

*Science involves analysis,  
synthesis and recombination,  
all of which constitute creativity.*

George G. Mallinson

## Creativity in Science and Mathematics

IT IS indeed a sterile and desolate task to attempt to define "creativity." The limits of human vocabulary place restrictions on the denotation of such a dynamic concept. In effect, the linguistic barriers on creativity of expression are self-defeating. Yet, from an empirical point of view, it is possible to recognize certain attributes of creativity and also to identify differences among persons in terms of their possession of these attributes.

Among the many statements concerning creativity, one by Trow<sup>1</sup> seems to summarize the concept better than others:

... the creative process is very elusive. It can be observed only introspectively and then only in retrospect after the creative act is completed. . . . However, it may be surmised that the phenomenon is very similar to, if not identical with, that of insight. Components of experience are abstracted from their familiar pattern and recombined into a new organization. Thus, the discovery of a solution to a problem is a creative act even though the outcome is not a work of art.

<sup>1</sup> William Clark Trow. *Educational Psychology*. Second Edition. Boston: Houghton Mifflin Company, 1950. p. 655.

Such a view of the creative process is consistent with the dynamic nature of science. In 1951 Conant<sup>2</sup> emphasized the dynamic nature of science<sup>3</sup> by classifying it as an activity, rather than an accumulation of knowledge. He stated that "science is an interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observations." Such a view of the scientific activity broadens the realm of scientific knowledge, rather than provides rapid transit to the end of the trail. The visible spectrum of concepts, ideas and new problems in science is thus increasing geometrically in magnitude.

### Need for Creative Minds

Any discipline, in order to flourish, must acquire personnel with the desired functional attributes. The discipline must also provide a climate in which these attributes can be nurtured. In science,

<sup>2</sup> James B. Conant. *Science and Common Sense*. New Haven: Yale University Press, 1951.

<sup>3</sup> In this paper, the term "science" is construed to refer to the fields of both science and mathematics.

therefore, the personnel and the climate must manifest creativity. Many persons, however, find it possible to believe, without basis in fact, that creativity is not a general endowment for all mortals. Thus, during the educative process, the direct concern for creativity is often neglected. The respect for creativity of the genius, and the deference now being paid to the "talented," unconsciously induce the belief that creativity is a special attribute that the average person lacks. Also, it seems to be accepted that the able person must become a disciple of "Joe Science" in his educational and occupational allegiances. Such views are not scientific. Without doubt, as is true with all attributes, every person possesses creativity to some degree.<sup>4</sup>

Indeed among scientists and those who deal with the products of science, the need for creative expression in scientific behavior is evident at all levels. Oppenheimer<sup>5</sup> made this point most cogently in his speech at Roosevelt University. He stated:

Among the founders of the United States it is natural for us to remember Franklin and Jefferson; they were both in some real sense men of science as well as statesmen. They looked to science as an essential part of this country's heritage. They saw first that in practical terms it was a strong tool against misery and poverty and squalor. They rightly understood that science would contribute to the well-being and the civility of life in America. They saw it in intellectual terms as a guard against ignorance and superstition. They saw it in political terms as a guard against tyranny, barbarism, repression, and bigotry, that they associated

**George C. Mallinson is Dean, School of Graduate Studies, Western Michigan University, Kalamazoo.**

with centuries past, with the religious wars, the inquisition, and what they thought of as the dark ages. For them it was incompatible only with an authoritarianism, by which, they were determined, this country should never be darkened.

The need for creativity in scientific behavior is recognized at all hierarchies of the cultural complex. The aristocracy of science has long since given way to the recognition that science is an activity that pervades all dimensions of man's pursuits. Lehner<sup>6</sup> for example sounded the death knell of the purchase of the "bent back" when he made the following assertion:

The day of common labor is coming to a close, but there is no cause for regret. To meet the requirements of improved technology, the common laborer is becoming skilled, and the skilled worker is becoming a technician. This is upgrading rather than retrogression, and the increasing use of minds rather than muscles has been reflected in the sharp climb of wages and salaries. We are all better off.

For those at the professional end of the spectrum of scientific endeavor, the criterion of creative effort has also been emphasized. Dean Burchard<sup>7</sup> of Massachusetts Institute of Technology decried the scientists and engineers who pursue their professions as exercises in science and mathematics rather than view themselves as shapers of their environment. He pleaded for the crea-

<sup>4</sup> Samuel Lehner. "A New Horizon for Scientific Education." A paper presented at the Convention of the National Science Teachers Association, in Washington, D. C., March 16, 1956.

<sup>4</sup> Kimball Young. *Personality and Problems of Adjustment*. Second Edition. New York: Appleton-Century-Crofts, Inc., 1952. p. 185.

<sup>5</sup> J. Robert Oppenheimer. *Science and Our Times*. Roosevelt University Occasional Papers: No. 2. An address at the Annual Dinner of the Association of Founders and Friends of Roosevelt University, Conrad Hilton Hotel, Chicago, Illinois, May 22, 1956.

<sup>7</sup> *Creative Leadership*. The Cooper Union for the Advancement of Science and Art. The President's Report to the Trustees for the Ninety-Eighth Year Ending June 30, 1957. The Cooper Union, Union Square, New York 3, N. Y. p. 11.

tive engineer who can recognize the social principle in his efforts at scientific leadership.

It would seem redundant, therefore, to discuss further the need for creative minds at all levels of scientific behavior.

### Aim of Creative Science

There occasionally arises the idea that anything of practical and useful value is beneath the dignity of a gentleman and scholar. Whether such an idea is a cause, or a symptom, nevertheless it is part and parcel of the dichotomy of pure versus applied science, pure versus applied mathematics, and science versus technology and engineering. Perhaps the best illustration was expressed many years ago by Hilbert, one of the greatest and "purest" of mathematicians. He is alleged to have said, "One hears a good deal nowadays about the hostility between science and technology. But that is not true, ladies and gentlemen. That is not true at all. How could it be true? They have nothing whatsoever to do with each other."<sup>8</sup> Such views are not consistent with the role of creative science as it is viewed today. Science and technology are symbiotic because technology would be crippled without the knowledge sought for other reasons.<sup>9</sup> Also, technology provides science with new instruments and new techniques. There is a constant and reciprocal feedback between the two that demands creative efforts in both. This point was supported by Mortimer Adler, Director of the Institute for Philosophical Research, who indicated that creativity in-

<sup>8</sup> J. Robert Oppenheimer. "The Need for New Knowledge." *Symposium on Basic Research*. Publication No. 56. Washington, D.C.: American Association for the Advancement of Science, 1959. p. 9.

<sup>9</sup> *Ibid.*

volves more than originality and novelty. If creativity is to be intrinsically good, it must be productive of things of lasting value.<sup>10</sup>

Indisputably, then, creativity is an aim of all science and all mathematics at all levels and in all dimensions. The aim must pervade both teaching and learning and be sought, elusive as it may be.

### Fostering Creativity Through Science

As stated by Bertrand Russell, in *The Impact of Science on Society*, science has two functions, namely, to teach people to know things and to teach people to do things. The latter point envisions the creativity under discussion. How best can it be fostered?

Dean Keppel of the Graduate School of Education at Harvard University has indicated that three approaches may be used to foster creativity. One way is to let "nature take its course" with the view that creativity is a facet of learning that is fostered without cultivation. The second approach is to provide an atmosphere conducive to creativity without an effort to analyze its dimensions, and the third is to provide learning situations that give students the opportunity to ask questions, analyze situations and solve problems.

The weight of the research evidence completely discredits the efficacy of the first approach and eminently supports the desirability of a combination of the second and third. In his summary of research investigations concerning the attainment of objectives of science teaching, Mallinson concluded that recent evidence completely supported what was already conclusive, namely, learning objectives

<sup>10</sup> *Creative Leadership*, op. cit., p. 13.

are attained maximally through direct effort.<sup>11</sup>

Obviously, the overt manifestation of creativity is a matrix that cannot be taught *in toto*. It would seem reasonable, therefore, that in science, a careful scrutiny should be made of the intellectual dimensions of scientific performance. At present such dimensions are neither clearly recognized nor understood.

This point may be illustrated by comparing science with other disciplines. For example, when teachers are asked to list the desirable outcomes of language arts, they name, among others, the dimensions of "to read," "to write," and "to spell." If asked the same question for science, too often there emerges, "know something about rocks," or "birds." Or, under pressure, they may list the outcomes as being able "to think critically," or "to use elements of scientific method." The first are not objectives at all, but merely the tools; the latter are but nebulous platitudes. The solution does not come either from the true pedagogue who might suggest, "think critically about birds."

The important step is to define in words of one syllable, and which all can understand, the dimensions, not the matrix of scientific performance. This means the development of a series of simple statements identifying what an individual is expected to *do* better as a result of his studies in science. This must be followed by a conscious and directed effort to provide situations in which the "doings" can be practiced. The ecology of the frog cannot be learned by memorizing his "innards," nor the flow of elec-

<sup>11</sup> George Greisen Mallinson and Jacqueline V. Buck. "Some Implications and Practical Applications of Recent Research in the Teaching of Science at the Secondary-School Level." *Science Education* 38:58-81, February 1954.



COURTESY NEA. CARL PURCELL

***Learning objectives are best attained through direct effort.***

tricity understood by memorizing  $E = \frac{1}{R}$ . The creative mind in science is developed not by memorizing the output of other creative minds, but by participating in the creative act. These opportunities for participation must be provided for all, without regard for their extent of use of science.

*(Continued on page 42)*

theory and quality; and (d) quality to gain quality. This covers the full sweep of matters to be addressed by the growth criterion. Educators are brought that much closer to choosing and orchestrating the plethora of means-ends—learnings—in such a way that growth in one direction is seen in its relation to “continuing growth in new directions.”

A creative curriculum would rest upon an esthetic foundation. For in the long haul Dewey would “award the palm,” not to science, but to art experience. “Art—the mode of activity that is charged with meanings capable of immediately enjoyed possession—is the complete culmination of nature, and . . . ‘science’ is properly a handmaiden that conducts natural events to this happy issue.”<sup>13</sup> And, “Esthetic experience is a manifestation, a record and celebration of the life of a civilization, a means of promoting its development, and is also the ultimate

<sup>13</sup> John Dewey. *Experience and Nature*. Chicago: The Open Court Publishing Company, 1929. p. 358.

judgment upon the quality of a civilization.”<sup>14</sup>

But a creative education in theory and quality carries with it the courage and responsibility to relinquish, if necessary, some of our current and, in some cases, closely guarded conceptions.

For, if the hypothesis herein advanced is tested and found to hold, then we must be willing to give up the emotional theory, the notion that art experience is restricted either to the “fine arts” or to departments of art education, the view that theory is of value only when it leads *immediately* to non-theory (practice) and the conception that removes from the domain of public education those qualitative moments of sympathy, sorrow, “celebration of ideals realized” so precious to shared living and so important to sustaining us during turning points in our personal lives. It remains to be seen whether or not we will pay the price.

<sup>14</sup> John Dewey. *Art as Experience*, *op. cit.*, p. 326.

## Science and Mathematics

(Continued from page 27)

McCloy<sup>12</sup> stated the point well in his admonition to scientists and those who survive in a world of science:

You have to do more than sign an intermittent manifesto from the isolation of your laboratory demanding of the government some immediate course of action. It requires added knowledge, added reading, added thinking and added experience, all inspired by the scientific spirit. It requires dealing,

<sup>12</sup> John J. McCloy. “Obligations of a Scientist.” An Address at the 92nd Commencement Exercises of the Massachusetts Institute of Technology, Cambridge, Massachusetts, June 13, 1958.

incidentally, with subjects wherein the variables are apt to be far more numerous and baffling than in any scientific problem you have thus far encountered.

The implication is clear. Science does not end with logical analysis of the holes in knowledge, with the logical search for logical materials to be logically ordered. It involves a broader dimension of analysis, synthesis and recombination, all of which constitute creativity. Without such creativity, the atmosphere of science can at best be sterile and humid.

As stated by Charles Kettering, “Logic enables you to go wrong systematically.” Creativity is the key to the escape from our older misconceptions.

Copyright © 1960 by the Association for Supervision and Curriculum Development. All rights reserved.