# Creative and Critical Thinking in the Arts and Sciences: Some Examples of Congruence

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## Introduction

In his landmark 1959 Rede lecture and subsequent publication, physicist Charles Percy Snow expressed concerns over what he saw as a growing rift between scientific and literary scholarly communities (Snow 1959). In the fifty years since that time, scholars and other commentators have expended a great deal of intellectual capital in the analysis of observed cultural differences between the sciences on one side, and the arts and humanities on the other. While it is important to acknowledge and explore these differences, both perceived and actual, it is also worthwhile to recognize those ideas and practices shared in common between the two cultures.

One such area of common ground is the utilization of creative and critical thinking skills by practitioners within both the arts/humanities and the sciences. Although creative thinking has traditionally been associated with the former and critical thinking with the latter, even a brief examination of the evidence suggests the essential nature of both creative and critical thinking within each of the two cultures. In this paper, I would like to begin with a sampling of modern definitions for both critical and creative thinking, then discuss a few selected examples illustrating how these modes of thought can play complementary roles in traditions of both scientific and humanistic thought.

## Some Modern Definitions of Critical Thinking

The foundations of critical thinking may be traced back for thousands of years in Western thought. The modern literature on the subject is quite extensive, and a comprehensive review would be far beyond the scope of this paper. For the purposes of this brief discussion, I would like to cite a few definitions of the term, as presented in selected works from the modern literature.

Proponents of the teaching of critical thinking skills frequently cite twentieth-century American psychologist, philosopher and educational reformer John Dewey as the intellectual founder of the modern movement. Dewey defined his version of the practice, which he termed "reflective thinking," as "active, persistent and careful consideration of a belief or supposed form of knowledge in the light of the grounds which support it and the further conclusions to which it tends," and "the kind of thinking that consists in turning a subject over in the mind and giving it serious consideration" (Dewey 1910, 9). Over time, Dewey's general model has proven to be well suited for the analysis of existing ideas, but makes no mention of any process for generating new ones.

In subsequent years, scholars have expanded and developed Dewey's ideas. Edward Glaser, co-author of the highly popular *Watson-Glaser Critical Thinking Appraisal* (Watson-Glaser), has posited that the process of critical thinking involved three things: "(1) an attitude of being

disposed to consider in a thoughtful way the problems and subjects that come within the range of one's experiences, (2) knowledge of the methods of logical inquiry and reasoning, and (3) some skill in applying those methods" (Glaser 1942, 5). In 1987, Philosophy of Education Professor Robert Ennis developed one of the most widely used definitions of critical thinking today, beginning with "reasonable reflective thinking that is focused on deciding what to think or do" (Ennis 1987, 10). In the process of refining and elaborating his conception over time, Ennis ultimately proposed that a critical thinker exhibits the following characteristics:

1. Is open-minded and mindful of alternatives
2. Tries to be well-informed
3. Judges well the credibility of sources
4. Identifies conclusions, reasons, and assumptions
5. Judges well the quality of an argument, including the acceptability of its reasons, assumptions, and evidence
6. Can well develop and defend a reasonable position
7. Asks appropriate clarifying questions
8. Formulates plausible hypotheses; plans experiments well
9. Defines terms in a way appropriate for the context
10. Draws conclusions when warranted, but with caution
11. Integrates all items in this list when deciding what to believe or do
    (Ennis 2002)

In the process of fleshing out Dewey's basic outline, Ennis identified several important characteristics of critical thinking, including some that involve the generation of new ideas. These include being well informed, open-minded and mindful of alternatives, and formulating plausible hypotheses. In doing so, Ennis' model highlighted areas of confluence between the processes of critical and creative thinking, suggesting the interconnectivity of the two.

Also in 1987, Joan Boykoff Baron and Raymond S. Nickerson published an even more extensive list of characteristics they considered to be essential for a critical thinker:

- uses evidence skillfully and impartially
- organizes thoughts and articulates them concisely and coherently
- distinguishers between logically valid and invalid inferences
- suspends judgment in the absence of sufficient evidence to support a decision
- understands the difference between reasoning and rationalizing
- attempts to anticipate the probable consequences of alternative actions
- understands the idea of degrees of belief
- sees similarities and analogies that are not superficially apparent
- can learn independently and has an abiding interest in doing so
- applies problem-solving techniques in domains other than those in which learned
- can structure informally represented problems in such a way that formal techniques, such as mathematics, can be used to solve them
- can strip a verbal argument of irrelevancies and phrase it in its essential terms
- habitually questions one's own views and attempts to understand both the assumptions that are critical to those views and the implications of the views

- is sensitive to the difference between the validity of a belief and the intensity with which it is held
- is aware of the fact that one's understanding is always limited, often much more so than would be apparent to one with a noninquiring attitude
- recognizes the fallibility of one's own opinions, the probability of bias in those opinions, and the danger of weighting evidence according to personal preferences
  (Baron and Sternberg 1987)

The vast majority of these characteristics involve skills in analytical and critical thinking. However, as discussed below, the ability to see similarities and analogies that are not superficially apparent is also a creative thinking skill. As with Ennis, the model proposed by Baron and Nickerson appears to require a measure of creativity among the characteristics of a critical thinker.

By this point, the discussion may seem rather familiar, perhaps even obvious, to someone trained in the scientific process, also commonly known as the scientific method. As in critical thinking, the scientific process involves asking relevant and researching questions, developing and testing hypotheses, and then analyzing and reporting results. As described in 1991 by geologist Steven D. Schafersman:

> Critical thinking can be described as the scientific method applied by ordinary people to the ordinary world. This is true because critical thinking mimics the well-known method of scientific investigation: a question is identified, an hypothesis formulated, relevant data sought and gathered, the hypothesis is logically tested and evaluated, and reliable conclusions are drawn from the result. All of the skills of scientific investigation are matched by critical thinking, which is therefore nothing more than scientific method used in everyday life rather than in specifically scientific disciplines or endeavors.
>
> (Schafersman 1991)

All of the models discussed thus far share features in common with the scientific method, particularly the one developed by Baron and Nickerson. In outlining the similarities between critical thinking and the scientific process, Schafersman highlighted the debt owed by modern critical thinkers to the analytical process used so successfully in scientific thought and practice. As in the other definitions listed above, Schafersman described a thought process that is intentional, reflective, open-minded, rigorous, and self-correcting. In the identification of questions and the formulation of hypotheses, it is one that involves creative elements as well.

**Some Modern Definitions of Creative Thinking**

As in thinking reflectively, critically and analytically, discussions of creativity and its cultivation also have been going on for thousands of years. One of the earliest twentieth-century models for the creative process was developed by British sociologist and social scientist Graham Wallas. In his 1926 book *The Art of Thought*, Wallas proposed that the process of creative thinking involves four distinct "stages of control," consisting of:

1. Preparation: a problem is investigated consciously and systematically;
2. Incubation: a period of abstention from conscious thought about the problem;
3. Illumination: the creative idea appears in a sudden "flash" of inspiration, following a series of subconscious trains of association;
4. Verification: the validity of the new idea is tested, and the idea is reduced to exact form. (Wallas 1926, 79-107)

Wallas' model for creative thinking balances creative elements in the Incubation and Illumination phases with critical ones in the Preparation and Verification phases. His notion that creative insight takes place largely in the subconscious has remained popular to this day. However, others have proposed that the creative thinking process can be a fully conscious effort to balance imagination with analysis.

In 1931, chemical engineer and psychologist Joseph Rossman studied questionnaires completed by 710 inventors and proposed the following seven-step model:

1. Observation of a need or difficulty
2. Analysis of the need
3. A survey of all available information
4. A formulation of all objective solutions
5. A critical analysis of these solutions for their advantages and disadvantages
6. The birth of the new idea - the invention
7. Experimentation to test out the most promising solution, and the selection and perfection of the final embodiment by some or all of the previous steps. (Rossman 1931, 57)

Like Wallas, Rossman highlighted insight and innovation as key features of the creative process. However, he also emphasizes the critical, analytical and experimental aspects in steps 2, 5 and 7. In so doing, Rossman's model draws notable parallels with the scientific method.

Advertising executive Alex Osborn, who first developed the technique of "brainstorming," also stressed the importance of creativity in science, both in the development of initial working hypotheses and in the use of the imagination in experimentation and testing (Osborn 1953, 13-21). In 1953, Osborn proposed another model for a seven-step creative process:

1. Orientation: pointing up the problem
2. Preparation: gathering pertinent data
3. Analysis: breaking down the relevant material
4. Hypothesis: piling up alternatives by way of ideas
5. Incubation: letting up, to invite illumination
6. Synthesis: putting the pieces together
7. Evaluation: judging the resulting ideas (Osborn 1953, 125)

Osborne's model includes an emphasis on Wallas' "incubation" phase, but is otherwise quite similar to the process developed by Rossman. Both models place a strong emphasis on the purposeful formulation of solutions/hypotheses, along with experimentation/evaluation to test

their validity. Each also emphasizes the need for fluidity and flexibility in following the steps for the creative process.

Osborne's colleagues Scott Isakson and Sidney Parnes refined his conception in the development of the Creative Problem Solving (CPS) model, used for instructional seminars conducted by the Creative Education Foundation. As outlined by Isakson and Parnes, the CPS process comprises six steps:

1. Objective-Finding: list broad objectives, goals or purposes, then select best statement;
2. Data-Finding: list data dealing with each chosen objective, then select most pertinent;
3. Problem-Finding: list problems or challenges for attainment of each objective, then select most promising definition for creative attack;
4. Idea-Finding: list ideas, alternatives, approaches, strategies, means or options for handling chosen challenge, then cull out those that are most interesting or promising;
5. Solution-Finding: list criteria for evaluating culled-out ideas, then choose criteria use them to and evaluate the chosen ideas;
6. Acceptance-Finding: list ways of implementing the ideas, then develop plans, carry them out, obtain feedback and monitor results.
   (Isakson and Parnes 1985, 27-29)

In the CPS model, each step in the process suggests the use of creative facilities in developing the initial lists, and critical techniques in selecting and evaluating them. Along with the other examples given above, the CPS model suggests that there can be large areas of overlap between the processes of creative and critical thinking. While a comprehensive discussion of these congruencies and their historical underpinnings would fall beyond the scope of this brief paper, I hope to undertake such an in-depth exploration in a future publication.

**Modern Examples of Creative and Critical Thinking in the Arts and the Sciences**

In the remainder of this paper, I would like to briefly discuss one twentieth-century scientist and one twentieth-century artist, each of whom used a combination of creative and critical thinking skills to develop some of the most influential works in their respective fields. For my example from the sciences, I would like to cite the theoretical physicist, philosopher and author Albert Einstein (1879-1955), who is widely regarded as one of the most influential scientists and intellectuals in modern history. Einstein moved beyond Newtonian physics with groundbreaking theories attempting to reconcile the laws of mechanics with the laws of the electromagnetic field.

By 1905, Einstein had come to understand that quantum properties of light meant that that electromagnetism contradicted the traditional Newtonian laws of physics (Einstein 1905). He knew that new laws would have to replace them, but he did not know how to go about finding those laws. He surmised that simply hypothesizing formal relations would not be productive, so he chose to focus on *a-priori* principles instead. *A-priori* principles are statements about physical laws that can be understood to hold in a very broad sense even in domains where they have not yet been shown to apply. Einstein reasoned that once a sufficient number of such

principles were discovered, then the new physics created would comprise the simplest theory consistent with the principles and with previously known laws.

The first general a-priori principle he developed was the principle of relativity, i.e. that uniform motion is indistinguishable from rest. As a young man, Einstein had imagined himself running alongside a beam of light, and wondered what it might look like. If he was moving at the speed of light, the wave would appear to him to be stationary:

> I should observe such a beam as a spatially oscillatory electromagnetic field at rest. However, there appears to be no such thing, whether on the basis of experience or according to Maxwell's equations. (Einstein 1949, 53)

Einstein realized that there is a logical contradiction with respect to Newtonian physics and electromagnetism with respect to what a light ray would "look like" when the observer is moving at the speed of light. Einstein's solution was that only massless photons can move at the speed of light, and that matter must remain below the speed of light regardless of how much acceleration is applied. This "thought experiment," as Einstein referred to it, led directly to his development of the Special Theory of Relativity.

This theory had a wide range of consequences, which have been experimentally verified in the years since then, using the scientific process. But Einstein's initial thought experiment came from creative insight and invention, followed by intense mathematical verification and analysis. In fact, Einstein is quoted as having said that:

> After a certain high level of technical skill is achieved, science and art tend to coalesce in esthetics, plasticity, and form. The greatest scientists are always artists as well. (Henderson 1955)

As an example of creative and critical thinking in the arts, I would like to discuss a contemporary of Einstein, the renowned Spanish painter, draughtsman and sculptor Pablo Picasso (1881-1973). Picasso is perhaps best known for co-founding (with George Braque) of the early twentieth-century Cubist movement, and for the wide variety of styles embodied in his work. His revolutionary artistic accomplishments brought him universal fame and immense fortune throughout his lifetime, making him one of the best-known figures in twentieth-century art.

Picasso demonstrated uncanny artistic talent in his early years, painting in a realistic manner through his childhood and adolescence. During the first decade of the twentieth century his style changed repeatedly, as he experimented purposefully with different theories, techniques, and ideas, gradually moving toward greater degrees of abstraction and expressionism. Picasso's creative process is exemplified in one of his best-known works, the painting *Guernica*, created for the Spanish Pavillion in the Paris World's Fair of 1937 (Weisberg 1993, 202-09).

During the Spanish Civil War, the German Luftwaffe, operating in concert with the Nationalist faction of General Francisco Franco, bombed the Basque town of Guernica for over three hours,

causing widespread civilian death and destruction. Picasso, a self-styled Pacifist, decided to use his commission for the World's Fair to express his outrage over the atrocities committed on helpless civilians by the Nationalist forces.

Completed three months later, the finished work measures more than twenty-five feet long by eleven feet high (PBS Treasures Online). Painted entirely in shades of gray to create a documentary feel, it depicts humans and animals in an ambiguous setting, and expresses Picasso's feelings through their responses. On the right, a woman with burning clothes falls out of a building, while another woman holding a lamp flees through an open door. Below, another woman rushes toward the center of the painting, toward the central figure, a screaming horse beneath a bright lamp. On the left, a large bull stands above a woman holding her dead child in her arms, her head falling back in mourning. Across the bottom of the painting are the broken pieces of a statue of a warrior.

The painting was meticulously planned, with approximately forty preparatory sketches. Through these sketches, it can be seen that Picasso repeatedly experimented with different settings, characters, poses and combinations. Picasso also had photographs of the painting taken in various stages of completion. These show that the various elements of the painting, many of which recur throughout Picasso's works, were constantly rearranged to change their emphasis. These include the bull and the horse, representing heroism and suffering in the bullfighting tradition, the light-bearing woman, who represents a character from a Spanish children's story who illuminates evil deeds by the powerful, and the prostrate warrior, representing death. The sketches indicate a process of analysis and experimentation to produce a desired combination of effects, described by one cognitive scholar as "blind-variation and selective-retention" (Simonton 2007).

In his work, Picasso displayed extraordinary innovation and creativity. But, as seen in his creation of the painting *Guernica*, Picasso's innovations in style often came as a result of research, analysis and experimentation. Picasso is also quoted as having said:

> Paintings are but research and experiment. I never do a painting as a work of art. All of them are researches. (Liberman 1956)

**Conclusion**

Although my examples are admittedly few and selective, I hope that they nonetheless illustrate that broad areas of overlap can exist within the processes of creative and critical thinking, in both the arts and sciences. As scholars, we spend many years training to think and see through the different lenses of our respective disciplines, and for good reason. This is how research is done, and this is how progress is made within each discipline. And yet, while it is important to acknowledge our differences, it is also important not to lose sight of those things that we share in common, and to recognize that, as educators, we are not only providing our students with

specialized knowledge to help them succeed in their chosen field of study. We are also engaged in a collective effort to help our students learn to think more clearly, critically and creatively than they did before coming under our care.

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