# *Modelling Applied Creativity As a Cognitive Process: Theoretical Foundations*


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# Modelling Applied Creativity As a Cognitive Process: Theoretical Foundations

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This paper presents a model of applied creativity which identifies the cognitive processes involved, and shows how they are related. Previous concepts of cognition, intelligence and learning are integrated with a number of significant themes in creativity research, and their relationships to the proposed model are discussed. Knowledge apprehension and knowledge utilization are identified as two bi-polar dimensions of cognitive activity involved in creative thinking. These two dimensions form the basis for a dynamic model of applied creativity, which identifies four distinct and successive stages of the creative process called generation, conceptualization, optimization, and implementation. Examples of how the model has been applied in organizational settings are provided, explaining how and why the theory works. Implications are discussed.

Since Wallas (1926) presented his pioneering model of the creative process, psychologists and educators have increasingly debated the concept of creativity. In this article we present a simplifying theory of applied creativity which integrates elements from previous models of cognition, intelligence and learning that have addressed creativity. This theory shows the connections between a number of significant themes in creativity research including Osborn's (1953) model of applied imagination, Gordon's (1956) learning-inventing dichotomy, Guilford's Structure of Intellect (SOI) model (1967), Parnes, Noller and Biondi's "disciplined freedom" paradigm (1977), and Sternberg's concept of triarchic intelligence (1985; 1988).

We also illustrate the practical implications of this theoretical framework for enhancing creativity, and identifying limitations to creative thought, in organizations, and provide examples of how it has been applied in organizational settings. These examples show how applied creativity works in practice and also explains why it works.

## APPLIED CREATIVITY AS A PROCESS

Many researchers have considered creativity as a process. Most recognize that creativity requires more than the generation of a variety of ideas in response to a cue, and often does not begin with or depend on "given information." Guilford (1950) stressed

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the importance of "sensitivity to problems" in creativity and related it to our everyday notion of curiosity. Wakefield (1991) contrasted the type of thinking that deals with problems that are closed in terms of the problem definition but open in terms of the problem solution ("single open") with the type of thinking that involves the "double open" situation of first formulating a previously undefined problem and then generating alternative solutions. Others have emphasized that *discovering and defining* new important problems to solve ("problem finding") and *implementing* new solutions ("solution implementation") are equally as, or even more important than, creating the new solutions ("problem *solving*") (Ackoff, 1979; Getzels, 1975; Levitt, 1963; Leavitt, 1975; Livingston, 1971; Mackworth, 1965; Simon, 1960). Basadur (1979) and Basadur, Graen and Green (1982) provided empirical evidence that attitudes, behaviors and skills associated with problem finding were distinctly different from those associated with problem solving and that such attitudes, behaviors and skills can successfully be learned in appropriate training.

Kabanoff and Rossiter (1994) cited problem finding as one of the most vital and difficult frontiers for creativity researchers -- a "messy" concept that is hard to define and operationalize yet is a crucial element of creativity, especially real-world creativity in applied settings. Basadur, Ellspermann and Evans (1994) identified two separate components of problem finding activity. The first component is problem generation, which involves discovering new problems for subsequent definition. This is similar to what Simon (1977) called "opportunistic surveillance." The second component involves formulating a previously discovered but undefined problem. This second component is called problem formulation (or conceptualization, or definition). Edwin Land (1972) attributed his invention of the Polaroid camera to his unexpected finding of the problem (how to obtain instantaneous pictures), not its subsequent solution. He stated, "if you can define a problem, it can be solved". Albert Einstein is reputed to have said that given an hour to solve a problem to save the world, he would devote 55 minutes to defining the problem, and only 5 minutes to solving it.

As for the importance of solution implementation, one needs only to remember Edison's famous quotation: "genius is 1% inspiration and 99% perspiration". Similarly, Osborn (1953) once said, "a fair idea put into practice is better than a good idea left on the polishing wheel". The world is full of people who have great ideas but are unable to take them through to completion. How can an artist claim to have been creative without having drawn the picture? Indeed, a new industry has recently emerged made up of small consulting companies who specialize in helping larger organizations put ideas into practice and move projects through to completion because these organizations simply are not up to the task. Overcoming resistance to change and procrastination for implementation are identified as important parts of creative thinking by many, including Leavitt (1975) and Basadur et al (1982).

These viewpoints contrast sharply with research that confines creative thinking merely to generating ideas to presented problems using techniques such as "brainstorming." Such research dominated the literature from the 1950s into the 1980s (see review by Basadur, 1994). Practitioners who employ such limited conceptions of creative thinking seldom attain practical results (Sternberg, O'Hara & Lubart, 1997). More recent literature contains more complete conceptions of applied creativity (Basadur 1994, 1995; Kabanoff & Rossiter, 1994; Rickards, 1994). Such complete models include not only multiple stages (beyond simply solving presented problems) but other important individual, group and organizational variables affecting creative performance such as motivation, cohesiveness, environment, linkage to goals, and specific skills, behaviors and attitudes.

Kabanoff and Rossiter (1994) reviewed the growth of cognitive models of multi-stage creative thinking and problem solving processes. They credited Wallas (1926) with providing the first influential model to specify four main stages: preparation, incubation, illumination and verification. Later models include the Parnes, Noller and Biondi (1977) five-step process: fact finding, problem finding, idea finding, solution finding, and acceptance finding; Isaksen and Treffinger's (1985) model which added an extra step, "mess finding" to the beginning of Parnes et al's (1977) model; Amabile's (1988) five steps: presentation, preparation, generation, validation and assessment; and Basadur, Graen and Green's (1982) three phases across eight steps: problem finding, fact finding, and problem defining (Phase 1, problem formulation); idea finding, and idea evaluation and selection (Phase 2, solution formulation); and planning for implementation, gaining acceptance and taking action (Phase 3, solution implementation). All of these models represent a sequential flow through specific stages, phases or steps.

## A NEW THEORY OF APPLIED CREATIVITY

In this section, we introduce a theory of applied creativity consisting of four stages: Generating, Conceptualizing, Optimizing and Implementing. This four stage theory defines each stage in terms of two distinct cognitive processes: Apprehension, the acquisition of understanding or knowledge; and Utilization, the application of understanding or knowledge. We shall argue that two different modes of Apprehension and two different modes of Utilization lead to four cognitive orientations, which together delimit the conceptual space of creative activity. We suggest that the Apprehension and Utilization of knowledge can be viewed as two separate bipolar dimensions. If we plot these two dimensions at right angles, we obtain four types of creative activity (quadrants) each defined by a different combination of Apprehension and Utilization as illustrated in Figure 1. Each quadrant can be identified with a specific stage of the creativity process. Considered consecutively, these quadrants provide a comprehensive and temporally ordered description of the mental operations involved in real-world creativity and problem solving.

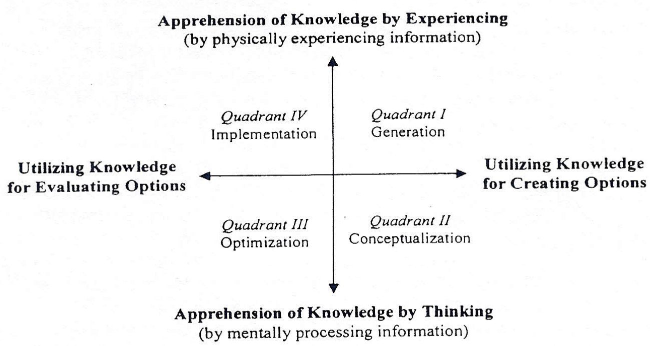



**Figure 1.** Four Combinations of Different Methods of Gaining and Using Understanding

## THE FOUR STAGES OF APPLIED CREATIVITY

The first two quadrants of Figure 1 represent the two components of problem finding: generation and conceptualization The third and fourth quadrants of Figure 1 represent problem solving (optimization) and solution implementation (implementation) as the final two stages of the creative process. Following is a brief description of the four quadrants integrating the concepts of the various researchers above.

**Quadrant 1: Generating** The first quadrant gets the creative process rolling. Creative activity in this quadrant involves gaining knowledge and understanding by physical contact and involvement in real world activities and utilizing this knowledge to create new problems, challenges, opportunities and projects that are potentially worth defining, undertaking through subsequent solving and implementing. Understanding is derived from what is experienced, including emotions and feelings of self and others through empathy. New possibilities are imagined from what is concretely experienced. Quadrant I activity thus consists of sensing, seeking or anticipating problems and opportunities, and is called generation. An outcome of this stage is a problem worthy of investigation but not yet clearly defined or understood. Edwin Land (1972), in a Life Magazine cover story told the tale of his invention of the Polaroid camera. Having snapped the last exposure on his film, he suggested to his three-year-old daughter that they take the film for processing so they could see the pictures in about a week's time. Her frustrated response was, "why do I have to wait a week to see my picture?" Like a flash bulb going off in his mind, her simple question sparked a challenge that had never occurred to him: "How to make a device that yields instantaneous pictures?" Within about an hour, he had formulated several directions toward a solution. And within about four years, he had commercialized a product that has changed our lives. Looking back, the then-chairman of Polaroid said the most important part of the process was not finding the solution itself – the camera – but finding the problem – how to get instantaneous pictures. If Land had not experienced the chance encounter he might never have created the problem to be solved. Land thus demonstrated the generation stage of the creative process – the initiating of problems to solve instead of waiting for problems to be provided. At Japan's electronics giant, Toshiba, most engineers and scientists beginning their careers in research and development actually start working in the sales department (Basadur, 1992). This apparently backward approach is designed to teach them the process of problem finding. Since these people will spend their working lives creating products to solve customers' problems, then what better start than by learning first-hand about their customers, their needs, their habits and their problems – both visible and hidden. At Nippondenso, a major auto parts supplier, employees are trained and encouraged from day one to find problems, to be discontented with their jobs. Employees write down their "discontents" and post them for co-workers to read. At Nippondenso and many other Japanese companies, this is actually the start of the creative process called the employee suggestion system. What's important is that the entire suggestion system hinges on problem finding.

**Quadrant II: Conceptualizing** The second quadrant, conceptualizing, keeps the creative process going. Creative activity in this quadrant involves gaining knowledge and understanding mentally, that is by working in the abstract – analyzing, pondering and theorizing about the information received to create a sound conceptualization or model of the problem domain. Understanding is not gained by direct experience, but instead by detached, abstract thinking. What is understood through rational, systematic analysis is turned into new insights that help define problems, and create theoretical models and ideas to explain things. Quadrant II activity consists of turning a problem recognized in Quadrant I into a well understood problem definition and some fledgling solution ideas and, thus, is called conceptualization. For example, the senior author was once asked for help by a Procter & Gamble product development team formed at short notice to respond to a competitor's new product. Colgate's green-striped Irish Spring had been the first striped soap bar introduced to North America. With its aggressive advertising campaign emphasizing "refreshment", Colgate's new product was finding ready consumer acceptance.

Procter & Gamble worked by the rule that, if a team (or person) were the second entrant into a new market it had to demonstrate a product's competitive advantage before it could carry out a market test. When asked what was going wrong, the team members said that they had been unable to produce a green-striped bar that worked better than Irish Spring in a consumer preference blind test. The team had experimented with several green-striped bars, all of which merely equaled Irish Spring in blind testing. It became evident that the team had chosen to define its problem as, "How might we make a green-striped bar that consumers will prefer over Irish Spring?"

During a creative problem solving meeting, one of the important activities was to develop alternative ways to define the challenge. The flash of inspiration came from an answer to a question posed from a consumer's point of view: "We want to make a bar that makes people feel more refreshed." This led to the new conceptualized challenge: "How might we better connote refreshment in a soap bar?" This less restrictive conceptualization, which included no mention of green stripes, provided more room for creative solutions. The team broke this new problem into three separate components – "How might we better connote refreshment in appearance, shape and odor?" – a new conceptualization – and then focused their imaginations on ideas. Beginning with the product's appearance, the team members visualized scenes, images and situations that suggested refreshment. One pictured himself at the sea coast. Another imagined sitting on a beach and looking at a blue sky and white clouds. Later, when the team sat back to evaluate its many ideas, these two ideas were selected and combined. The result was the concept of a blue- and white-swirled bar with a unique odor and shape. The concept later achieved market success under the brand name Coast. By leaping prematurely into solutions, the team had wasted almost six months before coming up with a superior conceptualization.

**Quadrant III: Optimizing** The third quadrant moves the creative process further. Creative activity in this quadrant involves gaining knowledge and understanding mentally by working in the abstract – thoroughly analyzing a defined problem and utilizing this knowledge to develop and evaluate ideas and options and create an optimal, practical solution. What is understood through rational, systematic, and orderly analysis is used to mentally evaluate situations and options to convert abstract ideas into practical solutions and plans. Quadrant III activity is called Optimization. At this point, a good solution to an important, well-defined problem exists, but has not yet been implemented. For example, the newly defined concept of a refreshment bar in the example above still had to be converted into a practical solution. The team's engineering members created and evaluated several optional versions of the new appearance, odor and shape. The options were evaluated on several criteria including cost, feasibility and time to implement. A final optimal prototype was chosen and successfully tested with consumers, showing an exploitable competitive advantage over its competitor.

**Quadrant IV: Implementing** The fourth quadrant completes the creative process. Apprehension in this quadrant involves gaining knowledge and understanding by physical contact and involvement in the real world. Utilization consists of employing evaluation to convert this knowledge into implemented solutions that work and accomplish valuable results. What is experienced and felt is used to evaluate. Creative activity in this quadrant consists of gaining experience with new solutions, evaluating the outcomes, and making adjustments to successfully implement them. Thus this stage is called Implementation. For example, in the above refreshment bar example, the team was still not finished. Before the new soap formula could be sold, a patent problem in the machinery design had to be overcome. There were already no fewer than six worldwide patents restricting how blue and white soap pastes could be blended. The team had to find a machine design to make the new product without infringing on anybody else's technique.

The team assembled diverse points of view in a special group of engineers, technicians, lawyers and even a few people who were unfamiliar with this technology. Sketches and prototypes of the patented processes were displayed and examined until a breakthrough insight emerged. The equipment was adjusted and rebuilt repeatedly until the new product was produced satisfactorily for delivery for purchase. A full cycle of the creative process was now complete.

## TWO DIMENSIONS OF APPLIED CREATIVITY

The recognition of Apprehension and Utilization as distinct mental operations is apparent in the work of Osborn (1953), who pioneered the study of the deliberate development of creativity. Osborn modeled the brain as having four functions: absorb, retain, create, and judge. "Absorb" and "retain" involve the acquisition of knowledge: "create" and "judge" involve the application of knowledge (using imagination and judgment). Osborn advocated the deferral of judgment principle in which the "create" and "judge" functions are used independently, and also suggested that people learn a three-step process of creative problem solving, beginning with fact finding (Apprehension) followed by idea generation and idea evaluation (Utilization).

Others have also identified these two dimensions. Myers (1994) identified the bipolar judgment-perception (JP) scale, which represents the degree to which individuals prefer to perceive (Apprehension) or to evaluate and decide (Utilization). Guilford's (1967) three-dimensional SOI model can also be understood in terms of Apprehension and Utilization. Guilford maintained that the standard single "g"-factor or "IQ" approach to explaining and measuring "intelligence" is inadequate, partly because it ignores thinking skills related to creativity. Using factor analytic methods, Guilford identified 120 different kinds of intelligence based on combining five different mental operations, four different kinds of contents and six different kinds of products. The five operations were labelled: cognition, memory, divergent production, convergent production, and evaluation. Cognition was defined as "the immediate discovery, awareness, rediscovery or recognition of information in various forms; comprehension or understanding." Memory was defined as "the retention or storage, with some degree of availability, of information in the same form it was committed to storage and in response to the same cues in connection with which it was learned." Divergent production was defined as "the generation of information from given information where the emphasis is upon variety and quality of output from the same source." Convergent production was defined as "the generation of information from given information where the emphasis is upon achieving unique or conventionally accepted best outcomes and the given information (cue) often fully determines the response." Evaluation was defined as "reaching decisions or making judgments concerning criterion satisfaction of information."

**Guilford's Apprehension and Utilization Operations** Setting memory aside, one way of organizing the other four Guilford mental operations is that convergent production and cognition represent two contrasting methods of Apprehension and that divergent production and evaluation represent two contrasting methods of Utilization. First, let us consider two contrasting modes of Apprehension. Convergent production can be equated with Apprehension by rigorous thinking – "finding the answer" where "finding" is something more than mere retrieval and "the answer" suggests that the domain is so systematic, ordered, rational and deterministic that there are rules or principles for converging on the solution. Convergent production is the SOI ability that dominates formal education and is almost synonymous with curriculum assimilation (Meeker, 1969). However, the SOI operation called cognition represents a different method of Apprehension: more open; less restrictive; focused on pure knowledge acquisition by non-directed, non-deterministic, non-rational experiencing and absorption through the senses. According to Meeker (1969):

> "Cognition is perhaps the most obvious of all the SOI operations. ... In terms of the dynamics of learning it seems to be the primary process since every other activity presupposes perception and awareness of stimuli with the associated ability to discriminate or attend. Without registration there would seem to be no content for further processing."

Second, let us consider the two contrasting modes of Utilization in the SOI model. Divergent production is non-judgmental while evaluation is judgmental. The purpose of divergent production is to generate options, while the purpose of evaluation is to apply judgment and choose among options. Thus, divergent production and evaluation are polar-opposite operations of the SOI. The former operates on knowledge (information) non-judgmentally to create options focusing on increasing variety; the latter operates on knowledge judgmentally to choose among options, thus reducing variety.

**The Dual Nature of Apprehension** Thus, the Guilford SOI mental operations axis may be organized into two distinct bipolar dimensions. The first dimension, Apprehension, concerns acquiring knowledge or understanding in two different ways. One (cognition) is relatively more open, non-rational, experiential, non-analytical and divergent and the other (convergent production) is relatively closed, rational, theoretical, analytical and convergent. In a similar vein, Jung also differentiated between irrational and rational mental functions (Hyde & McGuinness, 1994). The former were called "sensation" and "intuition" and the latter "thinking" and "feeling."

In academia, many students are still primarily exposed to (and graded upon) the theoretical/analytical (convergent production) method of acquiring understanding and comprehension rather than the experiential, non-analytical (cognition) method. For example, SAT scores are used to admit students to many North American universities. GMAT scores are used for admission to most North American business schools. The scoring of both SAT and GMAT is performed mainly by computers. In contrast, some thinkers have placed primacy on learning by the experiencing/non-rational (cognition) method. For example, the educator Quine concluded that "a person can only understand the world empirically, that is, through his or her direct experience in it" (Lehmann-Haupt, 2000). The poet Keats once wrote "nothing is real until it is experienced."

The recognition of this dual nature of knowledge Apprehension is longstanding. The philosopher Kant divided cognition into two components: sensory and intellecttual (Hatfield 1998; Kant, 1798/1978). Sensory and intellectual representations of cognition are fundamentally different and were labeled "intuition" and "concept." Kant held that cognition requires both active elements (concepts) and passive elements (intuitions). Intuitions arise from sensations while concepts perform the active function of ordering intuitions. Descartes (1641/1984) separated sensory receptivity from intellectual judgment and stated that "the senses do not err because they do not judge." Thorndike (1931) distinguished between "learning by trial and error" and "learning by ideas," the former being characterized by association and the latter being characterized by analysis.

McTaggart (1997) further explored these two forms of acquiring understanding using Stake's (1978) presentation of differing viewpoints as follows. First, Stake quoted Francis Bacon as stating:

> "There are and can be only two ways of searching and discovering truth. The one flies from the senses and particulars to the most general axioms... this is now the fashion. The other derives axioms from the senses and particulars, rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all. This is the true way, but as yet untried."

Second, Stake quoted William Blake as offering an opposing view:

> "To generalize is to be an idiot. To particularize is the lone distinction of merit. General knowledges are those that idiots possess."

Stake brought the two viewpoints together as follows:

> "Generalization may not be all that despicable, but particularization does deserve praise. To know particulars fleetingly is to know next to nothing. What becomes useful understanding is a full and thorough knowledge of the particular, recognizing it also in new and foreign contexts. That knowledge is a form of generalization too, not scientific induction but *naturalistic generalization*, arrived at by recognizing the similarities of objects and issues in and out of context and by sensing the natural co variations of happenings. To generalize in this way is to be both intuittive and empirical and not idiotic."

Some educators advocate learning approaches that emphasize both ends of this bipolar spectrum of knowledge acquisition (e.g., Bruner, 1960, 1966; Flavell, 1963;

Harvey, Hunt & Shroeder, 1961). Kolb (1976) emphasized the importance of using experiential learning to complement theoretical learning.

Eisenhardt and Tabrizi (1995) investigated strategies for accelerating product development under uncertainty and distinguished between understanding through direct contact and through compressing already well understood system links. Similarly, Cheng and Van de Ven (1996) distinguished between learning from chaotic patterns of interaction and learning by analytical coupling of outcomes and consequences.

McGrath (2001) recommended a contingency approach to knowledge acquisition. At one contingency pole lies learning by discovery through enactment to create variety. This represents high "exploratory learning." At the opposite contingency pole is learning by directed search, a process of homing in and deepening initial insights. This represents low exploratory learning. The greater the need for coping with increasing complexity and rapid change, the greater the need for "exploratory learning" (Eisenhardt, 1998; McGrath, 2001). In highly novel situations, experimentation is necessary to create a variety of information that cannot be obtained in any other way, since no base of cause-and-effect understanding exists. Weick (1979) suggested that, before such an analytical understanding can exist, organizational members must first enact a base of knowledge. As more knowledge is enacted in this way, greater effort can be focused on developing increasingly systematized, codified, and well-understood procedures (Nelson & Winter, 1982). Guidebooks come to replace improvisation, roles and jobs become more clearly defined, and rules for "how we do things here" gradually replace trial and error. The overall gist of these writings on the contingency approach is to promote the ability to move along a continuum of knowledge acquisition ranging from experiential learning to learning by thinking according to changing situations.

In summary, there is ample support for the dual nature of acquiring knowledge and certainly for expanding this concept beyond the limits of acquiring knowledge only by theoretical/analytical (Convergent Production) means. Perhaps Thorndike's "trial and error learning," Guilford's "Cognition," and Descartes' "sensory receptivity" could be categorized as "learning by non-rational, non-analytical, physical processing of information," while Thorndike's "learning by ideas," Guilford's "convergent production," and Descartes' "intellectual judgment" could be categorized as "learning by rational, analytical, mental processing of information." What is suggested is a bipolar dimension. At one pole is acquiring understanding physically, by experiencing ("by just being there" to non-directively experience, absorb, and discover). At the other is acquiring understanding mentally, by thinking (analyzing and manipulating thoughts in one's mind to create explanations and theories).

**The Dual Nature of Utilization** The second dimension, Utilization, concerns applying such knowledge or understanding in two different ways – non-judgmentally creating new information to increase the variety of options (divergent production) and making judgments and reaching decisions about new information to reduce the variety of options (evaluation). The importance of including both divergent, non-judgmental thinking and convergent, judgmental thinking as aspects of creativity is well established in the literature. Farnham-Diggory (1972) suggested that both kinds of thinking are essential to creative performance. The balancing of the divergent production and evaluation operations of the SOI supports Osborn's early call for the separation of the imagination and evaluation functions of the brain. The "creativity equation", C = f(K x I x E), of Parnes, Noller and Biondi (1977) also emphasizes this balanced approach. According to this equation, creativity, (C) is a function of knowledge (K) and both imagination (I) and evaluation (E); the multiplication signs are intended to convey the notion that no creativity results if any of the elements K, I or E are absent. Thus creativity results when imagination is applied to knowledge (however acquired) to create new options, and then judgment is applied to the new options to select appropriate ones.

As documented above, there is also ample support from the literature for a second bipolar dimension of mental operations, that of the application of knowledge. This second dimension concerns applying understanding (however acquired) in two different ways – creating new information and options (as in divergent production) and judging new information and options (as in evaluation).

Osborn (1953) advocated "deferring judgment," which means separating the process of non-judgmentally *creating* options from the process of judgmentally *evaluating* options. Other researchers have also bipolarized option-producing and option-judging thinking processes (Joyner & Tunstall, 1970; Maier, 1967; Parnes, Noller & Biondi, 1977; Simon, 1960; Simon, Newell & Shaw, 1962). Basadur, Graen and Green (1982) identified a separated, sequenced two-step thinking process called "ideation-evaluation." They defined ideation as the generation of options without judgment and evaluation as the application of judgment to those options. During ideation, all judgmental, rational, convergent thinking is deliberately deferred in favor of non-judgmental, imaginative, divergent thinking. During evaluation, the reverse takes place. Basadur and Finkbeiner (1985) identified and created measures for attitudinal factors related to one's preferences for non-judgmental (diverging) and judgmental (evaluating) modes of knowledge Utilization.

Meeker (1969) emphasized the importance of distinguishing between "divergent production" with "creativity." In their review, Kabanoff and Rossiter (1994) credit Guilford with introducing the concept of divergent production, but emphasize research that positions the concept as only one element of applied creativity. Cooper (1993) and his colleagues have written extensively about the vital importance of evaluation skills in creating successful new products. Meeker (1969) suggested that the desire for adequate measures of creativity has prompted some to erroneously equate divergent production with creativity. According to Meeker, while the association may be close, a distinction between the two must be maintained. Divergent production should be considered as a necessary, but insufficient, condition for creative thinking. The worthwhile generation of information requires discipline and guidance. Meeker suggested that creativity includes flexibility, individuality, and an ability to break away from the conventional, but that it also includes evaluation to ensure quality, relevance, and discipline. Similarly, Jackson and Messick (1964) balanced "unusualness" with "appropriateness" as two opposing criteria for judging the creativity of a product.

**The Ambiguous Nature of Knowledge** It is important to point out here that much ambiguity exists over the nature of knowledge itself. There are also many different definitions of "learning," or how Apprehension happens.

Although we have discussed apprehending and utilizing knowledge in this article, we must acknowledge that there is no universally agreed-upon definition of "knowledge." For example, Schwab (1969) maintained that all of the social and behavioral sciences are marked by competing schools of thought and enquiry, and because each subject is so complex and intimidating, each school selects only the small fraction of the whole with which it can deal. This produces multiple, co-existing and incomplete theories as ways of understanding such "fields of knowledge." McTaggart (1997) suggested managers must build an understanding of how three different kinds of knowledge interact: distilled knowledge (theories), knowledge of the situation, and knowledge embedded in experience. Some researchers and practitioners emphasize distinctions between information, data, and knowledge (Akbar, in press). To Davis and Botkin (1994), information is the "meaningful conversion of an unorganized sludge of data." Strydom (1994) considered knowledge as the sum of information acquired, and Machlup (1984) described knowledge as the "stock of expertise" and described information as the "act of informing." Knowledge has been also positioned as the intervening variable between "mere information" and "relevant and purposeful information" (Drucker, 1998).

Knowledge has also been differentiated in terms of its private or collective nature, and its explicit and tacit forms. Organizational (collective) knowledge refers to the sharing and distribution of individual (private) knowledge among organizational members (Lam, 2000). Such collective knowledge is stored in the goods and services of an organization (Davis & Botkin, 1994) or in its rules, procedures, routines and shared norms (Lam, 2000). Explicit knowledge refers to hard, codified data (Nonaka, 1991), including an organization's routines, procedures, practices, know-how and conduct (Leroy & Ramanantsoa, 1997). Such knowledge is formal and structured (Kim, 1993), and can be aggregated at a single location and stored in objective forms (Lam, 2000). Tacit knowledge, on the other hand, refers to the highly subjective insights, intuitions and hunches (Nonaka, 1991), and the skills and experiences that a person accumulates over time (Leroy & Ramanantsoa, 1997). Tacit knowledge is personal (Chesbrough & Teece, 1996; Howells, 1996; Lall, 1985) and often is too specific and singular in nature (Leroy & Ramanantsoa, 1997) to be easily formalized or organized (Kim, 1993) or easily aggregated at a single location (Lam, 2000). The interest in tacit knowledge dates back to Polyani's (1962; 1966) consideration of all knowledge as either being tacit or rooted in the tacit component. Over the years, such knowledge is recognized as playing a significant role in sustaining a firm's competetiveness (Winter, 1987), technological innovation (Howells, 1996), and overall success (Nonaka, 1991).

Some have modeled knowledge as a process. Nonaka (1994) suggested that knowledge is a dynamic process of "justifying personal belief" as part of an aspiration for truth (rather than an absolute, static and non-human end state that is equated with "truth" in traditional epistemology). According to Lam (2000) and Nonaka and Takeuchi (1995), new knowledge is created through dynamic interactions between explicit and tacit knowledge. Others have offered the following views. The transformation of explicit knowledge can be achieved through practice, repetition, reinforcement, imitation and socialization (Leroy & Ramanantsoa, 1997). The transformation of tacit knowledge is more problematic because it is difficult to codify (Leroy & Ramanantsoa, 1997). Such knowledge is transmitted through experience and trial-and-error (Leroy & Ramanantsoa, 1997); "learning by doing" and practical experience in the relevant context (Lam, 2000); observation, imitation and practice (Nonaka, 1991); or the process of immersion (Baumard, 1999). Critical to this acquisition is the active involvement of the individual in the "context" (Nonaka, 1994) and a close interaction among the knowing subjects (Lam, 2000).

Other approaches to defining knowledge include concepts such as "single loop vs double loop learning" and behaviourism vs cognitivism. Argyris (1976; 1977) suggested that true learning organizations go beyond understanding the "what" and the "how" (single loop) to understanding the "why" (double loop). Debate has gone on for decades between theories of organizational learning that split along behaviourism and cognitivism lines. The latter school insists on the importance of the individual's internal cognitive and affective uniqueness in mediating learning while behaviourism insists on considering only external variables based on observable experience.

"Organizational learning" has been defined as the process of detecting and correcting errors (Argyris, 1977), gaining experience (Dibella, Nevis & Gould, 1996), improving actions (Fiol & Lyles; 1985), the acquisition and development of cognitive and behavioural skills (Leroy & Ramanantsoa, 1997), and knowledge about action-outcome relationships and the external effects on these relationships (Shrivastava, 1983). These definitions are usually used in terms of improved performance or action as the objectives of "organizational learning."

For our present purposes we equate knowledge with understanding and comprehension. We have also chosen to define learning as "acquiring knowledge, understanding or comprehension," or "Apprehension", and we distinguish this from Utilization, which we have defined as the application of knowledge, understanding or comprehension, however acquired.

## INTEGRATING FOUR INFLUENTIAL THEORIES OF CREATIVITY – AND UNCOVERING EXPERIENTIAL INTELLIGENCE

In this section, we show that the two modes of Apprehension and the two modes of Utilization discussed above provide a unifying conceptual framework within which four major theories of creative thinking (Sternberg, 1996; Guilford, 1967; Parnes et al., 1977; Osborn, 1963) can be understood. When discussed in terms of Apprehension and Utilization, similarities between these four theories, and missing mental operations in them, become evident.

Sternberg (1996) suggested that "successful intelligence" requires a combining of three different kinds of "intelligences": "theoretical (or analytical) intelligence"; "creative intelligence"; and "practical intelligence." "Theoretical intelligence" represents "academic knowledge," which we acquire in school under highly structured conditions. It is what we use to analyze, compare and select. It is what we need to score well on IQ tests, which in turn are used to measure likelihood of success in school. This theoretical (analytical) intelligence is virtually identical to Guilford's (1967) concept of convergent production and represents a form of understanding that is not acquired through concrete experience, but is based on one's ability to process abstract concepts and develop "correct" conclusions. It is also similar to Jung's mental function of "thinking." The thinking "type" is one who prefers to "think things out," or come to conclusions based on logic, order and rationality (Fordham, 1953).

"Practical intelligence" is the ability to apply knowledge acquired in school and in real-world contexts to new or different contexts. Practical intelligence permits one to judge and decide wisely among different "dispositions to act," and is akin to "common sense." It is primarily learned not in school but by "being there," or by real-world experience.

"Creative intelligence" is the ability to produce ideas and is best expressed in unstructured, unconstrained situations. Creative intelligence is used for designing and making. It requires using past experience as the knowledge base to both cope with novel situations effectively and to optimally use one's time and efforts to handle re-curing situations efficiently, thus permitting one to move on to more productive pursuits. Sternberg suggests that such creative intelligence can be learned. For example, students can acquire creative intelligence by observing and emulating teachers who model appropriate behaviors, such as questioning standards, risk-taking and allowing for mistakes.

This suggests that a fourth kind of "intelligence" may be buried inside Sternberg's practical and creative intelligences. In Sternberg's descriptions, "practical intelligence" and "creative intelligence" both recognize <u>using</u> a kind of knowledge that is acquired in a different way from the theoretical or academic knowledge acquired in school. This is knowledge gained by experiencing the world around us, or by "being there." This is the knowledge Guilford calls cognition: the non-judgmental absorption of sensory experience simply for the sake of understanding (Meeker, 1969). Similarly, Jung (Fordham, 1953) defines the sensation function of the psyche as taking everything as it comes: experiencing things as they are without valuation. What counts is the strength and pleasure of the sensation. "Practical intelligence" and "creative intelligence" include the application of two distinct kinds of knowledge: theoretical/analytical/academic, and real-world experience/being there. Creative intelligence uses both kinds of knowledge to create new options. Practical intelligence uses both kinds of knowledge to evaluate options wisely. Sternberg has not labeled this latter form of knowledge, which is in effect "<u>experiential intelligence</u>." This hidden fourth kind of intelligence represents real-world knowledge that we acquire by experiencing, by "being there," by physically encountering unstructured situations and unanticipated stimuli. For example, Mintzberg (1989) related how Japan's Honda Corp. stumbled across an opportunity for its small scooter in North America. The company had sent four marketing managers to Los Angeles to establish the market for Honda's new giant "macho" motorcycles. To reduce taxi costs, the four managers rode errands around the city on Honda's small scooters. (Honda headquarters had assumed there would be little market for such a small vehicle on the open roads of North America.) The scooters attracted attention, something that did not escape the notice of the managers. Rather than decide that no market existed for the large motorcycle (evaluational thinking), they used divergent thinking to pursue their newly discovered opportunity. Their real mission, in retrospect, had been to learn whether they could sell something – anything – in North America. Rather than attempt to cover every base early, the company resisted the lure of over-rationality and came to America prepared to learn by doing, rather than remain in Tokyo using second-hand information residing in their computers or gathering answers to pre-determined questions by telephone or questionnaire.

Stated another way, the "K" in Parnes et al.'s equation above (C=f(K x I x E)) is only partly represented by Sternberg's theoretical/analytical intelligence. What is apparently missing is the part that is acquired by experiencing – outside of the classroom, as it were – by simply "being there," being involved in real life: absorbing, sensing and developing a kind of understanding or comprehension that is more <u>tacit</u> and less <u>explicit</u>. It is non-directed, non-analytical and non-judgmental (that is, Guilford's "cognition" and Jung's "sensation"). In contrast, theoretical/analytical understanding or comprehension is developed by remaining detached and producing quantifiable decisions in more structured situations (Guilford's "convergent production" and Jung's "thinking"). Sternberg appears to bury the concept of "experiential intelligence" partly inside the concept of practical intelligence and partly inside the concept of creative intelligence. However, these practical and creative intelligences are primarily methods of explaining different applications of knowledge, not its acquisition. Practical intelligence is primarily the application of knowledge in judging and deciding among options, and creative intelligence is primarily the application of knowledge in the production of options. Some knowledge can be discovered only by first-hand experience of new and unexpected things. When such knowledge is utilized for creating options, new opportunities are discovered.

Thus, if we extract the experiencing ("being there") component of knowledge acquisition from both concepts of (primarily) knowledge application, and then use that component to expand the theoretical/analytical thinking component of knowledge acquisition, we can make Parnes et al's equation more explicit and more in parallel with Sternberg's model.

The same can be done for Guilford's SOI model above, which already has expanded the concept of acquiring knowledge beyond just theoretical/analytical comprehendsion. Guilford's concept of cognition emphasizes experiential comprehension, or the open-ended absorption of experience by just "being there." Guilford's convergent production concept, which represents the opposite way of comprehending, is virtually identical to the knowledge acquisition component of Sternberg's theoretical/analytical intelligence concept. Recall that Guilford's memory operation refers to the storage of knowledge (no matter how acquired.). Guilford's other two operations involve not the acquisition or storage of knowledge but the application of knowledge. Guilford's divergent production (of options) and evaluation (of options) are similar respectively to the application of knowledge components within Sternberg's creative and practical intelligences.

Furthermore, adding knowledge acquisition by experiencing (cognition) to knowledge acquisition by thinking (convergent production) produces a more complete match of Guilford's approach with the Osborn (1963) and Parnes et al (1977) models. Table 1 shows how the models of Sternberg, Guilford, Parnes et al. and Osborn fit together using the Apprehension and Utilization framework.

## CREATIVITY AS A CIRCULAR PROCESS

Gordon (1956, 1971) also recognized that Apprehension ("learning") and Utilization (for "inventing") represent two different modes of thinking. Learning was characterized as a mental process of *making new* connections (thus making the strange familiar), while invention was characterized as a mental process of *breaking old* connections (thus making the familiar strange). These separate processes of knowledge acquisition (learning) and knowledge application (for inventing) flow continuously into one another in sequence. Field research by Carlsson, Keane and Martin (1976) supported Gordon's approach by showing that the research and development (R&D) process in organizations follows a continuous, circular flow of creating new knowledge to replace old knowledge.

Based on extensive field research and practical experience within business organizations consistent with Gordon's theory and Carlsson, Keane, and Martin's empirical

**Table 1**

*Fitting the Osborn, Guilford, Parnes, Noller and Biondi, and Sternberg Models Together Using the Apprehension and Utilization Framework*

| Theory/ Model | Component | Apprehension of Knowledge by | | Utilization of Knowledge for | |
|---|---|---|---|---|---|
| | | Experiencing | Thinking | Creating Options | Evaluating Options |
| Osborn | Absorb | ✓ | ✓ | | |
| | Create | | | ✓ | |
| | Judge | | | | ✓ |
| Guilford | Convergent Production | | ✓ | | |
| | Cognition | ✓ | | | |
| | Divergent Production | | | ✓ | |
| | Evaluation | | | | ✓ |
| Parnes, Noller & Biondi | Knowledge | ✓ | ✓ | | |
| | Imagination | | | ✓ | |
| | Evaluation | | | | ✓ |
| Sternberg | Theoretical/Analytical Intelligence | | ✓ | | |
| | Experiential Intelligence[a] | ✓ | | | |
| | Creative intelligence | ✓ | ✓ | ✓ | |
| | Practical Intelligence | ✓ | ✓ | | ✓ |

[a] New

evidence, Basadur (1974; 1979; 1981; 1983) introduced the concept of the creative process as a circular ongoing cycle. Here the different stages of the creative process are arranged in a circle, recognizing that as new problems are sought, discovered and defined, and new solutions subsequently developed, optimized and implemented, new problems and opportunities arise. For example, the automobile's invention provided not only a new solution to an old problem (improving transportation) but created many brand-new problems (e.g., pollution, energy and accidents). This circular process, which emphasizes continuous creativity beginning with problem finding, reflects Mott's (1972) research which showed that effective organizations synchronize two vital but very different characteristics: efficiency and adaptability. Efficiency means mastery of routine (standard, prescribed methods by which the organization carries out its main tasks). Efficiency involves optimizing and implementing current products and methods to attain the highest quantity and quality for the lowest possible cost. On the other hand, adaptability means mastery of deliberate change and disrupttion of routine for innovation. Adaptability means continually and intentionally changing routines and finding new products and methods. Adaptability includes scanning the external environment to anticipate new opportunities and problems (opportunistic surveillance (Simon, 1977)) and developing and implementing new solutions which then disrupt the environment.

This concept of adaptability is virtually synonymous with the four stage creativity process of Figure 1. For example, adaptability begins with generation and conceptuallization. Generation focuses on proactively seeking out such new problems to define and solve. Conceptualization means insightfully defining such newly discovered problems and forming ideas on how to solve the challenges so defined. Adaptability also requires creating optimal solutions (optimization) and taking action on solutions (implementation). Thus adaptability may be represented as a continuous four-stage process of creativity as shown in Figure 2.

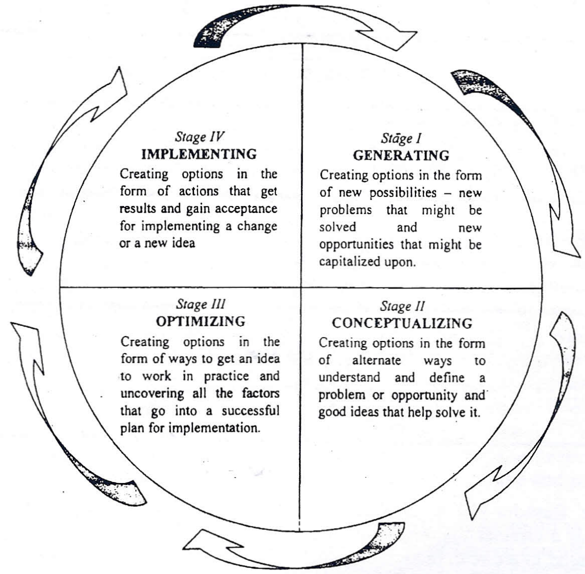



**Figure 2.** The Four Stages of the Creative Process.

## STATES NOT TRAITS, AND ALL FOUR STAGES ARE CREATIVE

No one stage is considered any more "creative" than any other. All four stages require creativity of different kinds. Each stage contributes uniquely to the overall innovative process and innovative results. Most people enjoy some stages more than others. An individual's particular *style* reflects their relative preference for each of the stages of the process: generating, conceptualizing, optimizing, and implementing. A person's thinking processes cannot be pigeonholed in any single stage. Rather, they are a combination or blend of stages. A person will likely prefer one stage in particular, but also have secondary preferences for one or two adjacent stages. Skills are needed in *all* stages.

Everyone has a different valuable creative contribution to make to the innovation process as a whole. One goal is to capitalize on an individual's preferred orientation, thus making their work more satisfying and pinpointing development opportunities. Another goal is to tap resources in all four stages to help the individual, team, or organization cycle skilfully through the complete innovation process.

## ORGANIZATIONS HAVE THEIR OWN STYLES

Just as individuals have different styles so do organizations. An organization's style influences, and is influenced by, such factors as the kinds of people it hires, its culture, and its values. For example, if an organization focuses almost entirely on short-term results, it may be overloaded with implementers with few conceptualizers or generators. The organization will show strengths in processes that deliver its current products and services efficiently. But it will show weaknesses in long-term planning and product development that might help it to stay ahead of change. Rushing to solve problems, this organization will continually find itself reworking failed solutions without pausing to conduct adequate fact finding and problem definition By contrast, an organization with many generators or conceptualizers and few implementers will continually find good problems to solve and great ideas for products and processes to develop. But it will never carry them to their conclusion.

Following are a case study and additional real-world examples of how organizations may apply the theory presented in this article to diagnose problems and improve creativity and innovation performance.

## REAL-WORLD APPLICATIONS OF THE THEORY

**A Case Study** By 1981, an automobile manufacturer had suffered several losing business quarters. In an effort to change its operations, the company had launched many initiatives. One of the most important was its decision to involve its people in improving quality and customer satisfaction and increasing innovation. The company wished to involve managers in actually "managing the business" rather than just "doing my job."

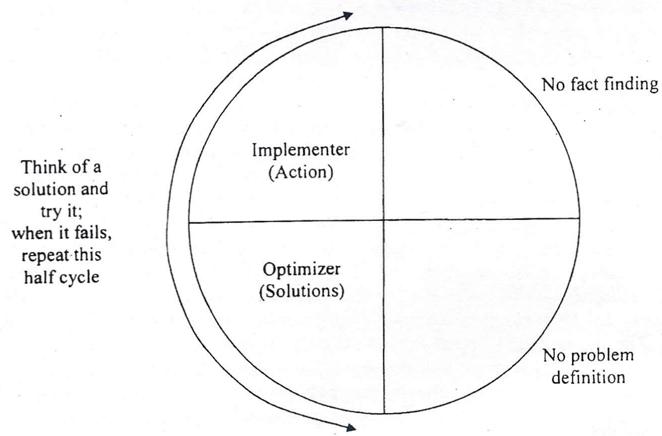
The company and its union had agreed to implement a joint employee involvement (EI) program for unionized employees. Both sides provided resources, including both unionized and salaried employees, to diagnose important training needs and to create strategies and programs to meet those needs. Their first step was to form problem solving groups in the plants, guided by local and national joint steering committees. To build skills in problem solving, these groups had been taught standard analytical tools borrowed from statistical process control and total quality management programs (such as "cause-and-effect diagramming" and "cause-unknown diagnosis").

The company now wished to expand employee involvement to include salaried employees, and to develop problem solving processes that were better suited for their jobs. The organization hoped that these employees and their managers would take more initiative in identifying opportunities for improvement and tackling them creatively. During a preconsult and preliminary training workshop for several key employees, we agreed on a strategy to train a number of employees in applying the creative process and in training others in the company.

During this training, we had a chance to apply the process to a problem at a newly modernized plant that made a major component of the company's new front-wheel-drive automobiles. The plant was setting new records for quality and low cost, but one department was struggling. Only about one-third of its output met the company's high quality standards, and employees had to work heavy overtime schedules in order to keep up with orders. The plant managers had tried several quick-fix solutions to resolve the production and quality problems, but none had worked. We established a cross-functional team of 15 plant managers and supervisors in order to apply the Simplex Creative Problem Solving process to the problem.

Along with one of the company's internal consultants who was training as a Simplex facilitator and trainer, the senior author conducted the application session with this team. About half a day was set aside for training in the Simplex process and process skills, and two and a half days to apply the process to the team's fuzzy situation. During the training, the team members were asked to complete an instrument which measures and identifies individual differences in preferences for various stages of the creative problem solving process called the CPSP.

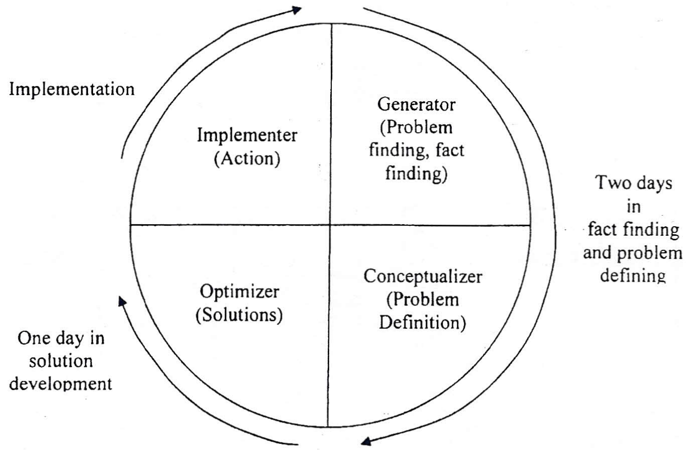
The team discovered a very revealing insight. Of the 15 team members, eight showed creative problem solving styles heavily oriented toward stage 4, or implementation. The other seven showed styles heavily oriented toward stage 3, or optimization. None had creative problem solving styles oriented toward stages 1 or 2 (generation and conceptualizing). The team was composed of people who preferred to jump quickly to action rather than carry out fact finding and problem definition. Team members were able to identify many instances when they had mistakenly made assumptions about this particular problem, leading to one failed solution after another. Rather than take the time to define the problem accurately, they had simply jumped from the fuzzy situation to one solution after another. They had spent all of their time alternating between stages 3 and 4, and none in stages 1 or 2 (Figure 3).




*Only half of the creative process used*

**Figure 3.** The Results of Heavy Orientation Toward Stage 3 and 4 Thinking Styles

These solution- and action-oriented individuals agreed to spend two days in stage 1 and 2 activity, gathering facts and defining problems (Figure 4)—even though the whole exercise was against their nature. Three specific problem definitions emerged from this exercise. On the third day, the group was able to create simple but specific



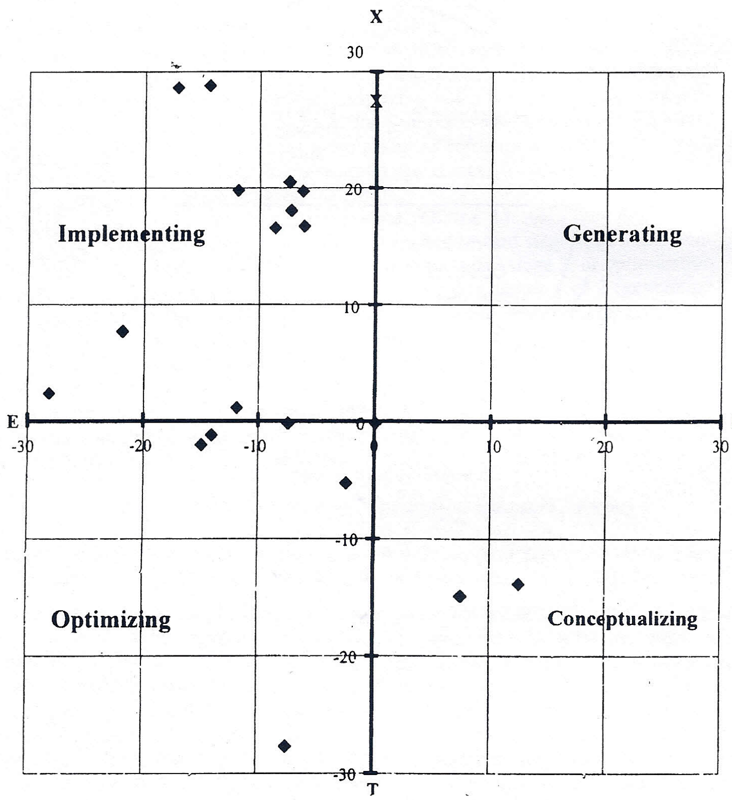

*The entire creative process used.*

**Figure 4.** Balancing Orientations Toward All Four Thinking Styles

solutions to each defined problem that it could quickly implement. Within several months, most of the plant's production was high quality and was still improving.

**Additional Examples** On the following pages are four examples of scatter diagrams, which depict the array of preferences for each of the four stages of the creative process for individuals within a team or organization. Each ◆ symbol represents an individual's pair of coordinates derived from their score on the vertical apprehension axis (XT) coupled with their corresponding score on the horizontal utilization axis (IE). The first scatter diagram displays the preferences of a typical group of managers in a large engineering company servicing the aircraft, airline, and aero-space industries (Figure 5). Most middle and senior managers in the company are strongly oriented toward action rather than toward generating new opportunities. The company has established high growth targets into new products and markets, but is failing to achieve them because of a strong organizational culture that favors quick fixes to short-term problems. To improve its short- and long-term balance, the company is developing a major training effort to increase awareness and encourage more generation and is also creating structures that will encourage employees to participate more in stages 1 and 2 activities.

In the second example, a large bank had formed teams to bring many new financial products to market quickly in a very competitive environment, but those teams were encountering a high percentage of failures. The organization's teams were found to be heavily weighted toward implementers (Figure 6). Further discussion showed that the teams often developed new products by rushing from an initial idea directly into implementation, without spending much time in conceptualization and optimization. Had the teams taken more time for conceptualization, they likely would have identi-



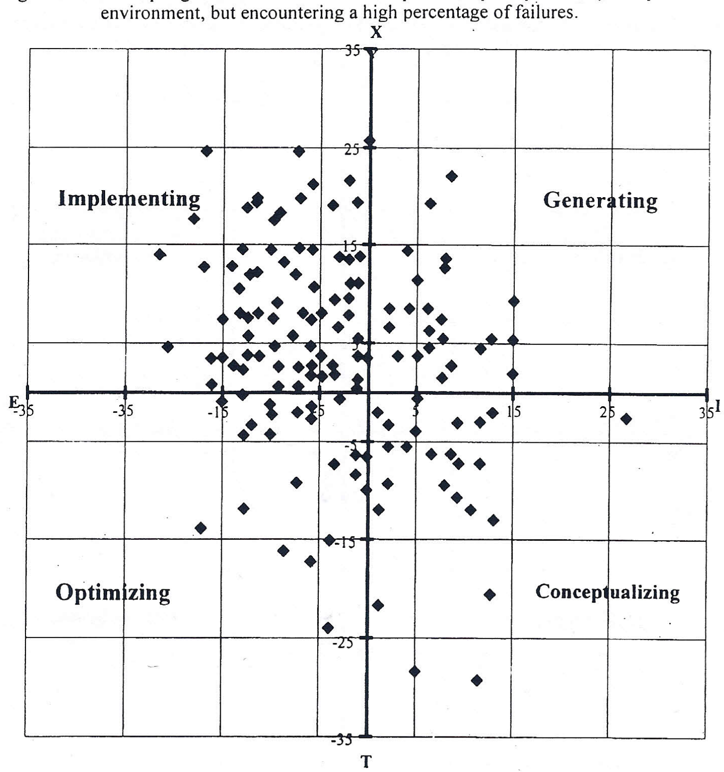

**Note:** Each ◆ represents an individual's pair of coordinates derived from their score on the vertical apprehension axis (XT) coupled with their corresponding score on the horizontal utilization axis (IE)

**Figure 5.** Scatter Diagram Example #1: Not Enough Generators

fied more limitations in many new product ideas. With more time in optimization, they would have reduced the frequency of product flaws reaching the market. By taking more time through these second and third stages of the process, the teams began to make wiser choices about which new, fledgling ideas to pursue (and which to terminate) and to develop more reliable product designs for market testing.

In the third example, a new managing director was hired specifically to develop a breakthrough product concept and bring it to market. He assembled a team that, in very little time, created a great new idea. However, the team had subsequently ground

An organization attempting to establish new financial products quickly in a very competitive environment, but encountering a high percentage of failures.

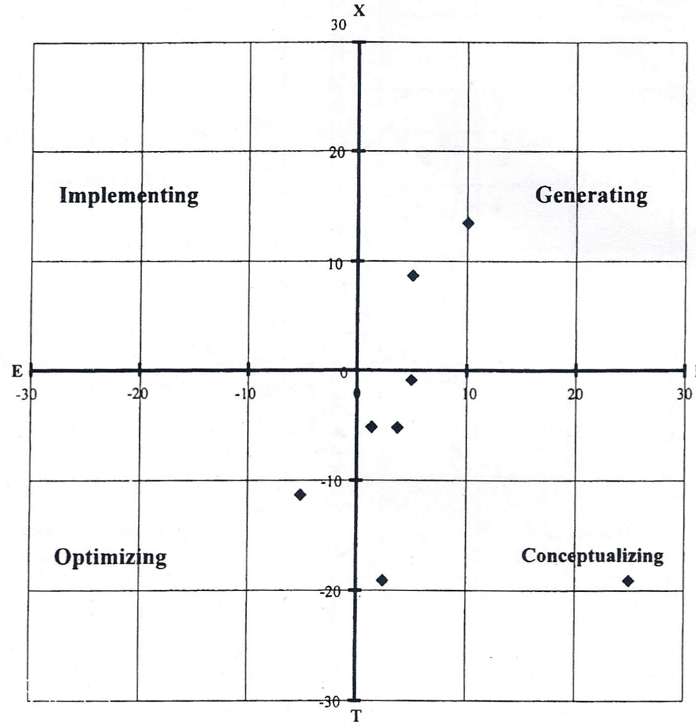



**Note:** Each ◆ represents an individual's pair of coordinates derived from their score on the vertical apprehension axis (XT) coupled with their corresponding score on the horizontal utilization axis (IE).

**Figure 6.** Scatter Diagram Example #2: Not Enough Time Devoted to Conceptualization and Optimization.

to a standstill. Members failed to attend meetings regularly and several felt that there was nothing important remaining to be done. Subsequent diagnosis found that all of the team members whom the managing director had intuitively selected were oriented toward stages 1 and 2. In Figure 7, the managing director is the lone individual in stage 3, and there is no one in stage 4, implementation. He now realized that the team needed to add people oriented toward stage 3 and especially 4 in order to implement the new product concept successfully.

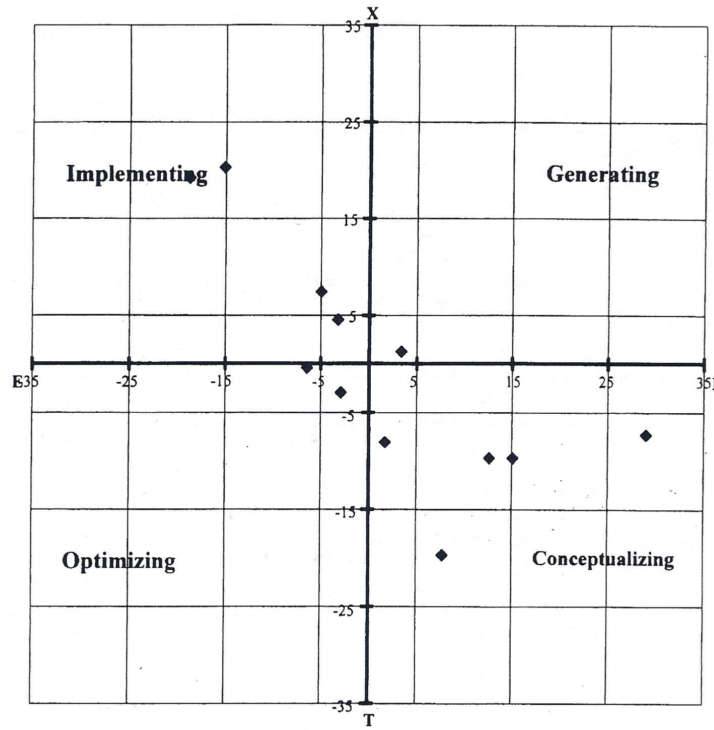
A special team of insiders and outsiders formed especially to find a new breakthrough product idea for an old traditional mid-size company, but now at a standstill.




**Note:** Each ◆ represents an individual's pair of coordinates derived from their score on the vertical apprehension axis (XT) coupled with their corresponding score on the horizontal utilization axis (IE).

**Figure 7.** Scatter Diagram Example #3: Not Enough Implementers

The fourth example comes from the management team of a small engineering company that was growing too quickly, allowing many human resource problems to pile up. The company had more business than it could handle: new engineering projects were being designed and implemented with customers all over the world. Left unidentified and ignored by the busy management team, the human resource problems left people feeling severely stressed, overworked, and underappreciated. Resulting high turnover and its deteriorating corporate reputation made it difficult for the company to hire replacements or new staff. As shown in Figure 8, the management team was unbalanced, being virtually devoid of generators or optimizers. Most members were implementers or conceptualizers, demonstrating little interest in either surfacing problems or solving them. As a first step toward ensuring that it identified and solved important people problems, the company hired its first human resources manager for this explicit purpose.




**Note:** Each ◆ represents an individual's pair of coordinates derived from their score on the vertical apprehension axis (XT) coupled with their corresponding score on the horizontal utilization axis (IE).

**Figure 8.** Scatter Diagram Example #4: An Imbalance: Not Enough Gnerators or Optimizers

## IMPROVING TEAM PERFORMANCE

In a creative organization, everyone is responsible for doing at least one of the four stages defined by Figure 2. Some people initiate new things. Some are responsible for understanding and defining new initiatives and planning. Some produce practical solutions to new problems and initiatives. Others are responsible for finishing things off, or taking action to implement new solutions. If the four-stage process of creativity outlined above adequately represents the creative process, it would be expected that teams with a heterogeneous mix of preferred creative process styles (Figure 1) would significantly outperform teams with a homogeneous mix of creative process styles in innovative work. In the former case, all stages of the process are readily available within the team. One could also predict that members of homogeneous teams would experience more satisfaction working with like-minded team mates.

The predictions were confirmed by a study by Basadur and Head (2001), which assessed groups of MBA students on a problem solving task. Groups consisting of individuals with different styles (heterogeneous groups) outperformed groups whose members all had the same style (homogeneous groups). Rated by a judges' panel on four dimensions of innovative performance, the mean score for the 21 heterogeneous groups was 4.22 (sd = 0.42) and the mean for the homogeneous groups was 3.69 (sd = 0.64); a statistically significant difference (Student's $t = 3.0$, $p < .01$). Asked about their teamwork experience, individuals in the heterogeneous groups expressed less satisfaction than those in the homogeneous groups. The mean overall satisfaction for the 57 participants in the heterogeneous groups was 7.50 (sd = 1.98) compared to 8.15 (sd = 1.32) for the 85 participants in the homogeneous groups; a statistically significant difference (Student's $t = 2.2$, $p < .05$).

Heterogeneity is often an inherent characteristic of cross-functional teams, as people in various occupations favor different creative process capture styles. For example, people in industrial engineering, training and development, and other improvement and change-initiation departments often favor the generator style. Employees in market research, strategic planning, and R&D often favor conceptualizing. People in accounting, finance, engineering, and systems development gravitate toward optimizing. People in manufacturing production, logistics/distribution/warehousing, sales, administrative support, customer service, and operations favour implementation. No matter which process style an individual prefers, however, a team's members have to learn to use their differences to advantage. Teams, especially those involved in continuous improvement and innovation, require a mix of people who enjoy working in different steps around the Creative Problem Solving process: finding new problems and opportunities, clarifying and refining those problems and creating ideas, developing practical solutions and plans, and making new solutions work. Whether in teams or not, helping individuals learn to shift among orientations also ensures that the entire organization has a complete blend of process styles. In fact, an individual's dominant orientation is less important than their ability to shift among the different orientations. Preferences for certain stages within the innovation process are not static "traits," but dynamic "states." Individuals can learn to work in any of the four creative problem solving stages in order to complement others in a given situation.

## CONCLUSIONS

Theorizing about creativity in psychology has until now been characterized by a proliferation of models and a diversity of construct definitions. A central problem for creativity researchers has been how to distinguish between the merits of these various conceptions. Although scientific diversity is laudable, the accumulation of evidence and understanding can be hindered considerably when different theories each use their own language, and scientific progress in this area seems to have been limited by, amongst other things, our inability to test competing theories of creativity against each other. What is now needed is a recognition that many features of these alternative theories are in fact redundant with each other, and that many of the apparent differences between them are simply differences of nomenclature.

The present paper has sought to address this issue by identifying four basic underlying mental operations (two modes of knowledge Apprehension and two modes of knowledge Utilization) and showing that several of the most influential theories of creativity can be successfully discussed in terms of these operations. We further suggest that these four operations provide a sound basis for a dynamic model of the creative process that adequately describes the stages of creative problem discovery, definition and solution, and solution implementation, and that has practical relevance for the process of creative problem solving and innovation in organizations.

This work is far from complete. In particular, the primacy of these four operations would be greatly strengthened by demonstrating that they are mental dispositions that either persist over time or change in predictable ways; that they may be identified in multiple cultural or ethnic groups irrespective of language; and that they may be demonstrated to have either a biological or a developmental basis.

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