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Programmed Instruction in Creative Problem Solving

DONALD J. TREFFINGER
RICHARD E. RIPPLE

RESEARCH in the area of creative thinking and problem solving has been characterized by Yamamoto (14) as being analogous to blind men "viewing" an elephant. There is an urgent need for systematization and integration of research findings to bring educational implications clearly into view. Among the most difficult problems confronting the researcher interested in creativity is the question, "Can creativity be developed?"

Research addressed to the facilitation of creative thinking and problem solving through instruction is beset by a number of problems. Some of these are at the level of definition and measurement: What is creativity? Does everyone have creative potential? Can it be recognized in children? How can it be assessed reliably? Other problems pertain to the adequate specification of instructional materials for developing creative thinking and problem solving.

Research related to a recently developed instructional program for creative development, the *Productive Thinking Program*, developed by Covington, Crutchfield, and Davies (3) will be considered in this paper. The program consists of 16 booklets, and proposes to develop creative problem-solving abilities and related attitudes among fifth and sixth grade pupils. Principles of creative problem solving and affective characteristics related to effective problem solving are presented in a series of mystery-story problems. Two youngsters, Jim and Lila Cannon, learn to become "detectives" under the direction of their Uncle John, a science teacher who doubles as the mysterious detective, "Mr. Search." The format and content of the programmed booklets are described in greater detail by Crutchfield and Covington (5) and Covington, Crutchfield, and Davies (4).

If the program can be shown to be effective in improving pupils' scores on measures of creative problem solving and related attitudes, one is confronted with several questions: What is the instructional content of the program? How are the effects achieved? Are some components more effective than others in influencing pupils' performance? What role, if any, does the teacher play in determining the effectiveness of the program? How important is it that the pupils identify (in a psychological sense) with the "characters" or the "story line"? What effect does the programmed instructional format have on pupil learning? How important are rate of presentation of the instructional booklets, and opportunities for supplementary pupil practice using the principles developed by the program?

In view of the contradictory results of recent research using this instructional program, it seems important that many of these questions should be raised. The purpose of this paper, then, is to review the research conducted with the *Productive Thinking Program* and to identify the theoretical constructs or variables needed to interpret those results in a systematic way.

Research with the Productive Thinking Program

Experimental evidence concerning the effectiveness of this instructional program was first presented by the developers. Covington and Crutchfield (2) reported two studies with fifth and sixth grade pupils in which a preliminary version of the instructional program (comprised of 13 rather than 16 lessons) was used.

In the first study, 195 pupils from Berkeley and vicinity were studied. These pupils were from four fifth grade and two sixth grade classes. Two of the fifth grade classes and one of the sixth grade classes were designated as instructional groups; pupils in these classes studied the 13-lesson programmed sequence. The instructional materials were used for one hour per day for a three-week period. Each child worked individually on each lesson. Control classes received a shorter set of booklets which did not provide instruction in creative problem solving. Following the training period, an eight-hour post-test battery was administered to all pupils. A one-hour follow-up test battery was also given five months later.

Pupils in both conditions were compared on several measures, including: number of problem-clarifying questions asked, number and rated quality of ideas generated, and number of solutions achieved. For each of these measures, the 98 pupils in the instructional group markedly outperformed uninstructed pupils. Differences between proportions of pupils solving the problems in instructional and in control classes far exceeded statistical significance. On some problems, the instructed pupils outperformed controls by as much as a three to one ratio. Significant differences favoring pupils in the instructed classes were also observed on various tests of divergent thinking abilities. Follow-up testing after five months showed continuing superiority for the instructed children over the control children.

The second study reported by Covington and Crutchfield (2) utilized all 16 lessons which comprise the present instructional sequence. A total sample of 286 pupils was studied. Results again indicated marked superiority for instructed pupils over controls on several criterion measures. The facilitative effects of the program were stronger at the fifth grade level than at the sixth grade level, when data were analyzed separately by grade level.

Ripple and Dacey (9) have reported research in which a ten-lesson experimental version of the program was used with 136 eighth grade pupils from ten classes. Five classes were randomly assigned to the instructional condition; pupils in these classes studied the instructional program. Pupils in control classes were given only their normal classroom instruction. All pupils in both instructional and control groups were given a post-test battery of divergent thinking measures scored for imagination, fluency, flexibility, and originality. There were no significant differences between instructional and control pupils on any of these measures. Twenty-five pupils in each condition were asked to attempt to solve the Maier two-string problem.

Although slightly more pupils in the instructed group successfully solved the problem than in the control group, the difference did not reach statistical significance. However, instructed pupils did solve the problem significantly *faster* than control pupils. Although Ripple and Dacey concluded that their results supported nonspecific transfer effects from the training materials to an acutal problem-solving criterion, their results were considerably less emphatic than those reported in the early studies by Covington and Crutchfield. Ripple and Dacey noted that the Covington and Crutchfield results were much less emphatic at the sixth grade level than at the fifth, and suggested that it may be the case that more challenging or differently oriented programs are required as grade level increases.

During the 1967-68 academic year, Treffinger and Ripple (11, 12) studied the effectiveness of the instructional materials, on a completely self-instructional basis, one lesson per day for 16 consecutive school days, among pupils in grades four, five, six, and seven. The criterion measures included the

Torrance Verbal Tests of Creative Thinking (10), a General Problem-Solving Test, two measures of arithmetic problem solving ability, Getzels and Jackson's Make Up Problems Test (6), and Covington's Childhood Attitude Inventory for Problem Solving (1).

At all four grade levels, there were no significant training effects with respect to verbal creativity, arithmetic problem solving, and the Make Up Problems Test. For general problem-solving measures, there were no significant differences between instructed and control pupils in grades six and seven. In grades four and five, instructed pupils' scores were significantly greater than those of the controls on only three of 20 comparisons. On the attitude inventory, at all four grade levels, instructed pupils' scores were significantly greater than those of the controls on Part I (General Attitudes About Creative Thinking) and on Total Score, but not on Part II (Self-Confidence in Creative Thinking Ability).

Recent reports from the Berkeley Creativity Project have been of research with the programmed instructional materials in several samples, all at the fifth grade level.

Wardrop *et al.* (13) have reported research in which the programmed materials were used with fifth grade pupils. In this study, 704 pupils from 44 fifth grade classes in the Racine, Wisconsin, public schools were involved. The instructional materials were used in 22 classes, one lesson per day, for four days of each of four school weeks. Students worked individually, at their own pace; the teacher's role was held to a minimum, emphasizing a test of the effectiveness of the materials themselves. Pretest and post-test batteries were administered, including extensive problems thought to emphasize convergent thinking and divergent thinking, brief problems emphasizing convergent and divergent thinking, and a general verbal test intended to assess a proposed "master thinking skill" (5). Mean performance of the instructed pupils surpassed that of control pupils on 30 of the 40 internal and post-test measures. Eleven of those differences reached statistical significance.

The authors observed that, although significant differences favoring instructed pupils were found, such differences were of considerably smaller absolute magnitude than those indicated in previous studies by Covington and Crutchfield (2). Failure to find larger differences was interpreted as reflecting differences between the studies with respect to teacher involvement and the pace at which the programmed materials were administered to the pupils. In previous studies, classroom teachers were deliberately instructed to supplement the lessons (although that fact was *not* explicitly stated in the 1965 paper by Covington and Crutchfield). In addition, the materials had not been used as rapidly (almost one lesson each day) in previous studies. Olton *et al.* concluded that large differences would not be likely to result from such a severe test of the materials.

In more recent work by Olton and Crutchfield (8), several modifications in the procedure for administering the programmed materials have been made explicit:

1. "Spacing" of the administration of the lessons, so that at least one full day intervenes between the presentation of each lesson, and often slowing the pace to as few as two lessons per week over an eight-week period

2. Increasing teacher involvement, utilizing a newly prepared *Teacher's Guide* (4), including warm-up and review discussions and "highlighting" key points of the lessons

3. Providing pupils with supplementary worksheets, which emphasize the "key point" of each lesson and provide the pupils with additional practice.

Recent research has utilized the programmed instructional materials with these modifications. Results suggest that the instructed pupils are substantially superior to control pupils on a number of measures. A recently completed study involved fifth grade pupils in the San Francisco area. The programmed lessons were administered at the rate of two per week, over an eight-week period. The program was supplemented by teacher discussions, 10 to 15 minutes in length, in conjunction with each lesson, and by use of 16 supplementary exercises. Instructed pupils were considerably superior to control pupils on most criterion measures. One criterion measure, intended to probe transfer effects to a typical classroom problem, involved writing an essay on "Poverty in Plenty." While instructed pupils' descriptions of poverty did not differ from control pupils' descriptions, instructed pupils made significantly more statements of possible causes of poverty. In addition, instructed pupils gave considerably more suggestions (3:1 ratio) for "solutions" to poverty (8).

An Interpretation of the Evidence

It seems clear in examining the available evidence that there are three general variables which have influenced results concerning the program's effectiveness:

1. *The conditions under which the instructional materials are administered.* This involves the period of time taken to administer the materials (essentially analogous to the question of massed versus distributed practice) and the amount and availability of supplementary practice.

2. *The self-instructional utilization of the materials,* which refers either to the absence of teacher involvement in the presentation of the program, or to its presence and degree.

3. *The criteria used to evaluate the effectiveness of the materials.* This includes questions of emphasis on the assessment of products or processes, and the degree of similarity of format between the training materials and the evaluation instruments.

It is our position that an adequate summarization of the effectiveness of these materials requires consideration of each of these three factors. Careful consideration of the available research suggests further that results have been confounded because these three factors have varied in several combinations. It is impossible, in our estimation, to understand the evidence only on the basis of any single factor. To do so would require the assertion, "Varying factor 1, when factors 2 and 3 have been held constant, results in x." This assertion does not appear valid; "all other things" have seldom been "equal." We

are confronted, then, with the task of summarizing the research evidence in the light of the interactions among the three critical factors we have identified.

The task is not as difficult as it might appear, however. In fact, one quickly discovers that, when all three factors are considered, the experimental evidence arranges itself quite readily, almost as a continuum or linear function. Figure 1 illustrates such a summarization.

In the first reports of research using these materials (2), instructed pupils' performance was considerably superior to that of control pupils. Although it was not noted at the time, teacher involvement during the administration of the program was included in those experiments. In addition, many of the criterion measures used were presented in a format highly similar to the instructional materials themselves.

Much subsequent research did not replicate the differences obtained in the 1965 studies, either with respect to frequency of differences or magnitude of the differences observed. Ripple and Dacey (9), for example, used the materials at a rapid rate (one lesson per day), and completely on a self-instructional basis. They found only limited support for the program's effectiveness (instructed pupils solved the Maier two-string problem faster than controls). Wardrop *et al.* (13) also used the program rapidly (four lessons per week over a four-week period), without teacher participation, and without supplementary practice. They found support for the effectiveness of the program, but there were significant differences on only about one-third of the criterion measures, and those were of smaller magnitude than had been reported in 1965. In addition, the differences which favored instructed pupils were, in general, on measures whose format closely approximated the programmed format of the instructional materials.

Even though they observed and commented on the absence of training effects on verbal and figural creative thinking measures, the authors interpreted their results only in terms of the concentrated presentation of the program and the absence of teacher participation. It was their position that "creativity" tests, such as Torrance's tests (10) or Guilford's divergent production tests (7), might not be expected to be useful criterion measures, in that the program seeks to develop more complex creative problem-solving abilities. This does not seem to us to account satisfactorily for the results. First of all, there is no clear evidence that the programmed booklet's problem-solving tasks, with which treatment effects were regularly observed, represent a criterion measure of the pupil's problem-solving ability rather

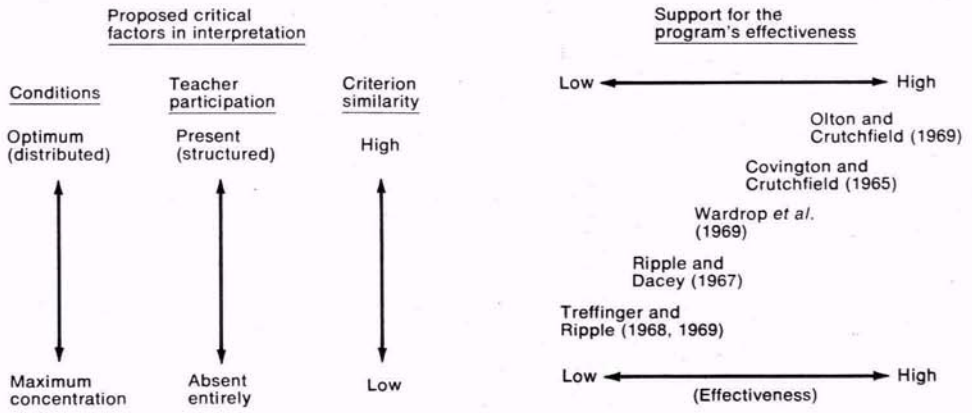

Figure 1. Effectiveness of the Productive Thinking Program as Influenced by Three Experimental Variables

than merely an extension of the training materials. Second, if the Torrance-Guilford test items were not expected to be adequate measures of the abilities developed by the program, why were they included as criteria? Finally, if the complex creative problem-solving process that the authors have described does *involve* such abilities as fluency, flexibility, originality, and elaboration (and no one has effectively argued to the contrary), would not one reasonably expect that adequate training in the more complex process would develop those "components" in a manner that would be reflected in pupils' performance on "simpler" measures?

The Treffinger and Ripple research (11, 12) in which the programs were used in a concentrated presentation, without teacher involvement, and with the least similar criteria of any of the other studies, yielded the least support for the effectiveness of the materials.

The most recent studies in which the materials were used (8) gave diverse criteria, but included both supplementary practice for pupils and systematic teacher involvement. In addition, the criteria used were not as severely different from the training as were the paper-and-pencil product-oriented problems used by Treffinger and Ripple (11, 12) or the Torrance Tests of Creative Thinking.

It seems clear, therefore, that all three of these criteria of interpretation are critical in understanding the results of research in this area. The third factor, the nature of the criterion measure, may be, from a researcher's point of view at least, the most important of all; nonetheless, it has received the least attention in experimental manipulations.

It also seems very clear that, before broad assertions of the effectiveness or ineffectiveness of the materials are warranted, research must be conducted in which each of the three variables we have identified is systematically varied or controlled.

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—DONALD J. TREFFINGER, *Assistant Professor, Educational Psychology, Purdue University, Lafayette, Indiana; and* RICHARD E. RIPPLE, *Professor, Educational Psychology, Cornell University, Ithaca, New York.*