answers. The 'impulsive' child tends not to be concerned about mistakes, making his decisions quickly.

Kagan, Pearson, and Welch (1966) studied the relationship of reflectivity to the child's skill in inductive reasoning tests. Working with a group of six-year-olds, they found a substantial relationship between reflectivity and inferential skills, as measured in the following kinds of tests.

(a) A picture-completion reasoning test, in which the child is shown three pictures telling a story and has to choose which of four alternatives is the most likely next step.

(b) An extrapolation reasoning test in which the child has to choose the next in a series of diagrams from four alternatives.

(c) A 'guessing-objects' test, in which the child is told three characteristics of a familiar object and asked to guess what it is.

A second study (Kagan, 1965) related reflectivity/impulsivity to reading ability in six and seven-year-olds. The six-year-old child learning to read was given a discrimination problem which contained considerable uncertainty about the response. The reflectivity/impulsivity of each child to the study was measured at age six when these children were about to learn to read. The research interest focused on whether this would be a good predictor of reading ability at the age of seven.

In addition, each child completed an intelligence test, so that Kagan could control any effects due to intelligence. The results showed that those children who were assessed as reflective at age six years were the better readers at age seven, even after allowance had been made for their intelligence.

According to these two studies, the reflective child is more successful both at reading and inductive reasoning. Kagan argues that contemporary 'discovery' methods of teaching involve considerable inferential skills,
so that one might wish to try to help children to become more reflective, were this possible. On the other hand impulsivity is not something to be stamped out. Kagan suggests that maximal productiveness and mastery of principles in aspects of the arts, social studies and humanities may be hampered by an excessively reflective orientation.

Attempts have been made to modify the impulsivity/reflectivity trait by trying to convince a child to copy an adult model. In these studies (Yando and Kagan, 1968, and Denney, 1972), the child watches an adult performing a similar task to the one she will perform. One child may see a model responding quickly and successfully, while another will see a slow and successful model. In both studies, the child's behaviour was found to have been modified: hitherto-reflective children imitated the successful impulsive model, while previously-impulsive children became more reflective.

(b) in designing

A first, impulsive, response to the concept of impulsive versus reflective cognitive styles might be that impulsiveness is bad, and reflection good. However, on further reflection, one might conclude that there are some advantages to a certain amount of impulsiveness in design.

We reach this conclusion because of the particular nature of the learning process that is involved in designing. From the studies that have been made of how designers design, it is clear that the designing-learning process proceeds by a series of attempts to propose an acceptable solution. The design 'problem' is learnt about, and gradually understood, through attempts to solve it.

This procedure was recognized, for instance, by Marples (1960) in his study of engineering designers. He suggested that 'the nature of the problem can only be found by examining it through proposed solutions and it seems likely that its examination through one, and only one, proposal gives a very biased view. It seems probable that at least two radically different solutions need to be attempted in order to get, through comparisons of sub-problems, a clean picture of the "real nature" of the problem'.

Without a certain degree of impulsiveness how are designers going to be able to propose 'at least two radically different solutions'? They are certainly not able to delay making a solution proposal until 'the problem' is fully 'understood', since they develop their understanding through the exploration and evaluation of proposed solutions. The attempt to impose too much reflection on designers, by means of elaborate design methods that delay solution generation until the problem is comprehensively analysed and understood, is now generally recognized as a mistaken approach.

Of course, a crude impulsiveness is not an adequate design approach either. What we are saying is that there appears to be some value in encouraging prompt, diverse responses to a design problem, which means employing an 'impulsive' cognitive style. Reflection comes afterwards, in the evaluation of the responses.

This approach to design has only comparatively recently received much acknowledgement in design theory, after a period in which the reflective style was dominant. Now it is being suggested that the previously
abhorred designer's preconceptions, or 'prestructures' (Hillier, et al., 1972), or a 'presupposition, or protomodel' (March, 1976), or a 'primary generator' (Darke, 1979), may be necessary in design.

In fact, it seems that design students do learn that the most productive design strategy is to concentrate on producing tentative solutions, rather than on trying to analyse the problem in any other way. Lawson (1979) found a marked difference between architectural students and science students in this respect. Given the same experimental, problem-solving task, fifth-year architectural students tended to adopt a 'solution-focussing strategy' (i.e. learning to understand the problem by proposing solutions to it) whereas fifth year science students tended to adopt a 'problem-focussing strategy' (i.e. learning to understand the problem by logically analysing its structure). There were no significant differences in strategies between first-year architectural students and a general sample of their university-entry cohorts, which suggests that architectural students learn to adopt the designerly, solution-focussing strategy in the course of their undergraduate education.

However, as with divergent/convergent cognitive styles, it would be wrong to assume that either the impulsive or the reflective cognitive style is overwhelmingly to be preferred in design. Once again, students need to be aware that they will need both styles and to learn to recognize when to switch from one to the other. For the design teacher, it is important to realise that the 'impulsive' student's approach can be valid and at times preferable to the usually more highly-regarded 'reflective' student.

FIELD-DEPENDENT AND FIELD-INDEPENDENT STYLES

(a) in learning

Witkin (1969) found that people differed from one another in the characteristic way they perceived the world and themselves. His research primarily focussed on the degree to which different people are influenced by the context in which they see something or in which they encounter a problem. Witkin viewed these differences as variations in cognitive style.

Figure 3 illustrates that a person's perception is influenced by contextual clues. A person is asked to say which of the two central circles is larger. The answer, in fact, is that they are both the same size, but people often perceive the one on the left as smaller because the context (i.e. the larger circles surrounding it) affects the way in which it is perceived.

Fig.3 Compare the sizes of the central circles
Witkin uses the term 'field-dependence' to describe the cognitive style of a person who is influenced by context, and 'field-independence' to describe the style of a person who is relatively free of context. In one experiment, conducted under strict laboratory conditions, Witkin places his subjects in a darkened room where all they can see is a luminous square frame and a luminous rod, both of which can be rotated about their common centre. When Witkin tilts the square frame, the subjects are asked to rotate the rod in order to make it upright. The results indicate that some subjects align the rod with one side of the frame, whilst others ignore the square and align the rod vertically. The latter group are 'field-independent'. Another of Witkin's tests involves recognizing 'embedded figures' in more complex diagrams (Figure 4); field-independent people find it easier to recognize the embedded figure.

It is clear from Witkin's experimental studies that people do, in fact, differ in their characteristic way of perceiving: field-dependent people perceive the overall organisation of the prevailing field as dominant and parts of the field are perceived as being fused with their background. In marked contrast, field-independent people perceive items as discrete from the field; their perception, according to Witkin, shows an analytical quality.
Witkin presents a great deal of evidence to demonstrate that people whose perception is field-independent perform much better than field-dependent people when asked to solve problems in which essential elements must be isolated from a particular context and redeployed in a new relationship. As an example of such a problem children are given a stick and asked to fit it across an open doorway, but the stick is too short. The children quickly learn that in order to solve the problem, they need to use a wedge to anchor the stick. Witkin deliberately leaves a 'wedge' in the form of a bottle with a stopper on the table. The stopper is exactly the right width to function as a wedge. The difficulty is that the child must perceive that the stopper has to be taken out of its usual functional context (i.e. stopping up a bottle) and use it in a very different, unfamiliar context (i.e. as a wedge). Witkin found an extremely high relationship between ability to solve problems like these and a person's degree of field-dependence, the person having difficulty being also likely to be very field-dependent perceptually.

Witkin contends that the more one is able to identify differences in perceptual and cognitive patterns in people, the more one is able to devise appropriate teaching methods to cater for such differences. He suggests that 'cognitive maps' reflecting the pattern into which one's cognitive characteristics fall is one way of identifying strengths and weaknesses in one's learning style. This then can determine how the person may best be taught.

(b) in designing

Most designers are familiar with the classic examples of visual illusions, such as the size of the circles in Figure 3, or with the figure/ground illustrations such as the vase/two faces (Figure 5). Recognizing the influence of context and appreciating the gestalt switch from ground to figure are parts of a designer's visual 'literacy'.

Fig. 5 Figure/ground : vase/faces
This kind of skill is also important in design in a more abstract formulation, in the 'problem-finding' aspect of design. 'Problem-finding' means recognizing a significant pattern in the available data - recognizing the spotted dog amongst the other spots in the picture (Figure 6). The 'important' features of the problem figure have to be mentally isolated from the distractions of the problem-field in which they are embedded.

In Jones' (1970) concept of 'transformation' in design, this kind of skill is particularly relevant. 'Transformation' is the stage of pattern-making in design, of making some sense of the incoming data. It is the moment of insight that establishes, for the designer, 'the general character, or pattern, of what is being designed, a pattern that is perceived as appropriate but cannot be proved to be right'. This pattern-making is, according to Jones, 'the creative act of turning a complicated problem into a simple one by changing its form and by deciding what to emphasize and what to overlook'. 
Of course, this perceived pattern or problem-figure did not pre-exist in the problem-field - it was not 'really there all the time', like the spotted dog. It is more like a face perceived in the clouds, or the face of the man in the moon - something 'really' only there in the eye of the beholder. These kinds of patterns are the perceptual and/or conceptual 'prestructures' that we impose on our environment.

In acknowledging their limitations, in that they can be too-readily invoked to impose a spurious 'order' on the problem-field. However, there is no doubt that pattern-making skill is something a designer is expected to have, in both the abstract sense of perceiving the problem-figure from the problem-field and in the more concrete sense of creating real patterns in three-dimensional objects.

Acquiring the designerly pattern-making skill has been likened by several authors to that of learning a language. An unfamiliar foreign language, heard spoken aloud, is just an indecipherable string of sounds - or like a string of data with no pattern. Gradually, with help, one begins to distinguish occasional 'words' in the string of sounds, and eventually one recognizes the meaning, or pattern, of the complete spoken phrase. Simultaneously, one learns to convey one's own meaning by structuring it into words and phrases that will be understood by the foreigner.

The language analogy has been used, for example, by Hillier and Leaman (1976). They suggest that, 'in effect, the designer learns to "speak" a language - to make a useful transition between domains which are unlike each other (sounds and meanings in language, artifacts and needs in design) by means of a code or system of codes which structure that connection'. One such code might be the 'language' of 'patterns' offered by Alexander et al. (1977) for architectural design. Each 'pattern' links a 'need' with a physical means by which it might be satisfied in a building. A novice architect can use Alexander's 'pattern language' to piece together a design - to make a statement, as it were, in architecture.

But learning only one such code means that the student learns to speak only one language (and on the example above, only an Alexanderian version of the language of architecture). This may be adequate for training a student as a designer in one particular profession, but clearly it does not make him into the design equivalent of a linguist. It is the 'linguist' model, rather than learning a particular design language, that needs to be developed in generalist approaches to design and design education.

In terms of field-dependence/independence, this discussion suggests that a high degree of field-independence is desirable in design. The designer needs to perceive pattern, structure and meaning in the fields of data. Furthermore, this ability needs to be developed beyond the level of recurrently imposing only one 'pre-structure'. This poses special problems for design teachers who must encourage a highly flexible field-independence in their students.
How can this be done? We can suggest a few ways. Firstly, through examples of the discovery of embedded figures (Figure 4), and perhaps through the reverse process - the student embeds a figure in a more complex figure (which could be the basis of a design game in which students challenge each other's figure-embedding and figure-perceiving abilities). Secondly, through encouraging the transfer of patterns from one problem-field to another, as in the case of the bottle-stopper/door-wedge. And thirdly, through the study of the design 'codes' by which needs are translated into artifacts. This last area is the most difficult in which to suggest examples, since design theory itself has not been developed sufficiently in this area. What it implies is something like the study of the anthropology and linguistics of design, rather than simply learning one culture and one language.

SERIALISTIC AND HOLISTIC STYLES

(a) in learning

This categorization of cognitive styles stems from Gordon Pask's general theory of learning and teaching which contends that there are two ways in which people learn; as a serialist or a holist. One is not judged to be more effective than the other, but rather both are conceived as two very different ways to approach problem solving and learning activities. Pask believes that certain types of teaching strategies are well suited to the serialistic style, but are unsuited to the holistic. Similarly, certain strategies fit the holistic learner but are very difficult for the serialist to grasp. In other words a teaching strategy may be matched or mismatched to an individual's learning style. Table 1 compares the characteristics of serialists and holists.

Pask and Scott conducted a number of studies concerned with matching and mismatching teaching strategies and learning styles. In one experiment (Pask and Scott, 1975), they identified people as serialists or holists from their free learning behaviour. Then, half of the group received instruction which, according to the theory, was matched to their competence, and half received mismatched information. The results were very clear cut. The matched students (serialist-to-serialist teaching programme and holist-to-holist programme) performed much better when tested on their knowledge of the programme than did the mismatched students - so much so that the least successful 'matched' student did better than the most successful 'mismatched' one. Furthermore, the matched students showed a significantly greater ability to generalise from their knowledge. Unfortunately, Pask and Scott's (1975) results are based upon only a small sample of students and cannot be safely generalized without much further investigation. But they are suggestive of individual differences that could be very important educationally and represent a rare attempt to investigate the merits of different teaching strategies which relate to difference in cognitive styles.

An obvious criticism of Pask and Scott's experiments is that both the task on which the serialist/holist identification was originally made and the
task in which the teaching strategies were matched or mismatched were of the same kind; consequently their generalizability is unproven. According to Pask's theory of cognition, these differences should manifest themselves in a variety of different learning situations. To provide evidence on this, Pask and Scott took a group of students who had been classified as holists or serialists through their performance on a learning task involving the classification of invented Martian animals known as clobbits and gandelmullers. Pask and Scott then taught them some quite different material having to do with the functioning of a biological system, again using serialist and holist kinds of instruction. As in the first set of experiments, the effects of matched and mismatched strategies were pronounced.

Table 1. Characteristics of serialist and holist learners

<table>
<thead>
<tr>
<th>Serialist</th>
<th>Holist</th>
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<tbody>
<tr>
<td>Proceeds by logical small steps.</td>
<td>Proceeds much more broadly than serialist, picking up bits of information that are not logically necessary, but which help him to remember certain facts.</td>
</tr>
<tr>
<td>Tries to get every point clear before moving on to next point.</td>
<td>Likes learning things in different ways.</td>
</tr>
<tr>
<td>Takes a straight route through teaching material with no digressing or unnecessary information.</td>
<td>Approaches ideas from different perspectives.</td>
</tr>
<tr>
<td>Studies a book page by page considering each new idea until it is understood.</td>
<td>Reads a book by skipping around from chapter by chapter, figure to figure, etc., in the expectation that the material will eventually fall into place.</td>
</tr>
<tr>
<td>Learns, remembers, and recapitulates a body of information in terms of string-like cognitive structures where items are related by simple data links - formally, by 'low-order relations'.</td>
<td>Learns, remembers, and recapitulates as a whole - formally, in terms of 'high-order relations'.</td>
</tr>
<tr>
<td>Teaches back in the same way as he was taught. If a serialist is asked to explain a particular concept, he reproduces the same line of argument presented to him.</td>
<td>Teaches back in a different way from the way in which he was taught (his own version reconstructed). If a holist is asked to explain a concept, his explanation may take many forms since his understanding of it will have been learnt in a variety of ways.</td>
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If the design process is a learning process, and people learn in very different ways - e.g., holistically or serialistically - then the way the design process is structured by (or for) the designer will have an important influence on the success of his designing/learning. Yet major differences in cognitive styles are rarely, if ever, explicitly acknowledged in design theory, design methods or design education.

With the benefit of hindsight, and a little knowledge of cognitive styles, we can perhaps now see some of the differences of approach that have been shown by different design theorists as stemming from differences in cognitive styles. Compare, for example, the structures of the design process as presented by Archer (1965) in his 'Systematic Method for Designers' and by Jones (1970) in his textbook of 'Design Methods'. Archer's design process is a methodical, step-by-step sequence of activities, with decisions being made at each point before moving onto the next, and it conveys a sense of a straight route being purposively forged. It clearly offers what we might now call a serialistic learning strategy.

In contrast, Jones offers a more generalised map of the design territory (his matrix of design methods, or 'input-output chart') and advice on how to construct one's own preferred route through it. Any route, however, is assumed to be rather exploratory, with the designer's path changing direction, back-tracking, etc. as new information is assimilated. In short, it offers a holistic learning strategy.

Normally, such differences in learning/designing strategies do not matter much, since any designer can choose the strategy that suits him best. But perhaps differences in cognitive styles help to explain why so many designers and design students have struggled so frequently in vain with one or another of the recommended strategies?

Differences in cognitive styles are also important in the many experiments in design research that require a number of subjects to tackle a prescribed problem. The difference is a variable that is not being controlled. Usually, the experimenter sets the design problem in just one way, but the way it is presented and structured influences the perceived difficulty of the problem for the subject and the actual difficulty he experiences in trying to solve it. A problem presented in a serialistic way is more difficult for a holistic learner, and vice versa.

Only one design research experiment that we know of has attempted to discover whether the way the problem is presented to the subjects affects their performance. This was an experiment in 'Presentation and Representation in Design Problem Solving' by Carroll et al. (1978). This experiment included three different styles in which the problem was presented to the subjects:

1. a 'hierarchical' presentation in which the problem goals were structured hierarchically
2. a 'clustered' presentation in which the goals were functionally grouped, and
3. a 'non-structured' presentation in which the goals were presented in no particular sequence, grouping or structure.
The experiments found no significant performance differences attributable to the styles of presentation. However, what if they had matched styles of presentation to their subjects' cognitive styles?

A very similar situation to that of the design research experiment exists in design education, where a class of students is set the same project in the same way. Not being in a controlled experiment, the students have more freedom to unravel, sort and structure the problem in their own preferred learning style, but the assumption of the design teacher always seems to be that one style of presentation is adequate. The 'over-the-drawing-board' tuition that is the mainstay of traditional design education can be an equally frustrating experience for both student and teacher if their cognitive styles clash, leading the teacher to suppose that the student has a learning 'difficulty', rather than just a different learning style.

The implications here seem fairly clear. Teachers need to be aware that their students inevitably have a range of different learning styles, and that a mismatch of teaching and learning styles is usually unproductive. The teachers can at least make some effort to provide a range of learning experience for their students in order to increase the chances of a match being made. Problems should certainly be presented to students in at least two different styles - a serialistic style and a holistic style - and, once again, students should be helped to know and to understand their own preferred cognitive style.
CONCLUSIONS

It is well known that there are two types of people, those who believe that there are two types of people, and those who do not believe in such crude simplifications. Our presentation of cognitive styles may have sounded like crude simplification of people's mental abilities and behaviour. This is probably because we tended to present cognitive styles as either/or categorisations: people are either divergent or convergent thinkers, either impulsive or reflective responders, either field-dependent or field-independent perceivers, either serialistic or holistic learners. Perhaps we should make it clear that such categorisations usually emphasize only the opposite ends of a spectrum of cognitive behaviours; most people will fall somewhere within the spectrum rather than decisively at one end. People tend towards a divergent or convergent style of thought, for example, but no-one is exclusively divergent or convergent.

Our discussion of the relevant links that might be made between learning and designing from the theory of cognitive styles has, we hope, thrown up some interesting ideas, particularly for teachers of design. For instance, the idea that 'impulsive' thought has a valid role in design runs counter to most teachers' preferences for 'reflective' student behaviour. This is perhaps part of the general bias in education towards 'scholarly' and 'scientific' modes of thought, and away from 'designerly' modes.

Within the spectrum of field-dependence/independence it seems clear to us that field-independence is a quality to be encouraged in design students, for the reasons connected with pattern making that we outlined. This offers a specific challenge to design teachers to develop teaching methods that encourage field-independence. In the divergence/convergence spectrum, however, our conclusion is that design demands the development of both types of thinking abilities, together with a self-awareness of one's own strengths and weaknesses, and the strategic skill to know when and how to switch from divergence to convergence and back again.

A similar 'self-awareness' conclusion must be drawn in respect of the holist/serialist spectrum. Knowing, understanding, and developing your own preferred learning/designing style means that your learning/designing can become more efficient and effective. In particular, we suspect that 'holistic' learners need to be reassured that their apparently ad hoc skipping, skimming and returning is a perfectly valid learning strategy. If you studied this paper in such a way, you probably learned just as much from it as the person who read it steadily through from beginning to end.
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