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A Dual-state Model of Creative Cognition for Supporting Strategies that Foster Creativity in the Classroom

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ABSTRACT: The generative thought processes that give rise to original ideas appear to be very different to those analytical thought processes required to refine them. Thus, design and technology provides a unique challenge to the teacher, since he/she must be able to support and encourage both types of thinking in the classroom. A review of the psychological and educational literature suggests an integrated 2-process model of thinking can be applied to provide a clearer indication of when and how different teaching strategies may be effective. Such a model reconciles apparent contradictions in the literature, offers a better understanding of the pragmatic strategies already used by teachers and helps suggest new strategies.

Keywords: creativity, design process, examples, reward, self-evaluation

1. INTRODUCTION

An increasing amount of attention is being drawn to the importance of fostering pupils' higher-order thinking and problem solving skills (Wu, Custer & Dyrenfurth 1996; Robinson 1999). Of the many different thinking skills required by pupils following a design and technology curriculum, creative thinking skills are considered to be essential and valuable (Fritz 1998; Lewis 1999). The advice available for the teacher on how to support such skills can, however, appear contradictory. By looking more closely at the cognitive mechanisms that may underlie creativity, a dual-state model of creative cognition emerges that can be used to resolve these apparent differences. Such a model can also provide a better understanding of when different strategies may be most effective during pupils' designing.

2. CREATIVITY

Although much research has emphasised the importance of the person in creating the product, most explicit definitions of creativity have centred upon the product itself. Definitions of a creative product have generally been based upon two distinct dimensions. Barron (1955) defined a creative outcome in terms of being both uncommon and appropriate, which was echoed by Stein's (1953) definition of creativity as 'a process which results in a novel work that is accepted as tenable, useful or satisfying by a group

at some point in time'. More recent studies have used similar definitions with, for example, workers such as Finke, Ward and Smith (1992) using ratings of originality and practicality to measure the creative value of inventions. Generally, there is now common agreement that creativity involves 'bringing something into being that is original (new, unusual, novel, unexpected) and also valuable (useful, good, adaptive, appropriate)' (Osche 1990).

2.1. *The effect of self-evaluation, reward and examples upon creativity*

Although there is an increasing emphasis given to encouraging creativity in design education, a brief review of the literature reveals some differences about how this is best achieved. Cropley (1997) encourages teachers to promote self-evaluation, in the belief that this will help the student learn independently. In a survey of teachers, Soh (2000) found a significant correlation between teachers' self-ratings of their creativity fostering behaviour and their encouragement of self-evaluation in the classroom. Self-evaluation is commonly advised as an essential activity during designing that should be undertaken at all stages (Department for Education 1995). However, empirical evidence indicates that self-evaluation has a negative influence upon creativity. In an alternate uses test, Szymanski and Harkins (1992) found that, when undergraduates were self-evaluating their own performance, they produced responses that were significantly less creative, as judged by an independent panel. Feedback, including self-feedback, is considered to undermine intrinsic motivation (Deci & Ryan 1985) and thus could be expected to reduce creativity according to the Intrinsic Motivation Principle of Creativity. This principle suggests that *the intrinsically motivated state is conducive to creativity, whereas the extrinsically motivated state is detrimental* (Amabile 1996, p. 119). A similar negative effect has been found for external evaluation, although some evidence suggests that the effect may depend upon the ability of the student, with low ability students actually benefiting from the knowledge that they may be evaluated (Amabile 1996, p. 151).

Without the encouragement to be self-critical, however, it is difficult to perceive how students can develop their own ideas independently of the teacher. Such autonomy is considered to be an important aspect of working creatively (Cropley 1997; Soh 2000) and here empirical studies back up the accepted pedagogical viewpoint, demonstrating that students are more likely to be creative when given more control over the task. For example, in a study in which fashion design students drew simple garment designs, those given the freedom to structure their own work produced more creative designs than those students given no such choice (Greenberg 1992).

Rewards and competitions are often provided by teachers as an inducement to motivate students, yet here is another area where research findings appear to contradict what is commonly considered as good practice. In

line with the Intrinsic Motivation Principle, the extrinsic motivation provided by reward and competition generally reduces creativity (Glucksberg 1962; Glucksberg 1964; McGraw & McCullers 1979; Kruglanski, Friedman & Zeevi 1971). It has been shown for children in tasks involving drawing and the design of collages that such negative effects can be reduced and, in some cases, reversed by careful 'immunisation'. Such immunisation might, for example, take the form of video-tapes showing other children emphasising their own intrinsic motivation towards their work (Eisenberger & Selbst 1994; Hennessey & Zbikowski 1993). Nevertheless, the use of a variety of forms of extrinsic motivation without such immunisation remains popular within design and technology education.

The use of examples to stimulate and inspire design students is also commonplace. In a typical evaluation exercise, the teacher will exhibit an outcome and discuss the advantages and disadvantages of its design with the class. Such exercises are intended, amongst other things, to broaden the awareness of the students with regard to possible features, pitfalls and approaches and, with a good example of an outcome, stimulate students to raise their own expectations of what is possible (DATA 1996). However, in a series of empirical studies (Jansson & Smith 1991), it was shown that undergraduate engineering design students tended to become fixated (i.e. acquired a blind adherence to a limited set of ideas) when first shown examples prior to a designing exercise. Indeed, many students included some of the poorer features of the examples, even though their shortcomings had been clearly pointed out to them. Similar effects have been well documented in other contexts in the pscyhological literature as early as the 1930's. For example, Maier (1931) noted that people have a tendency to restrict the use of an object to previously encountered functions, and termed this tendency 'functional fixedness.' Jansson and Smith (1991) went as far as suggesting that design problems should not be preceded by examples, so as to avoid 'design fixation' amongst students. Even in response to a problem possessing an infinite number of solutions, it has been shown by the author that an individual's ability to produce ideas drops quickly to a slower rate as fixation, caused by previous ideas, kicks in (see Figure 1).

3. MODELS OF CREATIVITY

The starting point for resolving these issues may be the essentially dual nature of creativity. A creative outcome has been described above as involving both originality and appropriateness. The determination of whether a product is appropriate is often quite straightforward. A specification giving the conditions under which it should operate and what it is expected to achieve can provide a guide for a critical analysis of its effectiveness. Such an analysis can often be carried out in step-wise fashion using procedures easily communicated by the teacher and followed by the pupil.

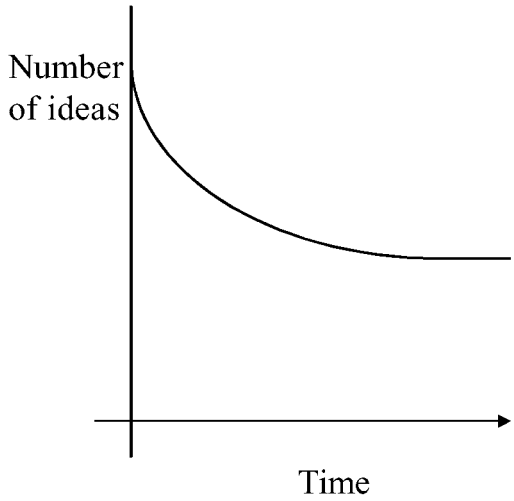

Figure 1. Even on simple problems, fixation quickly reduces the ability of students to come up with new ideas (adapted from Howard-Jones, 1998).

We can picture quite easily the type of mental model describing these sorts of thought processes. We can even produce a flow chart and encourage the pupil to focus upon each step sequentially. Strategies for supporting originality of thought, on the other hand, may be less effective when based upon focusing students' thinking upon a series of instructions. In fact, there is considerable evidence that focusing itself may restrict a person's ability to think in an original fashion.

As early as 1926, Wallas labelled the stages of the creative problem-solving process with the terms: *preparation, incubation, illumination* and *insight*. In the preparation stage, the individual concentrates upon analysis of the problem itself and the issues surrounding it. There is then a need for a period of incubation, during which the subject may not be consciously involved with the problem at all. This is followed by an apparently effortless, sometimes inspirational, arrival of illumination with a solution that often involves knowledge only remotely associated with the original problem. Finally, insight requires a critical evaluation, analysis and extension of the idea. The need for a period of incubation before a solution presents itself at first appears baffling. It may seem strange that *not* thinking about a problem can help solve it. Yet, stories abound of well-known cases where being involved in a relaxing or unrelated activity appears to have promoted a solution. In a controlled experiment, Forgays and Forgays (1992) demonstrated that adults scored higher in an alternate-uses test after a relaxing session in a flotation tank. The notion that some temporary suspension of 'rational' thought processes may improve problem-solving abilities has also given rise to the suggestion that meditation may improve students' design capabilities (Puk 1995).

There have been many other descriptions of the creative process, but most differentiate between the generation of the idea and its consequent evaluation. Finke et al. (1992) carried out a series of empirical studies based upon the design of novel inventions. He developed a model which suggests an alternation between a generative phase in which 'pre-inventive' structures are produced through combining elements, and an exploration phase in which these structures are interpreted. Both the personal and cultural models of creativity recently developed by Liu (1998) also feature such a generate-and-test component centrally in their framework.

In order to understand the mechanisms behind *incubation* and *illumination*, we have to ask how an individual can produce an original idea in the first place, if they have never encountered it before themselves. Campbell (1960) proposed that underlying this ability is a process of 'blind variation and selective retention'. He argued that a spontaneous construction of ideational combinations occurs in a more or less unpredictable fashion, only a small proportion of which are ever selected for further elaboration. Others have successfully used this theory to model the career trajectories of creative geniuses (Simonton 1997) and scientific communities (Kantorovich 1993). Incubation, then, refers to that period during which the individual is able to combine concepts and produce novel combinations. The greater the access to remotely-associated ideas, the greater the number available for combination into original concepts, and the greater the likelihood of producing an effective and original solution. Eventually, successful combination leads to the experience of illumination.

4. THE COGNITIVE AND NEUROPHYSIOLOGICAL BASIS FOR A DUAL-STATE MODEL

If the ability to create new ideas depends upon combining remotely-associated concepts, then the creativity of individuals should be bound up with the ability to access as many associates as possible. Therefore, Mednick (1962) argued, you would expect ability in word association tasks to be related to creative ability. Mednick also pointed to links between low productivity of words and steep declines in rate of response that had been reported in tests of verbal fluency. In these tests, individuals assessed as having only a small supply of words appeared to deplete these supplies at a faster rate, indicating the possibility of very strong associations interfering with access to weaker ones. In his explanation of creativity, Mednick hypothesised that 'less-creatives' would initially produce ideas more rapidly than their more productive colleagues whose pattern of ideation would also be characterised by a steadier stream of ideas. This latter claim was recently confirmed in ideational productivity tests on undergraduates (Howard-Jones 1999).

The notion that original thought is dependent upon a student's ability to access remote associates highlights an essential difference between the

thought processes required to critically evaluate an outcome and those required to generate new possibilities. When engaged in analytical thinking, a student is expected to be focused and to constrain their attention upon the analysis. When accessing remote associates, students will benefit from being less focused and allowing their attention to drift towards concepts that have not, previously, been directly associated with the problem. The existence of two distinct mental states is not a new one. Consideration of the need to broaden attention to generate an original outcome and to sharply focus attention to critically analyse ideas led the psychoanalytic theorist Ernst Kris (1952) to propose the existence of two modes of thinking: primary process and secondary process. Whereas secondary process thinking is concerned with conscious, focused and logical analysis, primary process thinking is more concerned with defocused, unconscious, more freely associative thinking. He suggested that the two formed a continuum along which consciousness varies. This concept is strongly allied with Wundt's (1896) associative versus intellectual, and Werner's (1948) dedifferentiated versus differentiated thinking. Secondary process thinking is essential for the critical exploration and validation of novel combinations of elements (corresponding to Wallas's insight, or Finke's exploration phase), but the initial production of ideas through the combination of remote associates would also require primary process cognition. Thus, creativity may be characterised by an ability to move from one mode of thought to the other without difficulty. How such an ability evolved in humans is, of course, a matter open to speculation, but may have been brought about by the same sort of selective pressures discussed by Calvin (1996) as responsible for honing primitive 'passing thoughts' into highly refined ones.

Mednick's concept of associative hierarchy and its relation to creativity remains of interest to those working in the area of problem-solving, and his ideas have recently enjoyed some renewed attention in attempts to explain the creative process in terms of connectionist models. Advances in connectionist modelling have suggested ways in which primary process (associative) thinking can occur in terms of the type of massively parallel architectures associated with the mind. Martindale (1995) has suggested that two states characterised by focused and unfocused attention may be supported by the those nodes associated with the problem becoming highly active and inhibiting weaker associations. Martindale argues that it is only when an individual's attention becomes less focused and such activation and its inhibitive effect subsides, that nodes activated by more remote associations can become active enough to come into consciousness. Further evidence for the model arises from measurements of how cortical arousal, a measure related to focus of attention, varies according to the creativity of the task being undertaken (Martindale & Hines 1975).

Alternatively, it may be the specialised functions of the right and left hemispheres that give rise the dualistic nature of the creative process. The right hemisphere appears linked with processes requiring access to remote associations while the left hemisphere appears to support more analytical

processing (Seger et al. 2000). Creative individuals appear to have freer access to mutual interactions of both hemispheres without marked inhibitory effects from either cerebral hemisphere (Hoppe & Kyle 1990).

Cognitive descriptions of the creative process thus provide insight into the mechanics of how the dynamics of the mind change when moving from thought processes for evaluating and analysing ideas to those requiring generation of new ideas. It may be possible for the two types of process to precede and follow each other in rapid succession, but it is clearly not possible for the two mental states to fully occur simultaneously. Some state representing a compromise between the two extremes may, however, frequently exist. The distinctiveness of the two mental states, or types of thinking process, makes it likely that a dual-state model of creative cognition will help explain what we know about the differences between conventional teaching approaches and those considered likely to foster creative behaviour (see Figure 2).

5. REINTERPRETING THE EVIDENCE IN TERMS OF A DUAL-STATE MODEL

To resolve the apparent differences in the literature, it is necessary to differentiate between those stages in the design process which are essentially generative and those that require analytical thinking. Johnsey (1995) carried out an extensive review of the many descriptions of the design process, concluding that there was little evidence to support any of them. It is also generally agreed that the stages involved in designing do not always proceed in a linear, cyclic or even an orderly way. However, there is a general consensus amongst authors about the types of tasks that may be involved, such as research or investigation, generation or invention of ideas, self-evaluating and selecting ideas, developing designs and evaluating outcomes.

Self-evaluation relies chiefly upon analytical thought-processes. Thus, when encouraged to self-evaluate during generative processes, we can expect a reduction in an individual's productivity, as reported in empirical studies.

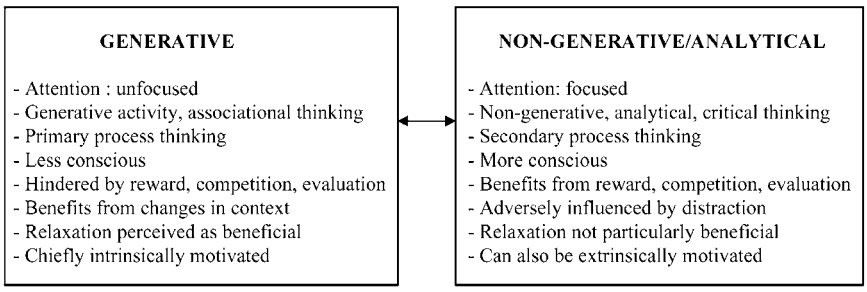

Figure 2. A dual state model of creative cognition: designing requires the ability to move between the two mental states, but individual stages may benefit more from support of one state than the other.

Nevertheless, the ability to evaluate these ideas is essential in the Design Process, and to the creative process in general (e.g. Wallas's verification stage). Cropley (1997) must indeed be correct in encouraging self-evaluation in the classroom as an essential basis for independent learning. However, it may be that self-evaluation should be discouraged during some initial stages of design generation, since it is likely to reduce students' abilities to access their more remote associations and produce novel ideas. Such an approach would be allied with the technique of *brainstorming* suggested by Osborn (1953). This approach specifically discourages any criticism of the ideas contributed by individuals until they have all been recorded. Osborn also developed lists of questions that apparently boosted creativity. The questions, however, did not encourage critical analysis (such as 'is it strong enough?', 'will the user like it?') but encouraged exploration and encouraged extension of the idea (e.g. 'what other uses are there?', 'what other features could be added?').

Similarly, the use of reward and competition may encourage students' general commitment and support their efforts to research, analyse and be critical of their own ideas, yet may not be conducive to the generation of novel ideas employing concepts more remotely associated with the brief. Sessions designed to support the generation of initial ideas appear to be better served by a relaxed and non-competitive environment. It has been suggested that the extrinsic motivation of reward and competition reduces creativity because it encourages a goal-orientated mentality (Amabile 1996). In other words, it supports secondary process thinking at the expense of primary process thinking.

Research has already been referenced that throws doubt upon the inspirational value of examples that show how a design problem may be solved. In terms of our dual-state model, such stimulus is likely to encourage over-focusing and fixation if presented at an early generative stage in the pupils' designing. Stimulus material, on the hand, that broadens the attention of the pupils is more likely to support their creativity. Such stimulus would be less related to the brief and extensive in its breadth. When initial ideas have been generated, the introduction of examples helps illustrate issues for evaluation and also encourages a more focused and analytical mind set that supports self-evaluation. Similarly, such material can help in evaluating final outcomes.

6. SOME FURTHER IMPLICATIONS IN TERMS OF TEACHING STRATEGY

If the empirical research literature may be interpreted in terms of a dual-state model of creative cognition, then it may not be directing teachers to discard strategies that are extrinsically-motivating, competitive, self-evaluating or potentially fixating. Rather, it may be indicating the need to match different teaching approaches to different stages in the design process.

The dual-state model can also be used to understand more direct attempts to stimulate creative thinking and to devise new ones. In his technique of syntectics, Gordon (1961) used analogies as catalysts for creative thinking. For instance, when designing for food storage, he suggested it might be helpful to consider how this is done by various plants and animals. Such techniques might encourage the designer to broaden the focus of their attention, and attend more to primary process thinking. Indeed, a study by the author (Howard-Jones 1998) found that interrupting the idea generation of undergraduates with tasks involving completion of nonsense sentences improved their ideational productivity. This study led on to a strategy to support the generation of initial design ideas that was tested in the classroom for 6–7 year olds (Howard-Jones and Murray, *accepted*). At this early stage in the Design Process, it was judged that the children would benefit from a broadening of their attention to facilitate making contact with as many design ideas as possible. Although the generation of a larger number of initial ideas does not automatically guarantee a better final outcome, the relationship between creative quantity and quality is well known (Diehl & Stroebe 1987), with larger numbers of initial ideas increasing the likelihood of developing a more original final solution. To defocus the children's attention and encourage their idea generation, the children were asked to travel on a 'brain-train' – an imaginary train that stopped in different parts of their minds (their last holiday, their favourite TV show, their bedroom, etc.). With two minutes at each 'station', the pupils were asked to think up ideas at every stop. Children using this strategy generated considerably more original ideas than when simply asked for all the ideas they could think of.

Inevitably, if we are to accept a dual-state model, we must also accept a degree of approximation in choosing appropriate teaching strategies, since a creative generative leap of imagination or a carefully executed analysis can be helpful at quite unexpected moments. It is not always very easy to compartmentalise a particular work scheme into individual tasks that are either essentially generative or non-generative/analytical. Whereas an ill-defined problem with few constraints is clearly and essentially generative, some problems that must be solved by a designer require almost simultaneous generation and analytical consideration of a large number of constraints.

Additionally, individual differences amongst pupils need to be considered. Although the evidence suggests that the two mental states cannot exist simultaneously, a good designer should be able to freely move between them, alternately generating ideas and critically evaluating them. Some pupils may particularly benefit from exercises that explicitly encourage them to experience and practise changing their mode of attention in this way. As well as differing in their ability to move between the two states, pupils vary with respect to the degree of focus they naturally exhibit. Pupils who are very self-critical and spend a considerable amount of time analysing their own work may benefit more from strategies that broaden

their attention during generative procedures. Pupils who are full of novel ideas may benefit more from higher degrees of extrinsic motivation intended to encourage their general application and their attempts to be self-critical.

7. CONCLUSIONS

A dual state model of creative cognition has been proposed and its characteristics and implications summarised in Figure 2. It is proposed that individual tasks during the design process should first be identified as chiefly generative or non-generative processes, and teaching strategies should be adapted accordingly. The model implies that some types of teaching strategies are potentially both beneficial and detrimental upon the progress of the student depending upon when, during the design process, they are implemented.

Future efforts to apply creativity-fostering research (such as Cropley 1997) to Design education will need, when recommending techniques, to link these techniques to the specific stages and tasks of the design process. Additionally, the dual-state model draws attention to the need to take account of individual differences amongst pupils with respect to whether they are inclined to be focused and analytical in their thinking or less focused and more generative.

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Recent Major Publications:

Howard-Jones, P. A. & Martin, R. J.: in press for 2002, 'The Effect of Questioning on Concept Learning Within a Hypertext Environment', *Journal of Computer Assisted Learning* **18**(2).
Howard-Jones, P. A., Whybrow, J. & Summers, I. R.: in press for 2002, 'An Evaluation of an Electronic Simulation of Hearing-impairment in the Training of Mainstream Teachers', *European Journal of Special Needs Education* **17**(1).
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