Introduction

> Every child is an artist. The problem is how to remain an artist once he grows up.
>
> – *Pablo Picasso*

Picasso is only one of many who have recognized that the transformation from a child into an adult entails losses as well as gains. Children may become both more able and, in some ways at least, less able as a part of normal development. This perspective is not limited to modern times or even to the Western cultural tradition. In a very different time and place, Chuang Tzu observed that in leaving childhood we "forget our way home" (quoted in Egan, 2002, p. 112), suggesting that in taking on more adult ways of thinking we lose the imaginative freedom we had as children. Does the development of knowledge and analytic thinking take a toll on creativity? Or can reason and rhyme coexist and be mutually beneficial?

The idea that knowledge, reason, and creativity are somehow at odds is hardly an uncommon notion, nor is it confined to the arts. Spontaneity and freedom from constraint, which characterize the thinking of children, may be essential to creativity; yet we know from both research and common sense that effort, practice, and study are also necessary for the highest levels of creative accomplishment (Hayes, 1989; Kaufman & Baer, 2002; Weisberg, 1999). The relationship of creativity to domain-based skills and knowledge is no doubt complex, and some have even gone so far as to argue that too much education and training can have a negative impact on creativity (James, 1908; Simonton, 1984; Weisberg, 1995). Minsky (1997), for example, theorized that a great deal of our knowledge is geared toward avoiding negative experiences – and yet it is these very negative experiences that may result in creative production. Yet, conversely, without adequate studying and training, a creative person runs the risk of being like the brilliant Indian mathematician Ramanujan, who made many original contributions but also unknowingly rediscovered many creative concepts

that had already been invented (Gardner, 1983; Sternberg, Kaufman, & Pretz, 2002).

As Csikszentmihalyi (1996) points out, there are many odd dichotomies present within creative people – the contrast between being outgoing and introverted, for example, or intelligence and naïveté. Perhaps the most striking dichotomy, however, is the clash between creative and analytical thinking. To be an accomplished creative individual, one needs to have appropriate knowledge and well-developed critical thinking skills, and yet one also needs to retain a naïve, spontaneous, and perhaps even childlike imagination. Imagination, skills, and knowledge are all essential to adult creativity.

To what extent do creativity and imagination decline in childhood, when students advance in their knowledge and learn reasoning skills? What factors might influence a decline? Theories of cognitive development typically show only unidirectional progress (although theorists may disagree whether such progress occurs steadily in small continuous improvements or comes in stages separated by plateaus during which developmental gains are consolidated). Declines in levels of skill, or even U-shaped developmental curves, are quite uncommon (Aldwin, 1995), yet many have observed just such an unusual pattern with regard to the development of creativity and of the imagination (e.g., Gardner, 1980).

Is there something about the development of one kind of thinking (such as the systematic, logical thinking whose growth and development Piaget and others have charted) that undermines imaginative and creative thinking (or that at least temporarily inhibits the expression of creative ideas)? Or is it perhaps the process of schooling itself, with its focus on the acquisition of knowledge and the production of correct (rather than imaginative) answers, that promotes this decline? The chapters that follow attempt to answer these important questions.

The first section, Cognitive Perspectives, starts off with two somewhat contrasting views, one by Weisberg that essentially equates domain expertise and creativity and a second by Simonton that argues for optimal levels of domain expertise, beyond which creativity tends to decrease (with optimal levels varying by domain). These are followed by several different approaches. Bristol and Viskontas use the latest in neurocognitive work to examine memory processes that underlie creativity. Pizarro, Detweiler-Bedell, and Bloom consider the creativity of moral reasoning, and Runco examines the kinds of reasoning needed for personal creativity and ways that kind of reasoning might differ from other kinds of reasoning skills. Mumford, Blair, and Marcy consider major knowledge systems and how they interact to produce creative thought. The next two chapters focus more specifically on knowledge and creativity; Feldhusen writes about the relationship of one's knowledge base to one's creativity, whereas Mayer discusses the kinds of knowledge required for creative mathematical problem

solving. Next, Fasko examines the relationship between creative thinking and reasoning in the work of both psychologists and philosophers, followed by TenHouten exploring the relationship between alexithymia and creativity. The Cognitive Perspectives section closes with a chapter by Keinänen, Sheridan, and Gardner that argues for a model of creativity focusing on two axes – horizontal versus vertical creativity and modular versus broad situational creativity – which can help explain the differing kinds of expertise required for different kinds of creativity.

The second section, Developmental and Educational Perspectives, starts off with a chapter in which Gelman and Gottfried have documented the very creative thinking of very young children and explained how this causes us to rethink some of our conceptions of creativity. This is followed by Rostan documenting the effects of advancing knowledge on the development of artistic talent and creativity in children. Guignard and Lubart explore connections between the development of reasoning and the development of creativity, and Niu, Zhang, and Yang examine the impact of culture on the development of these skills. Next, VanTassel-Baska writes about the need for teaching critical thinking in gifted education, focusing on its relationship with creativity. Beghetto and Plucker then argue that schools could, but unfortunately generally do not, facilitate the concomitant growth of knowledge and creativity. Finally, Paris, Edwards, Sheffield, Mutinsky, Olexa, Reilly, and Baer propose that creativity, reasoning skills, and knowledge all develop best in constructivist early childhood settings.

We conclude with a brief chapter of summations and (tentative) conclusions and thoughts for the future.

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COGNITIVE PERSPECTIVES

1

Expertise and Reason in Creative Thinking

Evidence from Case Studies and the Laboratory

Robert W. Weisberg

The thesis of this chapter is that knowledge and reason play an important role in creative thinking. I equate knowledge and *expertise* (e.g., Ericsson, 1996, 1998, 1999; Weisberg, 2005), the capacity to perform at a high level, acquired through practice (e.g., an expert pilot); or the possession of exceptional knowledge, acquired through study (e.g., an expert on medieval art). *Reason* is the ability to draw conclusions, a process in which one thought follows from another as the result of deduction or induction. *Creative thinking* refers to processes underlying production of *creative products*, which are novel works – or *innovations* – brought about through goal-directed activities. Thus, we examine the hypothesis that skill and knowledge, as well as reasoning processes, play important roles in innovation. That hypothesis is of interest because much theorizing concerning creative thinking assumes exactly the opposite, that is, that expertise and reason cannot support creative thinking (e.g., Csikszentmihalyi, 1996; Simonton, 2003; Sternberg, 1996). I first consider two general orientation issues: the definition of creativity and whether expertise and reasoning should be considered separate. I then examine the negative view concerning expertise and reason in creativity, which I call the *tension view*. I then present evidence, from case studies of creative achievements as well as from laboratory studies of problem solving, that expertise and reason play critical roles in creative thinking.

THE DEFINITION OF CREATIVITY

Creative thinking involves the intentional production of novelty (Weisberg, 1993), so you cannot be creative by producing something that you know has been produced before. If, however, you produce something that is new for you, but which was produced earlier by someone else, you are still creative (Weisberg, 1986). Also, according to this definition, you cannot

be creative by accident. If you knock over a can of paint unintentionally and in so doing produce a "work of art" that winds up in a museum, it is not a creative product. Most researchers who study creativity also assume that a product must have *value* to be creative: scientific theory must further our understanding; art must attract an audience (see chapters in this volume). In contrast, I do not include the criterion of value in the definition of creative. Value is included in the definition so that we are not trapped into calling any novel product a creative work – even the bizarre word *salad* of the schizophrenic. If we include intention as a criterion for calling something creative, then the word salad is excluded, because it is not intentional.

Including value in the definition of creativity also causes unsuspected problems for theorizing. Most critically, we will not be able to determine definitively what products are creative and what individuals are creative. This problem arises because the value of a product can change over time: an artistic innovation valued by one generation can be considered sentimental treacle by the next; a scientific innovation considered groundbreaking by one generation can be considered nonsense by the next. Theorizing about creativity will therefore be built on a constantly shifting foundation, as individuals and their works become "creative" and "not creative" over generations. We would continuously have to consider whether our previously established conclusions hold for the now-creative people, which is an impossible situation; we need criteria that do not change over time. The goal-directedness and novelty of some product, once determined, cannot change, so we should be able to determine the phenomena and individuals to study. Thus, I assume that any innovation generated as part of the goal-directed activity of an individual is, *ipso facto*, creative, whether or not it has value to anyone. The value of a person's work may change from one generation to the next, but its creativity cannot.

EXPERTISE AND REASON: DICHOTOMY OR CONTINUUM?

Expertise and reason are separated in the title of this chapter (as well as in the title of this volume). It might be better, however, to conceive of a continuum, ranging from domain-specific knowledge to more general knowledge. At one end we have, for example, a professional chef's knowledge and skills or those of a research scientist. At the other end, we all possess knowledge with wide applicability, such as the rules of arithmetic; or general knowledge of the language and the rules of logic, which you use to determine that what someone has just told you contains a contradiction. Those general skills, however, are not different in kind from what we designate as expertise; our ability to reason logically and our ability to do arithmetic, for example, have been acquired over long periods of time and

as the result of much practice. Thus, one could paraphrase the thesis of this chapter by saying that it is concerned with the relation between expertise – in both its domain-specific and general senses – and creativity.

EXPERTISE AND CREATIVITY

The study of expertise has in the past several decades become an area of interest to scholars from a broad range of disciplines. The recent interest in the study of expertise can be traced to de Groot's (1965) study of chess playing. De Groot's work was extended by Chase and Simon (1973), who proposed the *10-year rule* to summarize their finding that the development of superior (master level) chess performance depended on years of practice and study of the game. From this analysis was born the idea that many years of practice and study – what can be called *preparation* (Hayes, 1989) – are necessary to acquire expertise.

Demands versus Content of Expertise

The role of preparation in creative thinking might be seen in the necessity for domain-specific training before one made a significant contribution to a creative domain. Preparation would also be seen if individuals undergo formal or informal training before they make original contributions. This aspect of expertise could be called the *demands* of expertise: the necessity for training over long periods of time.

A second aspect of expertise centers on the *content* of the knowledge and skill acquired through training. One sees evidence of the world-class athlete's training, for example, as she demonstrates mastery during competition over aspects of skill that she has practiced. Similarly, in carrying out a diagnosis, a doctor uses everything he has acquired over years of experience. If one looks upon a would-be creator's domain as a series of problems to solve, then the creative thinker, *qua expert*, should use the content of the past as the basis for creating the new (Weisberg, 2003). So, for example, one should see traces of the content of a painter's expertise in her paintings. The content of a painter's expertise includes techniques for applying paint and rendering likenesses of various forms, as well skill in composing paintings. An artist also, through immersion in the world of art, acquires an intimate familiarity with previous works. Thus, we should see in an artist's work traces of the artist's knowledge of other works – both his or her own and those of other artists.

Figures 1.1A and 1.1B present an outline of how a hypothetical creative thinker in each of two domains might use the content of expertise in creative thinking. Consider first a scientist attempting to determine the structure of a protein involved in the development of Alzheimer's disease. The scientist might begin work based on what he or she knows about the structure of

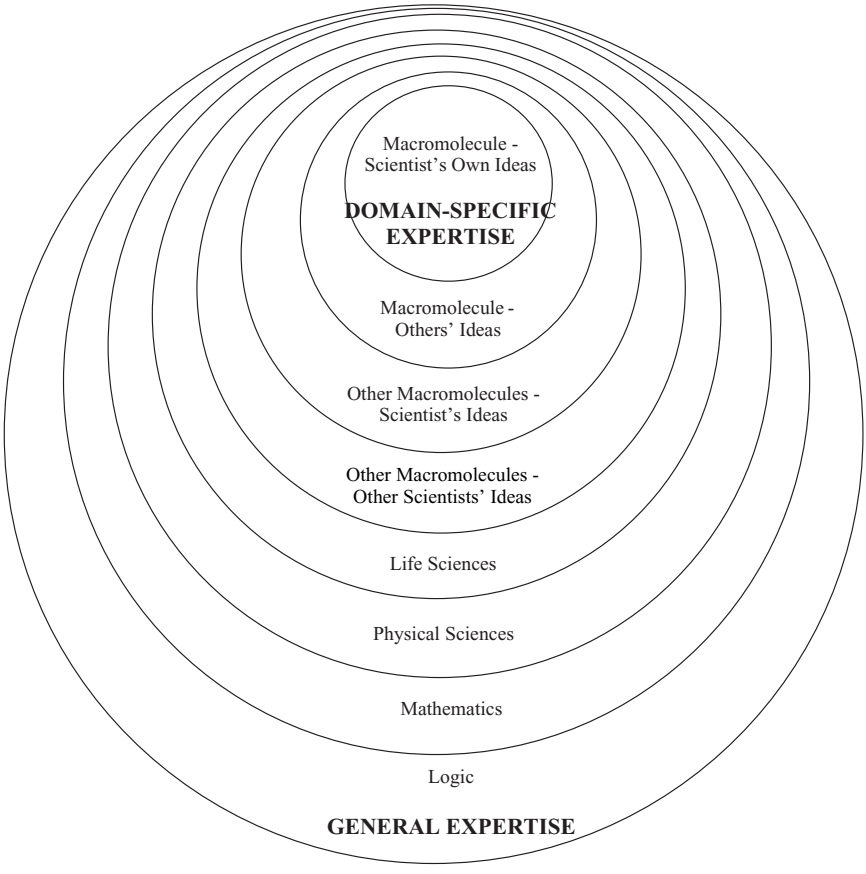

FIGURE 1.1A. Outline of use of expertise in a hypothetical example of scientific creativity: Determining the structure of an important organic macromolecule.

that protein, that is, on domain-specific expertise. In a widening search, the scientist might bring to bear what others have discovered about that molecule and what he or she and others know about similar molecules. Still more broadly, potentially relevant information from the life sciences might be brought to bear, as well as information from the physical sciences. Finally, on the most general level, the scientist might use logic to work through implications of the work that he or she knows and might also use mathematics as a tool. The specifics of the outline in Figure 1.1A are not critical for the conclusions being drawn here (i.e., that one can outline one possible way in which the content of expertise might serve in creative thinking).

This general perspective can also be applied to the arts. Figure 1.1B shows an outline of a situation facing a poet who has recently given birth

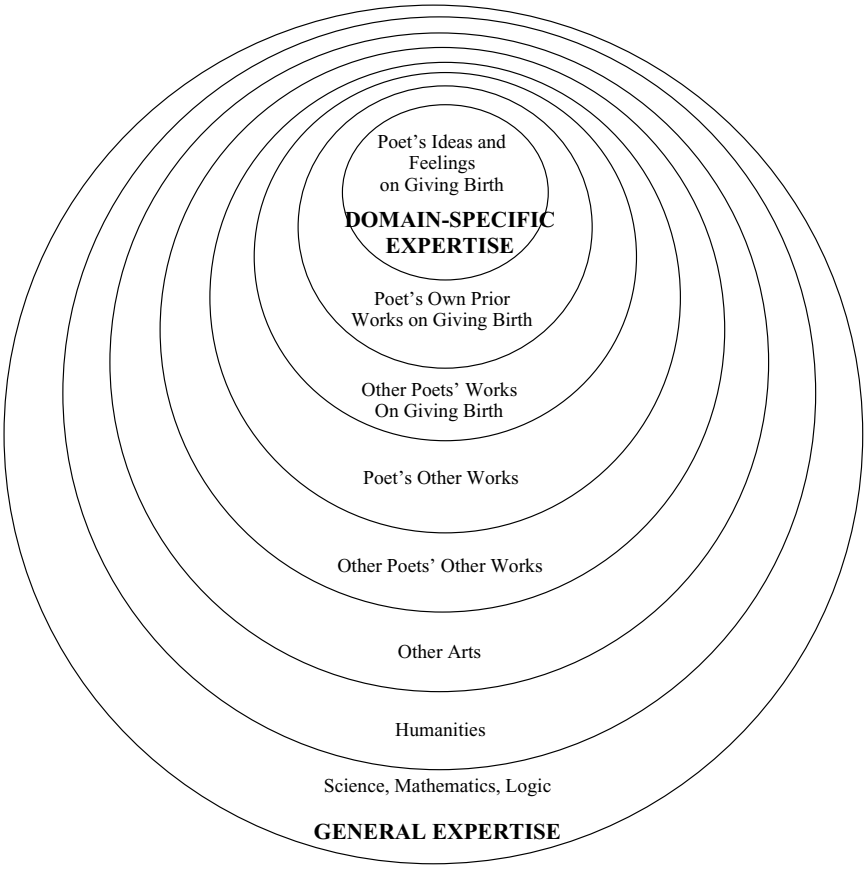

FIGURE 1.1B. Example of use of expertise in a hypothetical example of artistic creativity.

and who is stimulated to write a set of poems expressing her feelings about the experience and its implications. One can here also hypothesize a set of domains of expertise that the poet might bring to bear on her project. In addition, she may use logic as the basis for constructing aspects of her new work. The next several sections of the chapter attempt to put some actual flesh on the hypothetical skeletons presented in Figure 1.1A and 1.1B. Before doing so, however, it will be useful to discuss objections that have been raised to the view just outlined.

QUESTIONS ABOUT EXPERTISE AND REASON IN CREATIVE THINKING: THE TENSION VIEW

Many theorists addressing creativity have rejected the possible role of experience in both the narrow and broad senses. I consider two aspects of this