

# Styles of learning, designing and computing

Nigel Cross

*Design Discipline, Faculty of Technology, The Open University, Milton Keynes MK7 6AA, UK*

*People differ in the basic cognitive styles that they bring to any learning task. Their learning can be severely impaired if they are mismatched with teachers who prefer, or teaching programmes which impose, a different learning style. The introduction of specific design strategies can also result in a mismatch between the cognitive style of the designer and that implicit in the strategy. In general, designers prefer a holistic, solution-focused strategy rather than an analytic, problem-focused one. Differences in cognitive style may reflect fundamental neurological differences in the two hemispheres of the brain. The left brain dominates in propositional modes of thought, and the right brain dominates in appositional modes. This creates further problems of mismatch between the predominantly appositional cognitive style of designers and the propositional style of computers.*

*Keywords: cognitive styles, design education, design strategies, computer-aided design*

What are the aims of 'CAD-ED'—the introduction of computers into design education? One aim might be simply to train future designers in certain aspects and applications of computers which they will need for employment in offices where computer-aided design (CAD) systems are used. Another aim might be to introduce students to the possible use of the computer as a design aid in the projects they are set—rather as they might also be introduced to drawing and modelling techniques. A third aim might be to use computers as an aid to the central educational task of teaching students how to design.

This last aim is the most difficult and raises the most problems. In this paper I intend to concentrate on some of those problems, looking particularly at the mismatches of cognitive styles that can occur between students and teachers, designers and design strategies, and people and computers. These problems need to be resolved if CAD systems are to have any fundamental and positive role in design education.

## LEARNING 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 recognizing these individual differences in learners. These differences in the ways in which people learn are generally referred to in psychology as 'cognitive styles'. Such differences apply not only to children learning basic literacy or numeracy, but also to teenagers studying for examinations, to undergraduate students, and to adult learners.

One of the most important differences in learning styles appears to be that categorized by Pask<sup>1</sup> as serialist *versus* holist. A serialist prefers to learn by proceeding in logical small steps, tries to get every point clear before moving on to the next, and pursues a straight path through the learning task, avoiding any digressions. A holist proceeds much more broadly, picking up bits of information that are not necessarily logically connected, and learning things 'out of sequence'. A holist prefers to learn by having things presented in different ways, and approaching ideas from different viewpoints.

Teachers, as well as students, have different cognitive styles, and so styles of teaching vary as much as styles of learning. Pask believes that teaching strategies can be either matched or mismatched to an individuals' learning style. He has conducted a number of studies concerned with matching and mismatching teaching strategies and

learning styles. The results suggest that if students' learning styles are matched to the teaching strategy (serialist to serialist or holist to holist) then they perform much better in tests of what they are supposed to have learned than do mismatched students. In fact, the least successful matched students tend to perform better than even the most successful mismatched ones. Furthermore, matched students show a significantly greater ability to generalize from the knowledge they have gained.

Another distinction that has been made between cognitive styles is that between convergent and divergent thinking. Convergent thinking is primarily concerned with taking in information and producing, or 'converging' on, a single correct answer to the problem. 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. Problems requiring convergent thinking are usually 'closed ended', whereas problems requiring divergent thinking are 'open ended', in that students are asked to offer several possible solutions. 'How many uses can you think of for a brick?' is a typical question used by psychologists to test for divergent thinking ability.

Hudson<sup>2</sup> found from tests on sixth-form school students that about 30% could be classified as divergers, about 30% could be classified as convergers, and the remaining 40% were the all-rounders of middling performance. An interesting conclusion that Hudson also came to was that 'arts' students are likely to be divergers, and 'science' students are likely to be convergers. He suggests that arts students tend to be freer to use their imaginations about the different uses for a given object because they are not committed to being practical; science students are more likely to think about the 'right' use for an object and to be inhibited in making 'impractical' suggestions.

As with serialist and holist styles, convergent and divergent cognitive styles can be matched or mismatched to teaching strategies. Many teaching strategies used in mathematics, science and technology are characterized by logical, structured presentations, leading to a 'correct' answer. Consequently, they encourage convergent thinking and discourage divergent thinking. In contrast, many teaching strategies in the arts and design, which provide students with an area of interest and ask them to generate a project based on their study of the area, encourage divergent thinking.

Hudson also investigated the effects of matched and mismatched teaching strategies and learning styles. He identified students and their teachers at a London teaching hospital as either convergent or divergent thinkers. The results indicated that the convergent students learned best from the convergent teachers, while the divergent students learned best from the divergent teachers.

A third kind of distinction that is often made between styles of thinking is that between flexible thinking and focused or 'rigid' thinking. This difference might also be

characterized as 'lateral' *versus* 'linear' thinking. A typical problem which calls for flexible thinking might be posed like this: You are in a bare room. Two strings hang from the ceiling and your task is to tie the strings together. However, the strings are of such a length and distance apart that when you are holding the end of one you still cannot quite reach the other. The only tool in the room is a hammer. How can you tie the two strings together?

This problem can be solved if you stop focusing on the hammer in its usual context or role, as a tool for hammering things, and think of it instead as a weight. It could be tied on the end of one string and swung like a pendulum in the direction of the other string. Holding the end of the other string, you can catch the 'pendulum' when it swings toward you.

Witkin<sup>3</sup> used the term 'field dependence' to describe the cognitive style of a person who is overly influenced by context, and 'field independence' to describe the style of a person who is able to think relatively context free. He has demonstrated 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 one.

Like Pask and Hudson, 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 strategies to cater for such differences. He has suggested that 'cognitive maps' reflecting the pattern into which people's cognitive characteristics fall would be one way of identifying the features of individual learning styles. This 'map' could then help determine how a person might best be taught.

## DESIGNING STYLES

The design process is often likened to a learning process. For instance, Jones<sup>4</sup> has said: 'I think of (the design process) as a specially designed "education" or "course" which one devises, and undertakes, in order to complete the design.' A designer is quite clearly learning whilst he is designing. Much of his activity is concerned with attempting to clarify the problem as given, with seeking information, and with attempts to find or generate 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.

If the design process is a learning process, and—as we have seen—people have very different learning styles, then we would also expect them to have very different designing styles. Further, if the matching or mismatching of teaching strategies to learning styles significantly affects a student's success, then the way the design process is structured by (or for) the designer will have an important influence on his success, too. Design strategy must be matched to cognitive style. Yet differences in cognitive styles are rarely, if ever, explicitly acknowledged in design theory, design methods or design education.

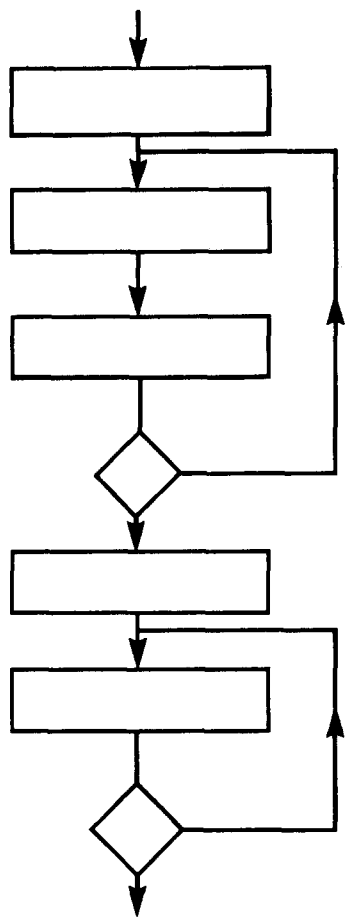


Figure 1. A serialistic design strategy

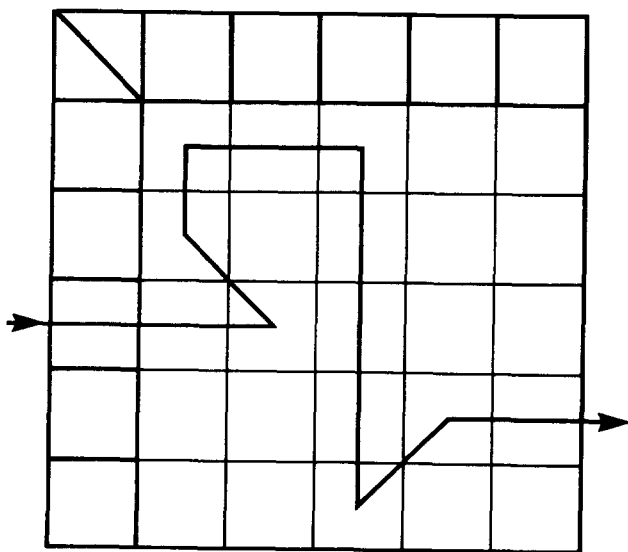


Figure 2. A holistic design strategy

We can perhaps now see some of the differences in the strategies advocated by designers and design theorists as stemming from differences in individual cognitive styles. For example, compare the structure of the design process as presented by Asimow<sup>5</sup> and by Jones<sup>4</sup>. Asimow's design process (his 'design morphology' chart) is a methodical step-by-step sequence, with decisions being made at each point before moving on to the next, and it

conveys a sense of a straight route being purposively forged. It clearly offers a serialistic learning/designing strategy (Figure 1). In contrast, Jones offers a more generalized 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, backtracking, etc., as new information is assimilated. In short, it offers a holistic learning/designing strategy (Figure 2).

Similarly, we might compare the orderly, rational, convergent view of the design process offered by March<sup>6</sup> (Figure 3) with the more *ad hoc*, intuitive, divergent view of Halprin<sup>7</sup> (Figure 4); or the focused, linear, critical-path approach of Archer<sup>8</sup> (Figure 5) with the more flexible 'cascade' approach of Alexander's<sup>9</sup> pattern language (Figure 6).

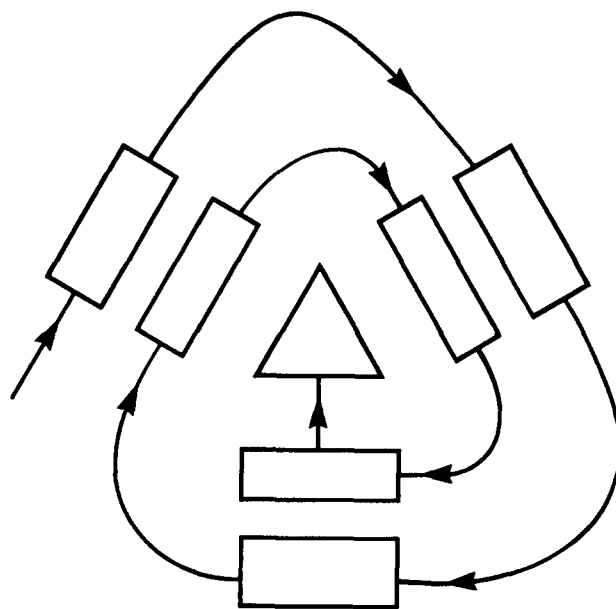


Figure 3. A convergent design strategy

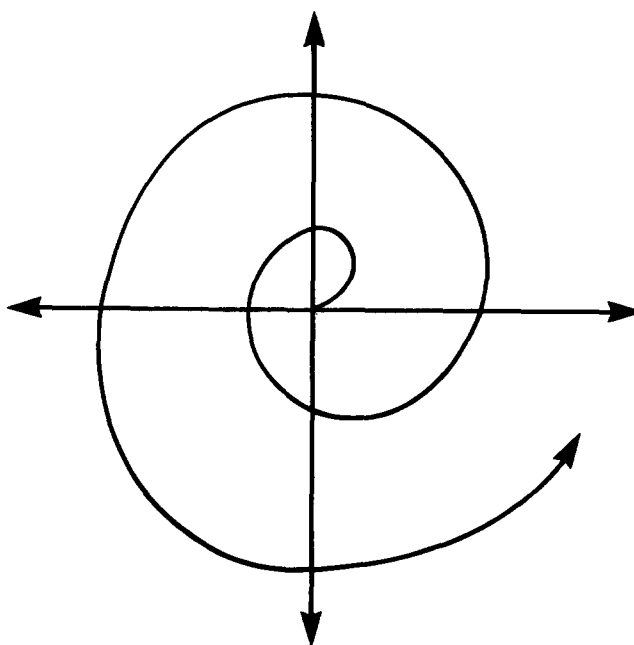


Figure 4. A divergent design strategy

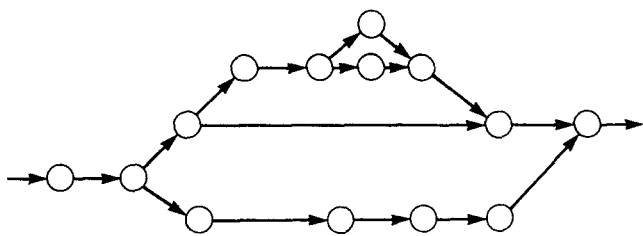


Figure 5. A focused design strategy

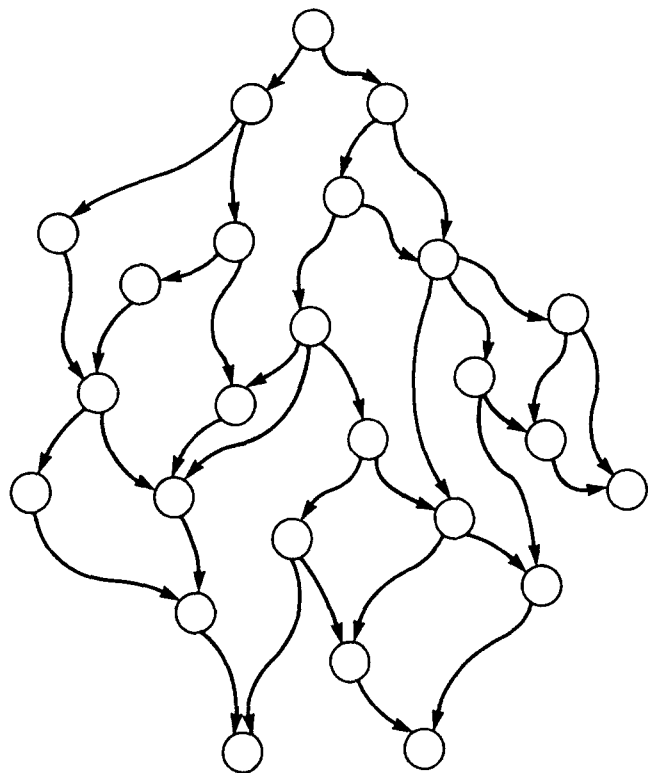


Figure 6. A flexible design strategy

With the development of explicit design strategies such as these, the match or mismatch with cognitive style becomes more critical than it was with the traditional design process. Perhaps differences in cognitive styles help to explain why so many designers and design students struggled so frequently in vain with one or another of the recommended strategies, and finally gave up the idea of 'design methods' altogether.

However, it may be possible to make some generalizations about the way designers tend to tackle their problems, drawing on the various studies that have been made of designer behaviour. Summarizing the findings of such studies, Lawson<sup>10</sup> concluded: '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.

Lawson's own studies of designer behaviour were made on architecture students. He devised some experimental problems which required arranging a set of coloured blocks so as to satisfy certain rules, and he set the same problems to both postgraduate architecture students and postgraduate science students. The two groups tended to use dissimilar problem-solving strategies. The scientists tried to understand the problem

by logical and systematic exploration of the rules, whereas the architects were more inclined to propose a series of solutions, and to have those solutions eliminated by the experimenter, until they found an acceptable one. Lawson characterized the two strategies as problem focused (scientists) and solution focused (architects). Whereas the scientists set out specifically to study the problem, the architects went more directly for a solution, but still learnt at least some of the critical features of the problem as a result of trying out solutions.

It seems that architecture students learn that the most productive design strategy is to concentrate on producing tentative solutions, rather than trying to analyse the problem in any other way. Lawson found no significant differences in problem-solving strategies between first-year architecture students and sixth-form school students, which suggests that the architects learn to adopt the solution-focused strategy in the course of their undergraduate education. Presumably they discover that this is the most effective strategy for tackling the kinds of problems they are set.

These research results lend support to the notion that there are particularly appropriate, 'designerly' strategies for solving design problems. These strategies are justifiably different from those used in other fields, such as the sciences, and arise from the intrinsically ill structured nature of design problems.

## COMPUTING STYLES

The view that there are fundamental dichotomies in cognitive style, which become manifest in learning, designing and other intellectual activities, has been reinforced by the recent research in the neurosciences which has concentrated on examining the apparently different functions of the hemispheres of the human brain.

The brain appears to have two different 'computing' styles, each associated with one particular hemisphere<sup>11-13</sup>. For a long time, the right hemisphere has been regarded as the 'minor' hemisphere, with relatively unimportant cognitive functions. Damage to the right hemisphere, for instance, usually produces no apparent significant loss of mental abilities. The left, or 'major', hemisphere, however, clearly controls many of the higher mental abilities such as speech and analytical reasoning.

It has now become clear that the two hemispheres tend to specialize in different styles of perception, cognition and communication. The left hemisphere does indeed dominate in verbal, analytical modes of thought. It controls serialistic, 'rational' ways of thinking. The right hemisphere dominates in nonverbal, visuospatial, synthetic modes of thought. It controls holistic, 'intuitive' ways of thinking.

These two modes of thought have been categorized by Bogen<sup>14</sup> as propositional (left brain) and appositional (right brain) styles. Because propositional thinking is the thought mode of verbal reasoning, logical argument and

science, it has dominated our educational system. Appositional thinking is the thought mode of nonverbal communication, imagery and analogy. It is the thought mode of design, and it has been largely neglected by our educational system.

Patients with brain damage to the right hemisphere have also been neglected by medicine, and their case histories are very few and sketchy compared with the studies of left-hemisphere damage. However, here is part of an account by Sacks<sup>15</sup> of a patient, Dr P, with a severe right-hemisphere syndrome. Sacks held up a glove and asked: 'What is this?' The patient examined the object and reported: 'A continuous surface, . . . infolded on itself. It appears to have . . . five outpouchings, if that is the word . . . A container of some sort? . . . There are many possibilities. It could be a change purse, for example, for coins of five sizes . . .' Sacks comments:

No child would have the power to see and speak of a continuous surface . . . infolded on itself, but any child, any infant, would immediately know a glove as a glove, see it as familiar, as going with a hand. Dr P didn't. He saw nothing as familiar. Visually, he was lost in a world of lifeless abstractions . . . (He) functioned precisely as a machine functions. It wasn't merely that he displayed the same indifference to the visual world as a computer but—even more strikingly—he construed the world as a computer construes it, by means of key features and schematic relationships.

The 'cognitive style' of computers is restricted to certain very limited aspects of propositional ability. This creates severe problems of mismatch between the 'cognitive abilities' of computers and those of people.

The problem is heavily masked in the normal comparisons made between computers and people, such as the 'Fitts list' comparisons. These tend to suggest that computers and people have complementary abilities, which can be successfully combined in human-machine systems to achieve a 'symbiosis' with greater capabilities than either humans or machines can manage in isolation. However, the comparisons are almost always false because they tend to describe human abilities in machine terms. Typically, human attributes are downgraded and machine attributes upgraded. The result has been the introduction of computer systems—in industry, business and design—which degrade, deskill and dehumanize the complex tasks of which people are capable.

There is growing criticism of these systems, with workers who have to operate them expressing concern about their job implications. Yet, in contrast, there is wide popular acceptance of home computers and video games, and Space Invaders machines dominate the amusement arcades. We can perhaps attribute the popularity of the latter to the way in which they demand intense concentration, combining mental agility, visual alertness and manual dexterity. The human being is completely absorbed in the task, but the machine's role is paradoxically—but perhaps rightly—very limited. Have the Space Invaders designers found the right combination of computing styles for humans and machines?

## CONCLUSIONS

In conventional design education, differences in student's cognitive styles do not raise serious problems for their tutors. This is because, in a project-based educational system, each student has the freedom to approach, unravel, sort and structure the problem in his own preferred learning style. Nevertheless, the 'over-the-drawing-board' tuition that is the mainstay of traditional design education can be an equally frustrating experience for both the student and the tutor if their cognitive styles clash. A tutor might even be led to assume that the student has a learning 'difficulty', rather than just a different learning and designing style. Many tutors, however, would have enough flexibility in their teaching style to cope with differences in student learning styles. The problem for CAD education is to devise equally flexible systems. The dangerous alternative is that only students with a certain preferred cognitive style will find the CAD-ED systems convivial.

Similarly in conventional designing, differences in cognitive style between designers do not matter much. Each designer has enough freedom to tackle the design problem in his own preferred style. But all will need CAD systems that support a solution-focused design strategy, rather than systems which offer problem-focused analysis strategies. If the former is the appropriate strategy for designers, then CAD-ED systems should enhance and encourage students' learning of such a strategy. For example, the emphasis should be on the generation of solutions, and this should be possible before the problem is fully 'understood'. In design, understanding of the 'problem' and of the 'solution' develops in parallel.

Finally, the big problem facing CAD-ED system designers is the inherent mismatch of computing styles between people and machines. There are some computer-based systems that are absorbing and stimulating to a wide range of users, not just to computer fanatics. The challenge is to design CAD-ED systems that are educational, designerly and fun.

## REFERENCES

- 1 Pask, G and Scott, B 'Learning strategies and individual competence' *Int. J. Man-Mach. Stud.* Vol 4 No 3 (1972) pp 217-253
- 2 Hudson, L *Contrary imaginations* Methuen, London, UK (1966); Penguin, Harmondsworth, UK (1967)
- 3 Witkin, H A 'Some implications of research on cognitive style for problems of education' in Gottesgen, M B and Gottesgen, G B (eds) *Professional school psychology* Vol 3 Grime and Stratton, New York, USA (1969)
- 4 Jones, J C *Design methods: seeds of human futures* Wiley, Chichester, UK (1980)
- 5 Asimov, M *Introduction to design* Prentice-Hall, Englewood Cliffs, NJ, USA (1962)

- 6 March, L J** 'The logic of design and the question of value' in **March, L J (ed.)** *The architecture of form* Cambridge University Press, Cambridge, UK (1976)
- 7 Halprin, L** *RSVP cycles: creative processes in the human environment* Braziller, New York, USA (1969)
- 8 Archer, L B** *Systematic method for designers* Design Council, London, UK (1965)
- 9 Alexander, C et al** *A pattern language which generates multi-service centres* Centre for Environmental Structure, Berkeley, CA, USA (1968)
- 10 Lawson, B** *How designers think* Architectural Press, London, UK (1980)
- 11 Cross, A** 'Towards an understanding of the intrinsic values of design education' *Des. Stud.* Vol 5 No 1 (1984) pp 31–39
- 12 Tovey, M** 'Designing with both halves of the brain' *Des. Stud.* Vol 5 No 4 (1984) pp 219–228
- 13 Ward, A** 'Design cosmologies and brain research' *Des. Stud.* Vol 5 No 4 (1984) pp 229–238
- 14 Bogen, J E** 'The other side of the brain: the appositional mind' *Bull. Los Angeles Neurol. Soc.* Vol 34 No 3 (1969) pp 135–162
- 15 Sacks, O** 'The man who mistook his wife for a hat' *London Rev. Books* Vol 5 No 9 (1983) pp 3–5