Insights into the creativity process

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Thinking skills models of creativity

It is frequently argued that particular ways of thinking lead to creativity. Access to specific thinking skills allows the generation of creative outcomes. There are two aspects to these thinking skills; being able to think in particular ways and knowing the value of thinking in these ways, being able to decide when to think in these ways and to use the ways of thinking selectively. Sternberg, (1999c, 2000) attributes creativity not to what one knows in terms of domain knowledge, but how individuals decide how to use what they know. This view differs from the traditional notion of creativity as a fixed ability (Guilford, 1968; Sternberg, 1999a).

Some researchers believe that thinking skills that lead to creative outcomes are part of the normal process of human thought The processes that lead to creative products are a subset of those that individuals use in their daily thinking (Simon, 2001); there is not a unique set of 'creative thinking strategies'. Creative thinking and "ordinary" thinking are points along a continuum. Adjectives used to describe this type of thinking include "inspired," "intuitive," "imaginative," "genius". In both the sciences and in the arts the thinking is typical of regular problem-solving, seen in the behavior of experts, who may or may not be creative.

Metacognition is a central aspect of creativity in most theories including creative problem solving (Jausovec (1994) and Boyce, Van Tassel-Baska, Burruss, Sher, and Johnson (1997), Davidson and Sternberg (1998). It is a key aspect of planning (Feldhusen, 1995). High planning scores --> aware of the task-strategy relationship and monitors strategy success - two essential aspects of metacognition (Das, Naglieri, & Kirby, 1994).

Divergent thinking and creativity

Creativity is sometimes seen as synonymous with divergent thinking. Wallach (1976) argued against this; while divergent thinking test scores predicted indices of creative activity (Wallach & Wing, 1969) creative thinking may sometimes involve divergent thinking. Runco (1992) proposed that divergent thinking contributes to the potential for creative thought; divergent tests predict potential for creative performance; but divergent thinking performance is not a criteria of actual creativity.

The link between divergent thinking and the convergent thinking measured by traditional intelligence is complex. Divergent thinking test scores sometimes correlate moderately with various indices of traditional intelligence (Getzels & Jackson, 1962). The level of association depends on whether students see the creativity tasks as standard tests of intelligence and think convergently or as more open-ended tasks with permissive instructions that encouraged them to think in original and divergent ways and were not tests that would be graded (Wallach & Kogan, 1965). The findings suggest that traditional intelligence tasks measures do not indicate creative potential.

Divergent thinking test scores are sometimes better predictors of certain achievements in the natural environment than were measures of traditional intelligence (Wallach & Wing, 1969); traditional intelligencer predicted performance in school and divergent thinking predicted extracurricular achievement better. Not only is divergent thinking different from traditional intelligence, but it relates to performance in the natural environment. Divergent thinking not only predicts the quantity of activity and achievement in the natural environment but in certain domains, the quality of those achievements and activities (Runco, 1986)

Planning is a key aspect of creativity

A key aspect of creativity is planning how to solve novel tasks, creating a plan of action, evaluating and monitoring its effectiveness, revising or rejecting it as the task demands change, and managing the impulse to act without careful consideration (Naglieri and Das , 1997b, p. 2):

- Of eight cognitive styles the planner was positively correlated with creative productivity (Guastello, Shissler, Driscoll, and Hyde, 1998.
- both planning and improvisation were positively related to creativity (Baker-Sennett , 1995)
- more time spent planning and re-planning a project results in higher creativity (Redmund, Mumford & Teach (1993) .
- theory of creative cognition proposes a Geneplore model (Finke, Ward & Smith, 1992) and features two central cognitive processes that contribute to creativity; generative, in which an idea is initially created and exploratory, in which this idea is examined and interpreted in different ways; this involves the regulation phase of planning.
- a creativity-relevant skill in the componential theory of creativity shows the influence of planning (Amabile, 1983, 1996) and includes exploring new pathways, keeping response options open for as long as possible, and suspending judgment.
- metacognition is a link between creativity and planning ability and is a key aspect of it (Feldhusen, 1995). High planning scores --> aware of the task-strategy relationship and monitors strategy success - two essential aspects of metacognition (Das, Naglieri, & Kirby, 1994).

Creative thinking in science

Creative thinking in science indicates some of the ways of thinking that have led to creative outcomes. Creativity in science involves search combined with recognition of patterns, enabling the use of information stored with those patterns to select the next step to modify the drawing. Evidence for the thinking used. The processes for creative production are indicated in diaries, laboratory notebooks, experiments.

Generalisations re thinking are hard to make. Physicists view the physical world in different ways, which probably result from genetic rather than environmental factors:

Some have mental images which seem to be largely mathematical.	<------->	Some think in physical models, picturing what goes on prior to mathematical analysis

The differences can be manifested early in life.

mathematical thinker	pictorial thinkers
Freeman Dyson as a schoolboy, spent Christmas holiday happily solving differential calculus problems. Ten years later this mathematical fluency played a major creative role in resolving divergent concepts in the early development of modern quantum theory; He reconciled the equations of Schwinger and Tomonaga and the radically new diagrammatic schemes of Feynman and showed they were equivalent.	Faraday and Maxwell, founders of classical electrodynamics: • Faraday thought of empty space as filled with lines of magnetic force • Maxwell saw an analogy between these lines and the flow of liquids. He pictured space near electric currents as a liquid filled with swirling vortices separated by frictionless ball bearings to prevent them from interacting and dissipating. • Einstein invented the term "thought experiments," to describe his thinking about the theory of relativity, which showed how time and space are modified for moving observers. The mathematics in it initially was simple algebra.

Creative people in science
- think about the domain; examine, analyze, experiment with, and modify.
- build on the creativity of those who have gone before and their own previous creativity.
- think creatively in incremental steps; the increments can, in principle, be large, but, in fact, are almost always small when the process is looked at in sufficient detail.
- display surprises that their 'prepared eye' picks up

- have questions they attempt to test through experiment - at that point they may not have a theory of the phenomenon
- no theory to explain the idea; the discovery may be induced solely from the empirical evidence
- often integrate observations into a picture they gradually built
- develop the idea through many small incremental steps.
- surprise plays a large role: the surprise of a prepared mind scrutinizing a sequence of experimental phenomena until one is recognized that violates educated expectations.
- expert problem solving as a combination of highly selective search through an immense problem space, punctuated by recognitions of (often surprising) features in the phenomena that evoke stored information and turn the search in new directions.
- process of heuristic search of the problem space combined with recognition of familiar patterns.
- the processes of scientific discovery as a cooperation between pattern recognition and selective search.

Thinking actions

Some of the ways of thinking that have been associated with the creativity include the following;

- think consciously about a domain; experiment with, interpret, analyze, question and modify.

- identify aspects that 'don't fit', ides that don't match what is expected, that violates educated expectations; they are prepared to tolerate these and to ‘run’ with them.

- Think metacognitively about being creative; plan how to solve novel tasks, create a plan of action, evaluate and monitor its effectiveness, revise or reject it as the task demands change

- synthesise and integrate ideas, observations, feedback with what is known into a picture or theory they are gradually building; they are often aware they are building on the knowledge of others and their own previous creativity. integrate ideas in different ways; mental images, physical models (Hewish, 2001); "thought experiments,"

  think divergently the use of metaphor or analogy transfer meaning from one domain to another; steam engine and Velcro discovered in this way(Runco, 2001).

- at the point of the creativity, their thinking is not guided by an intact theory of the phenomenon; the discovery may be induced from the empirical evidence, may be based on intuitions

- generate possibilities or options from the picture or theory they are building; they have enquiry or questions they attempt to test through trialing, they may entertain several possibilities, evaluate each in turn and think in or search in new directions,

- associate "feelings" with the experience; there is "hot cognition," thinking that arouses empathy and may involve an aspect of surprise, rather than the "cold cognition" .

- think or act incrementally develop the idea through many small incremental steps.

- process of heuristic search of the problem space combined with recognition of familiar patterns; interaction between pattern recognition and selective search through a problem space, identifying possible patterns, links.

In summary, the act of being creative can be likened to Darwin's theory of evolution (Campbell, 1960: Simonton, 1999). Any creative outcome follows a gradual process that involves taking account of what is known, varying it in often unexpected and unusual ways to lead to novel outcomes. Along the way several unproductive paths may have been taken and new information sampled and selected. The information may have come from a range of unrelated sources. The outcome is trialed, evaluated and adapted.

Indeed, most of the major theories of science have followed this path (Runco, 1999);

- Freud borrowed his model of the psyche from physiology;
- Piaget developed his model of knowledge development from biology and mathematical logic;
- Darwin developed his theory of biological evolution from geology.

The conditions most likely to lead to creativity

Most models of creativity we have already discussed identify the following conditions as necessary for creative outcomes:

- access to a body of knowledge that is relevant to the creative outcome This knowledge needs to be sufficiently extensive (that is, have sufficient breadth) elaborated and differentiated, and properly indexed and to be seen as expert (Simon, 2001). Newton, for example, attributed his creativity in part to "standing on the shoulders of giants." Pasteur noted that "Novel ideas come to the prepared mind."

- access to a set thinking skills that allow the generation of creative outcomes. There are two aspects to these thinking skills; being able to think in particular ways and knowing the value of thinking in these ways, being able to decide when to think in these ways and to use the ways of thinking selectively.

- the motivation to be creative.

- access to a supportive environment. Environments conducive to creative scientific research are characterised by (Hewish,2001):
  - freedom and encouragement to follow new leads spurred by one's curiosity,
  - lively interactions within the group to test out new ideas,
  - the courage to abandon fashionable theories and paradigms,
  - the provision of adequate resources for the necessary work.

How the nature of the task and the motivation to do it influences creativity.

Individuals in organisations such as schools can display creativity under different motivating conditions (Unsworth, 2001) :

- First, the reason for engaging in creative thinking (the driver behind the engagement) may be decided by the person themselves, or by others. Creativity can be initiated intrinsically by the person engaging in the creativity or by others, that is, extrinsically. In the latter case the person is thinking creatively to meet external or imposed demands.

- Second, the target or problem about which the person is thinking creatively may be open-ended or closed. Closed problems have known methods for solution, eg., classroom algebra problem (Getzels, 1975); students solve problems after being given the relevant equations. Open problems require thinkers to find, invent, or discover the problems (Dillon, 1982). They need to both scan the environment to find a problem and then define the problem in such a way that it can be solved.

These two dimensions yield four categories of creativity tasks, An example of each type is shown in the diagram below. As well, the name given to each type of creativity is provided.

		externally	internally
problem type	closed	Management want us to create a more efficient way for making chocolate ***Responsive Creativity***	We decide to create more efficient ways for making chocolate for management ***Expected Creativity***
	open	Management want us to find ways of making healthy types of chocolate ***Contributory creativity***	We want to discover way of making healthy chocolate for ourselves ***Proactive Creativity***

reason for engaging

Unsworth (2001) describes the characteristics of each type of creativity task. These are shown in the following diagram.

problem type			
	closed	***Responsive Creativity*** • most prevalent form of creativity studied. Individuals do a previously set creativity problem or task and complete it given the external demands and requirements • individual has the least control over problem solving choice	***Expected Creativity*** • external goal or outcome with a self-discovered solutions selected by the problem solvers. • example : students select from a set the particular problems / issues about which they will think creatively and contribute their responses
	open	***Contributory creativity*** • individuals self-determined and based upon a problem clearly formulated by others • individuals who elect to engage in creativity to help solve problems with which they are not directly involved	***Proactive Creativity*** • individuals think creatively about open ended issues and problems that interest them. • individuals spontaneously provide creative proposals that were not requested • difficult but important to assess • similar to Bateman and Crant's (1993) concept of a proactive personality and the concept of personal initiative
		externally	internally

reason for engaging

A key implication of this analysis for teaching creative thinking is that the types of creative thinking demanded for the four types of tasks differ in several ways:

- Creativity is more constrained when students are engaging in creative thinking for external reasons and are doing tasks or problems that are more closed (that is, ‘externally imposed’). Responsive creativity may be "less creative" than proactive creativity.

- Creativity will be stronger for those types requiring more effort (proactive and contributory creativity) than for those types requiring less effort (responsive and expected creativity).

- Evidence that the four types of creativity tasks measure different ways of thinking creatively is shown in the finding that responsive creativity, measured using Torrance's (1974) tests of creative motivation and other divergent tasks, does not correlate highly with expected creativity task scores (Davis, Peterson, & Farley, 1974) or with proactive creativity scores (Davis & Belcher, 1971; Guastello, Bzdawka, Guastello & Rieke, 1992; Oldham & Cummings, 1996). Teachers need to be aware that the four types of tasks measure different aspects of creativity.

- expected and proactive creativity involve more scanning and defining skill than responsive and contributory creativity. They are more affected by factors such as curiosity and training in identifying and framing problems.

- proactive and contributory creativity involve communicate one’s unique understanding, displaying one’s knowledge and to convince or persuade others of one’s thinking.

It should be noted that closed problems may not be fully closed and similarly with open problems; the open-closed dimension operates within limits or constraints. As well a particular task might represent different types of creativity, depending on the specific situational circumstances in which it is developed.

Unsworth, K. (2001). Unpacking creativity. *The Academy of Management Review,* 26, (2), 289-297.