

Training in Creative Problem Solving: Effects on Ideation and Problem Finding and Solving in an Industrial Research Organization

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The effects of training in a multistage "complete process of creative problem solving" on attitudes and behaviors of individuals were assessed both immediately after training and return to work. A controlled field "true" experiment was conducted within an engineering department doing applied research in a large industrial organization. Multiple methods and measures were employed on trained ($n = 16$), placebo ($n = 16$), and nonplacebo ($n = 13$) groups. The process trained addressed three critical stages: problem finding, problem solving, and solution implementation, each containing a fundamental diverging-converging two-step process called "ideation-evaluation." The main findings strongly suggest the training resulted in significant, systematically measurable effects both immediately after training and 2 weeks later at work. The trained participants were significantly higher in preference for ideation in problem solving, practice of ideation in both problem finding and problem solving, and performance in problem finding. The data give rise to speculation that there may exist differing "optimum ideation-evaluation ratios" for each of the problem finding, problem solving, and solution implementation stages. These ratios may also differ by field of endeavor.

A survey of the literature shows that creativity research has taken three distinctly different directions. First has been the *identification* approach; that is, can we develop cognitive and personality tests capable of identifying relatively more-or-less creative people? Guilford's work (1967) is among the best known in the cognitive realm and MacKinnon's (1962) in the personality realm. Dunnette (1976), Gough (1976), Roe (1976), and Torrance (1972) provide comprehensive reviews of this identification movement. A second research direction has been the study of *organizational factors*; that is, can we determine what factors in an organization tend to inhibit or nurture creativity? Baker, Sweeney, Langmeyer, and

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Winkofsky (1976) provide a review of the research in this direction. The third direction has been *training*, or *improvement*; that is, can we train people and make them more creative or increase their ability to use their innate creativity? Osborn (1963), Parnes (1959), Gordon (1956), and Prince (1970) were early pioneers in this movement and a summary is provided in Parnes, Noller, and Biondi (1977). The research reported here is a direct test of an attempt to train creativity. Two major issues are addressed. The primary focus is to test *if* creativity training "works." A secondary focus is to help understand *how* such training may work; that is, to explore the mechanisms that may operate in such training. It should also be noted that, as in most of the literature (see above references), the terms "creativity" and "creative problem solving" are used essentially interchangeably in this research.

Creativity training as a subset of industrial training suffers many of the problems of industrial training research in general and also faces some unique problems. For example, Dunnette and Campbell (1968) are critical that, in general, research on "laboratory training" (i.e., training intended to change behavior and/or skill) has provided no evidence about effects on individuals' problem-solving skills. Campbell *et al.* (1970) are disappointed in the small number of research studies dealing with attempts to teach problem-solving and decision-making skills. They conclude that "either such programs do not provide changes in behavior or we have not yet learned to detect them." Campbell (1971) made a similar report. The training reviews of Hinrichs (1976) and Goldstein (1980) indicate little change since these reports.

Second, those studies that have been done on creativity training have been mostly "nonreal world" in nature. Most often they involve college students generating ideas to solve a fictitious, neutral problem such as uses for a wire coat hanger (Parnes & Meadow, 1959; Meadow, Parnes, & Reese, 1959; Parnes & Meadow, 1960). Only a very few studies concerning real-world problems were found in the literature (see below). Moreover, much like training research in general, very few studies tried to assess behavior change back in the work setting (see, for example, Campbell, 1971; Smith, 1975).

Third, most training studies show methodological weaknesses, and creativity training is no exception (Campbell, 1971; Goldstein, 1980).

Fourth, many of the problems in creativity-training research involve *measurement* issues. Compounding these problems is the difficulty in arriving at even a common definition of what creativity means (Hinrichs, 1961). A major feature of this research was the development, application, and analysis of a variety of original measures of training effects.

Fifth, among the few real-world creativity-training studies available, results have been conflicting. For example, one of the studies (Cohen,

Witmeyer, & Funk, 1960) suggests that such training *is* useful to managers and professionals in improving creative problem-solving performance on real-world problems. Another study disagrees (Rickards, 1975) and suggests that such training leads to ideas which are only very similar to those produced without training.

Sixth, there appears to have been no studies conducted in an industrial applied research setting. For example, Parnes, Noller, and Biondi (1977) list as a prime question for research: "To what degree is a creativity-development program of benefit to a research laboratory in industry—chemical, electrical, mechanical?" (This research essentially is targeted in this direction.)

Seventh, there has been really no investigation of the mechanisms by which creativity training might "work." The training is done on a kind of "black box" basis; that is, provide training and check to see "what comes out at the other end" without attempting to find out what was going on inside in terms of intermediate attitudes and behaviors. Thus, virtually no multiple variable or multistep modeling has been done. For example, consider briefly a traditional training model as reviewed by Kraut (1976): training develops *Understanding* to change *Attitudes* to change *Behaviors* to achieve superior *Results*. Essentially none of the research in creativity training has addressed the intermediate steps in such a multistep model. For example, none of the research attempts to measure what effects brainstorming training has on attitudes and behaviors of participants.

Eighth, the value of training in a *complete* process of creative problem solving appears virtually uninvestigated. Instead, most of the studies have involved a technique called "brainstorming." Brainstorming is not a complete process of creative problem solving but rather one piece. Brainstorming is the generation of potential solutions without evaluation to a presented, predefined problem (Osborn, 1963). The literature emphasizes the need to study more complete processes of creativity (Parnes *et al.*, 1977). There appear to be two aspects to this line of thought. First, most researchers in creativity agree that evaluation is an important aspect of the creative process and, second, that there are stages to the creative process above and beyond simply finding solutions to already identified problems. There is increasing discussion that *finding* new useful *problems* to solve is a separate and more important stage of the creative process than finding useful *solutions* to already identified problems (Mackworth, 1965; Getzels, 1975). Einstein has said that the mere formulation of a problem is often far more essential than its solution (which may be merely a matter of mathematical or experimental skill). Other researchers emphasize solution *implementation* as another important stage of the creative process (Parnes *et al.*, 1977). Leavitt (1975) has proposed a tripartite model involving problem finding, problem solving, and problem imple-

mentation. Creativity processes which take into account evaluation and go beyond solution finding to problem finding and implementation considerations are termed "complete" processes.

Thus, the present research addresses three fundamental issues while examining the effectiveness of creativity training. The research design and measures employed attempt to remedy many of the previous methodological concerns outlined above. Also, the study was designed to examine mechanisms that may contribute to increases in creativity through training. Finally, the study addresses a *complete process* of creative problem solving. Before turning to the design of the study, let us discuss what is meant by a complete process of creative problem solving and how our training attempted to deal with these issues.

The problem-solving process trained is based on two major concepts. First, it is seen as having three different stages. It separates problem finding from problem solving and from solution implementation. (For perspective, brainstorming would be seen as only a piece of the second stage.) The second important feature of the process is that within each of the three critical stages, there is a common fundamental process. This is a two-step process called "ideation-evaluation." Ideation is defined as idea generation without evaluation (putting aside the judgment capability). This is the diverging aspect of the two-step process. Evaluation is the reverse. It is defined as the application of judgment to the generated ideas to select the best one(s). This is the converging aspect of the two-step process. Both aspects are believed essential to creativity (Farnham-Diggory, 1972).

There are three major premises underlying training based on this view. First, for most people, the ideation step is more difficult than the evaluation step of the ideation-evaluation process. Our society, general training, and school systems tend to reward and hone our evaluation capabilities and preferences and promote their use virtually to the exclusion of ideation (Thurstone, 1950; Wallach, 1971; MacKinnon, 1962, 1977; Osborn, 1963). Over a period of time evaluation starts to dominate. For example, some research has shown that engineering students upon graduation are less able to use their imaginations than when they entered, 4 years earlier (Altemeyer, 1966; Doktor, 1970). Second, even within the above context, there are individual differences. People differ in their relative preferences, aptitudes, and/or abilities in the two steps of the ideation-evaluation process (Guilford, 1967; Kolb, 1976). Some people may be relatively better in ideation or in evaluation. Third, while the training is designed to strengthen both steps of the ideation-evaluation process, it is expected to have the most effect on that step of the ideation-evaluation process that is least developed in each trainee.

The whole three-stage process model is schematically describable as

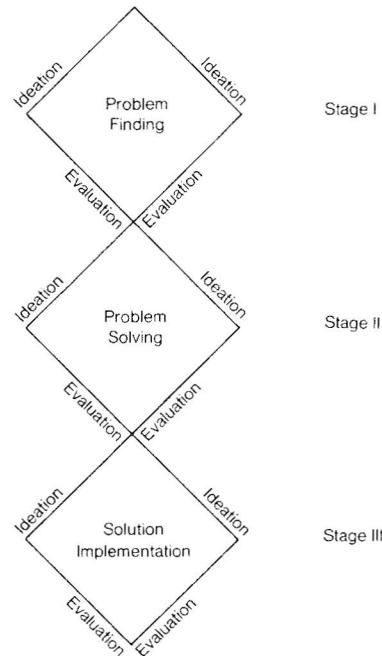


FIG. 1. A "complete creative problem-solving process" emphasizing ideation-evaluation as a two-step process in each of three stages.

shown in Fig. 1. Henceforth, in the rest of this article when reference is made to a "complete process of creative problem solving," what is meant is this three-stage process emphasizing the ideation-evaluation principle at each of the three stages in turn: problem finding, problem solving, and solution implementation. The training measures and all other aspects of this research are based upon this model of oscillating ideation-evaluation. Thus, the notion is that it is not sufficient to merely "solve" a problem creatively. Creativity must also be applied to the implementation of a solution and to the discovery of the problem in the first place. In other words, nothing creative has happened until something "gets done" and also you have got to "start somewhere"; that is, create the problem to be solved.

HYPOTHESES

There were four hypotheses formulated for testing in this research as follows.

In an applied research setting, given a sample that has a relatively low ideation tendency, training in a "complete process of creative problem

solving'' emphasizing the ideation–evaluation process in all stages (see Fig. 1) will lead to

- H₁: An increase in *preference* for ideation.
- H₂: An increase in the *practice* of ideation.
- H_{3A}: Improved *performance* in *problem finding*.
- H_{3B}: Improved *performance* in *problem solving*.

Thus, the hypotheses were limited to the first two stages and to the ideation portion of the two-step ideation–evaluation process of the model shown in Fig. 1.

Even though the evaluation step was not being measured in this research, the reader should always bear in mind that the evaluation step was trained throughout as part of the ideation–evaluation process. Similarly, the implementation stage (see Fig. 1) was not measured either but was similarly emphasized throughout the training. This approach is not only compatible with the concept of a complete process of creative problem solving, but it also focuses on those parts of the ideation–evaluation process that are the more difficult to do.

One reason there has been a preponderance of brainstorming in creativity research is that it is in the ideation stage that most people have more difficulty for the educational and societal reasons cited above. This is also not only why *this* research study focuses on ideation, but also why the particular sample (engineering personnel) was picked. Given their training and their jobs, engineers generally tend to have less of a strength for ideation than for evaluation (MacKinnon, 1962; Kolb, 1976; Altemeyer 1966; Doktor, 1970). This is why engineers are well suited for this study. This was verified for this particular sample by obtaining Learning Style Inventory scores and determining that they were highly consistent with Kolb's research findings (Kolb, 1976). In addition, it must be remembered that the rationale for the training was management's belief that ideation tendencies of this department were too low such that more ideation was specifically sought.

METHOD

Sample

The organization from which the participants were drawn was one involving engineers, engineering managers, and technicians of an engineering department of a large consumer goods industrial company. The participants in the sample have jobs which depend on creativity. Their organization requested the training to try to promote an increase in creative performance. The department was involved in applied research.

From this department's 220 engineers, engineering managers, and technicians, 32 were randomly selected.

Design

The design of the research is a simple true experiment:

$$R \begin{cases} X O_1 O_2 (E) \\ P O_1 O_2 (P) \end{cases}$$

The 32 participants were blocked on job type (as above) and then randomly assigned to two groups within those blocks. The number of participants in each group was thus 16. The two groups were designated "E" (experimental) and "P" (placebo).

The "E" group received a training treatment (X) and the "P" group received a placebo (P).

As discussed more thoroughly later under Procedures, a third group of participants ($n = 13$) was added during the experiment as a convenience group to be analyzed within the design. It was a totally untreated, nonplacebo group designated "U." Because completely random selection was not practical, this group was selected to match the other two groups on job type. Thus, the overall design looked like

$$R \begin{cases} X O_1 O_2 (E) \\ P O_1 O_2 (P) \\ O_1 O_2 (U) \end{cases}$$

$$\text{Total } n = 45$$

Procedures

The procedures of this research were such that the experimental design and measures were meshed with organizational realities and needs. The placebo intervention was designed to be seen by all participants as merely part of the training intervention, and the measures were designed to be seen as actual pieces of the training itself in some cases and as nonevaluative aids to developing future training in other cases.

The treatment consisted of 2 days of intensive training in creative problem solving (see Fig. 1). The training was primarily experiential. Parnes *et al.*, (1977), Prince (1970), and Gordon (1971) provide complete descriptions of various approaches to such training. Training experiences included a series of diverse tasks which permitted and encouraged participants to attempt to discover concepts not considered before, such as

ideation—evaluation and the value of divergence in thinking. For example, participants individually defined a problem from a case and then compared definitions with other participants, discovering that the same problem could then be viewed in many different yet fruitful ways. Another important aspect of the “learning by doing” emphasis was that the teachings and emerging skills in using the complete process (Fig. 1) were also applied to real-world work problems in addition to case studies. For example, each person generated an individual work problem and then developed a solution and implementation plan before leaving the training session. These processes encouraged transference of creativity concepts to personal frames of reference.

The training was presented and conducted as shown in Table 1. Both groups were led to believe they would receive similar training in two phases (training plan as presented in Table 1). In actuality, training was conducted to create placebo and treatment conditions (actual training plan in Table 1).

The placebo *P* consisted of two parts: (1) viewing a 40-min film on creativity (Koestler, 1971) followed by a 20-min guided small group discussion of the film, and (2) three hours of measurements immediately following (1). These measurements were given to all participants as merely a part of the training. The two groups of participants were previ-

TABLE 1
TRAINING PLAN AS PRESENTED TO TRAINEES AND ACTUAL TRAINING PLAN

Training plan	Beginning	2 Weeks later	4 Weeks later
As presented to trainees			
Group 1	Phase I training (1/2 day)	Confidential interviews and questionnaires about the effects of the training on the job (1/2 hr)	Phase II training (2 1/2 days)
Group 2	Phase II training (2 1/2 days)	Confidential interviews and questionnaires about the effects of the training on the job (1/2 hr)	Phase I training (1/2 day)
Actual			
Group 1 (placebo)	1-Hr film viewing/discussion + 3 hr measures	Confidential interviews and questionnaires about the effects of the training on the job (1/2 hr)	2 1/2 Days training
Group 2 (treatment)	2 Days training + 3 hr measures	Confidential interviews and questionnaires about the effects of the training on the job (1/2 hr)	1/2 Day training

ously informed that they would receive the same training (3 days in length) in two different phases, with one group getting Phase I ($\frac{1}{2}$ day) initially, then Phase II ($2\frac{1}{2}$ more days) 4 weeks later, while the other group would receive the Phase II portion initially and the Phase I portion 4 weeks later. The two groups were told that midway between the first and second portion of the training some questionnaire and interview measurements would be taken which would help the trainer understand more about how such training worked.

Within the design, the delayed measures were designed to reflect behavioral changes transported back to the regular work setting. Both groups were led to believe that the initial measurements were part of the training itself and that the final measurements were midtraining observations for the benefit of future training development.

At the 4-week point the final training portion was provided to each group (2 days to the former placebo group and $\frac{1}{2}$ day to the experimental group). Also at this point a third group of participants from the remaining population was obtained to serve as an additional control group. This group was used as a totally untreated, nonplacebo control group. It was selected to match the other two groups of participants on job type and was a convenience group to be inserted and analyzed within the design. This nonplacebo group was told that the trainer wanted to obtain data about some new learning techniques and about training in general. They were told that data would be gathered again in 2 weeks. The same 3 hr of initial measures were administered to this group at the time of the training of the (former) placebo group, and 2 weeks later the remaining measures were taken using these two groups to provide a complete set of measures of the untreated, nonplacebo group.

Shortly after the final measurements on the untreated (U) group were taken, the three groups of participants were debriefed about the training design. About 5 months later, when the data analysis was complete, a full presentation of results was provided to all three groups.

Measurement Methods

There were three methods of measurement: questionnaire, tape recorder, and interview. Within the questionnaire method there were attitudinal self-reports; paper and pencil tasks, all designed to be relevant to the context of the participants' work; and observations of on-the-job behavior by other participants, by supervisors, and by self-report.

The tape-recorder measure was a somewhat novel feature of this research. Each participant was provided with a tape recorder, sent to a

private soundproof room, assured of complete confidentiality, and asked to do an ambiguous task of a problem-finding nature (verbalize "wishes for a new product of the future" for 5 min). Participants were also asked to verbalize everything they were thinking *during* this task, even their thoughts in between task-related ideas. In other words, they were asked to verbalize and record all conscious thought during the task. Each participant practiced the technique before doing the task. Finally, they were assured that although these tape recording sessions might seem to be quite different and unusual tasks, they represented an important part of the training in creative problem solving. Some of the participants later informally volunteered that this tape-recording task was one of the most interesting training experiences they had ever received. The intent of this methodology was to tap into the individuals' stream of conscious thought during a problem-finding task. The tape-recorded responses were later listened to by independent judges blind to condition. Two judges, experienced in creativity training, were used to measure the practice of ideation during problem finding and the quantity of problem-finding ideas (see Fig. 2 for the judges' observation form). Two judges who were experienced product development managers were used to measure quality of problem-finding ideas. In each case, the two judges' scores were averaged for analysis.

Also, both open-ended and direct questions were asked in private confidential interviews with each participant. These interviews were conducted 2 weeks after return to work after either the treatment, placebo, or nonplacebo intervention. The interviews were tape recorded with each participant's permission (to get a better record). The questions concerned their observations of on-the-job behavior of other participants and themselves. Each participant was asked three questions twice, once about all other participants in the training and once about self. The three questions consisted of one open-ended question and then two direct questions. A large sheet of paper with all participants' names prominently displayed was posted in full view of the interviewee.

Here is a big sheet with a list of all the participants in the training.

1. What changes have you noticed, if any, in any of these participants in how they go about doing things on the job since the training?
2. What changes have you noticed, if any, in any of these participants in their ability to recognize and define problems on the job?
3. Same as above in (2) except the question was for "keeping an open mind."
(For each change volunteered for each person, a probe was made to pinpoint the specific change, and a specific rating on a 1 to 5 scale of size and direction of change was obtained, where (± 5 indicated a large change for the better/worse, and ± 1 indicated a small change for the better/worse.)

TASK Wishes for a new product

PERSON DOING TASK: _____

LISTENER/JUDGE: _____

MINUTE	No. of different wishes verbalized	No. of negative evaluative comments made on wishes verbalized	Estimated # of seconds spent in DIVERGENT, non-evaluative (or positive) verbalizing of wishes	Estimated # of seconds spent in EVALUATIVE negative thoughts about the wishes verbalized	Estimated DEAD AIR TIME (in seconds) (i.e., nothing verbalized at all)	Estimated BLANK TIME (in seconds) verbalized (e.g., "can't think of anything to say now" or "I'm stuck now").	Estimated # of seconds spent on non-evaluative DISCUSSION of a wish (rambling, explaining etc., a wish in detail)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
TOTALS	_____ Wishes	_____	_____	_____	_____	_____	_____
	_____ Seconds						

FIG. 2. Verbalized thinking observation form.

Then all three questions and rating procedure were repeated concerning the participant as self (self-report).

Final Measures

With these three methods, an attempt was made to get as much data as possible. There were 51 initial measures which were then subjected to an initial screening process. All 51 of the initial measures were scrutinized for possible deletion, revision, or incorporation into composite measures. It was desired to reduce the quantity, eliminate redundancy, and improve the quality of the final measures.

Twenty-four measures emerged from this process of which 22 are described below. (The two not described were omitted because of a further analysis which is described later.) Estimates of reliability are shown in parentheses.

1. Measures Obtained Immediately After Training

A. By Questionnaire

1. Tolerance for Ambiguity ($\alpha = .49$; see Budner, 1962). This is a 16-item scale developed by Budner (1962) which attempts to measure an individual's tendency to perceive ambiguous situations as desirable. This scale was chosen as a possible measure of an individual's PREFERENCE FOR IDEATION.

2, 3. Preference for Intuition rather than Sensing and Preference for Perception rather than Judgment. Mendelsohn (1965) estimated test-retest reliabilities for both scales to be .70. These are two of the four scales which make up the Myers-Briggs Type Indicator (MBTI) (Briggs-Myers, 1976). The first scale attempts to measure the tendency of an individual to prefer to look for possibilities than to work with known facts. The second scale attempts to measure preference for a flexible spontaneous approach to life more than a planned, orderly, decided way. There are 50 items of a multiple-choice nature across the two scales. They were each chosen as a possible measure of an individual's PREFERENCE FOR IDEATION.

4. Deferral of Critical Judgment ($\alpha = .45$). This is a 7-item scale newly developed for this research specifically to attempt to measure PREFERENCE FOR IDEATION (rather than evaluating ideas prematurely). Participants are asked to respond to each item on a 5-point scale from Strongly Agree to Strongly Disagree. For example, one item is "I feel that all ideas should be given equal time and listened to with an open mind regardless of how zany they seem to be."

5. First Reaction to New Unusual Product Ideas ($\alpha = .84$). This also is a newly developed measure. Participants were asked to react to each of

eight unusual or "wild" household product ideas on two 1–10 scales. An example is provided below.

"GREASE EATING ANT ARMY"

Live ants bred to eat greasy soils off surfaces. You buy them by the can and set them free in your kitchen. The ant self-destructs when it's finished eating.

FIRST REACTIONS (check one point on each scale)

1	2	3	4	5	6	7	8	9	10
I see nothing good in this idea at all								I see lots of good in this idea	
1	2	3	4	5	6	7	8	9	10
I would be very unwilling to listen to any more about this idea								I would be very willing to listen to more about this idea	

Scores on the two scales were combined to provide an indication of an individuals' PREFERENCE FOR IDEATION via a speculative, positive approach to ideas ventured.

6. Total Reaction to a New Unusual Product Idea ($\alpha = .91$). This measure also measured PREFERENCE FOR IDEATION and was similar to the above "First Reaction" measure except that participants were asked to *write a full* reaction to one presented "wild" idea as below:

Instructions

Attached is a new idea just recently thought of by one of our Product Development people. It is just a raw, "germ of an idea," far from being fully developed at this stage. If you had a chance to talk to this person about the idea, what would you say?

PLEASE WRITE AS MUCH AS YOU CAN—GIVE YOUR *TOTAL REACTION* AND MAKE AS MANY COMMENTS AS YOU CAN.

IDEA:

"MAKE YOUR DOG A WALKING DUST MOP"

Let Your Dog Do It!: Dogs, cats, etc., hold their own (and more). Clean pets with dirt/dust/hair clinger. Every dirt, dust particle (and those shedding hairs) around your house will be there but on "man's best friend's" back. The only thing you need to clean then is your *dog*. The more pets, the cleaner your house.

What would you say to this person? (Give your *TOTAL REACTION* in the space below.)

Two expert judges scored the respondents' reactions to the idea on a 1 (very negative reaction) to 10 scale (very positive reaction). Interjudge

reliability was calculated as the Pearson product-moment correlation coefficient. The judges' scores were averaged.

7. Number of Optional Problem Definitions Developed before Choosing One as Best. (For this measure reliability was calculated to be 0.82 by the parallel forms method as described by Lord & Novick, 1968b). Three different but parallel case study problem situations were given to each participant with instructions to *define*, not to solve, the problem in each, and, *if desired*, to list optional problem definitions before zeroing in on one as "best." The participant's score on each study was the number of optional problem definitions listed. The final measure was formed by averaging these three scores. It was thought that this measure might reflect PREFERENCE FOR IDEATION OR PROBLEM-FINDING PERFORMANCE. The first two case studies were taken directly from the literature (Parnes *et al.*, 1977), and the third one was newly developed from documented historical data on a major product development innovation effort (Petus, 1968).

B. By Tape Recording

Five measures resulted from the observations of the tape-recorded behavior (see Fig. 2). These are listed below with reliability data calculated as intercorrelations between two expert judges.

1. Number of Negative Judgments Expressed per Minute on Wishes Thought of during Private Divergent Thinking Task (.76).
2. Amount of Time Spent in Negative Evaluative Thinking on Wishes Thought of during Private Divergent Thinking Task (.71).
3. Amount of Time Spent in Divergent Thought during Private Divergent Thinking Task (.76).
4. Number of Wishes Generated during Private Divergent Thinking Task (.95).
5. Creative Quality of Wishes Generated during Private Divergent Thinking Task. (The Jackson & Messick (1964) methodology of assessing creativity of product was used by the judges. Reliability was calculated as .53.)

Measures 1 and 2 were seen as measuring PRACTICE OF IDEATION; measures 3, 4, and 5 reflect PROBLEM-FINDING PERFORMANCE.

2. Measures Obtained 2 Weeks after Return to Work Setting

(The same 1-5 rating scale for size and direction of changes described earlier under Measurement Methods was used for all the measures below.)

A. By Questionnaire

Confidential questionnaires to all participants and to their supervisors provided the following four on-the-job behavior measures.

1. Change Noticed in Self Being More Open Minded to New Ideas and Approaches. (Intercorrelation of individual participant's self-report with the mean rating by other participants = .52).

2. Change Noticed by Others in Being More Open Minded to Ideas and Approaches. (Intercorrelation of mean rating by other participants with individual participant's self-report = .52).

3. Change Noticed by Supervisor (since the training) in Ability to Recognize and Define Fuzzy, Ill-Defined Problems. (Test-retest reliability by Pearson product-moment correlation coefficient = .71).

4. Change Noticed by Supervisor (since the training) in Ability to Come Up with Creative Ideas on Already Well-Defined Problems. (Test-retest reliability by Pearson product-moment correlation coefficient = .73).

Reliabilities for Measures 3 and 4 were estimated by having supervisors make judgments on two different occasions separated by 1 to 2 work days. Measures 1 and 2 were intended to reflect PRACTICE OF IDEATION and 3 and 4 to reflect PROBLEM-FINDING PERFORMANCE AND PROBLEM-SOLVING PERFORMANCE, respectively.

B. By Interview

Open-ended and direct questions yielded the following six on-the-job behavior measures and reliabilities based on Pearson correlation coefficients between individual participant's self-report rating and the mean of the other participants' ratings of that participant.

1. Change Noticed in Self in Being More Open Minded to New Ideas and Approaches (.43).

2. Change Noticed by Others in Being More Open Minded to New Ideas and Approaches (.43).

3. Change Noticed in Self in Being Less Likely to Jump to Conclusions as to What the Real Problem Is (.38).

4. Change Noticed by Others in Being Less Likely to Jump to Conclusions as to What the Real Problem Is (.38).

5. Change Noticed by Others in Being More Likely to Try Unusual or Creative Approaches to the Problems (.29).

6. Change Noticed by Self in Being More Likely to Pause to Try Unusual or Creative Approaches to Problems (.29).

All these measures were to reflect PRACTICE OF IDEATION.

Analysis

Our four formal hypotheses predict effects on the outcomes of (1) preference for ideation, (2) practice of ideation, (3) performance in problem finding, and (4) performance in problem solving. Therefore, an attempt was made to sort the dependent variables into these four clusters.

TABLE 2
CLUSTER MATRIX

Measure	Preference for ideation in		Practice of ideation in		Problem- finding performance	Problem- solving performance
	Problem finding	Problem solving	Problem finding ^a	Problem solving		
Tolerance for Ambiguity	1					
Preference for Intuition rather than Sensing	1					
Preference for Perception rather than Judgment	1					
Deferral of Critical Judgment		1				
First Reaction to New Unusual Product Ideas		1				
Total Reaction to a New Unusual Product Idea		1				
Number of Optional Problem Definitions Developed before Choosing One as Best					1	
Change Noticed in being More Open Minded to New Ideas and Approaches						
In self				1		
By others				1		
Change Noticed by Supervisor in Ability To Recognize and Define Fuzzy, Ill-Defined Problems						1
Come Up with Creative Ideas on Already Well-Defined Problems						1
Number of Negative Judgments Expressed per Minute on Wishes Thought of during Private Divergent Thinking Task				-1		

Amount of Time Spent in Negative Evaluative Thinking on Wishes Thought of during Private Divergent Thinking Task	-1	
Amount of Time Spent in Divergent Thought during Private Divergent Thinking Task		1
Number of wishes Generated during Private Divergent Thinking Task		1
Creative Quality of Wishes Generated during Private Divergent Thinking Task		1
Change Noticed in Being More Open Minded to New Ideas and Approaches		
In self	1	
By others	1	
Change Noticed in Being Less Likely To Jump to Conclusions As to What the Real Problem Is		
In self	1	
By others	1	
Change Noticed in Being More Likely To Pause To Try Unusual or Creative Approaches to Problems		
In self	1	
By others	1	

^a Since both measures are negatively associated with ideation, they were reflected before summing.

The clustering procedure was as follows. (Recall that with three meth-

ods an attempt was made to get as much data as possible resulting in a proliferation of initial measures.) First, the 51 initial measures were screened to exclude measures which were merely arithmetic combinations of other very similar measures. When reliabilities of such similar measures were relatively high, they were collapsed into one, either by averaging or by selecting the one measure theoretically most representative of the construct intended to be reflected by the measures. When reliabilities of such measures were low, they were composited in hopes of getting an improved reliability. Measures of very low reliability were deleted if other similar alternative measures with higher reliabilities were available for compositing. In this way the list of measures was reduced to 24. Second, the 24 remaining variables were subjected to a cluster analysis to aid in the task of sorting them into the above four outcome clusters. Third, based upon correlations between measures and upon content of the scales, each measure was to be assigned to one and only one outcome cluster. Ideally, we would end up with all 24 measures fitting neatly into the four hypothesized outcome clusters.

However, empirical research seldom cooperates to produce such neat outcome clusters and this study was no exception. Instead of the four hypothesized clusters for the 24 variables, 22 of these variables required six clusters. Two of the measures did not fit into any of the six clusters. In addition, five of the variables fitted into two separate clusters each.

The final six clusters and their defining measures are shown in Table 2. As can be seen in Table 2, the four hypothesized clusters were expanded to six by splitting both preference and practice of ideation into problem finding and problem solving. Thus, we were forced to revise our a priori outcome classification based upon the correlations between outcome measures. In those cases where a measure shared adequate common variance with two separate clusters, it was placed in the one cluster where it shared the more content similarity.¹

Our success in sorting outcome variables into clusters is demonstrated in Table 3. As shown in this table, the unit-weighted cluster scores show decent homogeneity with the exception of the two clusters involving preference. Moreover, the correlations between clusters reveal adequate separation. It should be noted that no claim is made for the stability of these clusters. On the contrary, this procedure was employed to reduce the redundancy in the outcomes tested. This was accomplished as can be seen in Table 3.

Testing of the formal hypotheses was performed using a "protected procedure" throughout as follows. An overall F test was applied to the

¹ The complete cluster output is available from the senior author.

TABLE 3
INTERCORRELATIONS OF DERIVED SCORES REPRESENTING THE SIX DIMENSIONS^a

	Preference for ideation in		Practice of ideation in		Problem-finding performance	Problem-solving performance
	Problem finding	Problem solving	Problem finding	Problem solving		
Preference for ideation in problem finding	.55					
Preference for ideation in problem solving	.03	.60				
Practice of ideation in problem finding	.26	.09	.94			
Practice of ideation in problem solving	.18	.39	.32	.87		
Problem-finding performance	.30	.37	.33	.49	.83	
Problem-solving performance	.04	.35	.21	.35	.22	.73

^a Cronbach alphas have been inserted along the diagonal.

effect of the treatment on an outcome measure, and only when the overall test demonstrated statistical significance were the three pair-wise comparisons tested and interpreted post hoc. Thus, when the overall test failed to show statistical significance, the three contrasts between experimental, placebo, and untreated groups were not interpreted (Cramen & Swanson, 1973). The overall F test was a weighted-means analysis of variance with a single treatment factor (experimental, placebo, and untreated) (Winer, 1962).

RESULTS

Results are presented for individual outcome measures grouped by formal hypothesis. Hypotheses 1 and 2 were each separated into two subhypotheses following the results of the clustering procedure. For each hypothesis the three group means and the results of the three pair-wise contrasts for each measure are shown.

Hypothesis H_{1A}

H_{1A}: In an applied research setting, given a sample that has a relatively low ideation tendency, training in a "complete process of creative problem solving" emphasizing the ideation-evaluation process in all stages (see Fig. 1) will lead to an increase in preference for ideation in problem finding.

Three outcome measures (Tolerance for Ambiguity, Preference for Intuition rather than Sensing, and Preference for Perception rather than Judgment) were clustered as appropriate outcomes for this hypothesis. All three measures were taken immediately after training using questionnaires.

This hypothesis was not supported. The overall F test was not significant on either of the three outcome measures. The F ratio was highest (but not significant) on the Preference for Intuition over Sensing measure. On this measure, a post hoc t test comparing experimental versus the placebo contrast was significant ($p \leq .05$), but using our "protected procedure," all of the six comparisons are interpreted as not being significant on this measure.

Hypothesis H_{1B}: Preference for Ideation in Problem Solving

Three outcome measures (First Reaction to New Unusual Product Ideas, Total Reaction to New Unusual Product Ideas, and Deferral of Critical Judgment) were clustered as appropriate for this hypothesis. All three were assessed immediately after training by questionnaire.

As shown in Table 4, all three measures demonstrated significant ($p \leq .05$) effects overall. In addition, all three measures showed at least one significant ($p \leq .05$) supportive contrast. On all three measures, the experimental mean was higher than that for the comparison. In all, four of

the six supportive contrasts were significant ($p \leq .05$). None of the three contrasts between placebo and untreated approached significance.

Hypothesis H_{2A}: Practice of Ideation in Problem Finding

Two measures (Number of Negative Judgments Made per Minute and Amount of Time Spent in Negative Evaluation) were clustered as appropriate for this hypothesis. Both of these measures were derived from the thinking-out-loud task completed immediately after training.

As shown in Table 5, both of these measures showed significant ($p \leq .05$) effects overall and showed significant supportive contrasts and non-significance for the placebo vs untreated contrast. Thus, the experimental group made fewer negative judgments and spent less time making negative evaluations during a divergent thinking task than either the placebo or untreated groups.

Hypothesis H_{2B}: Practice of Ideation in Problem Solving

Eight measures (all assessed 2 weeks after training) were clustered as appropriate to this hypothesis. Four of these measures were reported by the participant's co-workers about the participant and four were self-reports of the participant. Both co-workers and participants responded to the same queries: (1) change in participant's openmindedness to new ideas and approaches (by questionnaire and by interview), (2) change in participant's tendency to jump to conclusions (interview), and (3) change

TABLE 4
PREFERENCE FOR IDEATION IN PROBLEM SOLVING AS MEASURED BY QUESTIONNAIRE

Measures ^a	First Reaction to New Unusual Product Ideas	Total Reaction to a New Unusual Product Idea	Deferral of Critical Judgment
Group means			
1. Experimental	5.5	6.0	12.6
2. Placebo	4.5	3.8*	10.9*
3. Untreated	4.3*	4.0	9.4**
Tests of statistical significance ($\alpha = .05$)			
Group 1 vs 2	ns ($p = .073$)	* $p = .020$	* $p = .044$
Group 1 vs 3	* $p = .031$	ns ($p = .062$)	** $p = .001$
Group 2 vs 3	ns	ns	ns
F(2,42)	3.6*	3.8*	6.7**

^a All measures taken immediately after training/placebo/nonplacebo.

* $p \leq .05$.

** $p \leq .01$.


 TABLE 5

PRACTICE OF IDEATION IN PROBLEM FINDING AS MEASURED BY TAPE-RECORDED, "THINKING-OUT-LOUD" TASK DURING AN INDIVIDUAL DIVERGENT THINKING TASK

Measures ^a	No. of Negative Judgments Made per Minute	Amount of Time (in seconds) Spent in Negative Evaluation
Group means		
1. Experimental	.06	2.3
2. Placebo	.34**	11.9*
3. Untreated	.36**	17.3**
Tests of statistical significance ($\alpha = .05$)		
Group 1 vs 2	** $p = .004$	* $p = .017$
Group 1 vs 3	** $p = .013$	** $p = .001$
Group 2 vs 3	ns	ns
$F(2,42)$	5.4**	4.5*

^a All measures taken immediately after training/placebo/nonplacebo.

* $p \leq .05$.

** $p \leq .01$.

in participant's tendency to try unusual approaches to solving problems (interview).

As shown in Table 6, all eight measures demonstrated significance ($p \leq .05$), and none of the placebo vs untreated contrasts was significant. All of the differences were in the supportive direction.

Hypothesis H_{3A}: Problem-Finding Performance

Three measures derived from the tape-recorded, thinking-out-loud task (Creative Quality and Quantity and Time Spent in Divergent Problem Finding) and one questionnaire measure (Number of Different Problem Definitions Developed) were clustered as appropriate to this hypothesis.

As can be seen in Table 7, all four measures produced significance ($p \leq .05$) overall and all four showed both supportive contrasts significant ($p \leq .05$). None of the differences between placebo and untreated groups was significant. Again, all mean differences were in the supportive direction.

Hypothesis H_{3B}: Problem-Solving Performance

Two measures (Superior's Ratings of Change in Ability to Recognize and Define Fuzzy Problems and Change in Ability to Come Up with Creative Ideas on Already Well-Defined Problems) were clustered as appropriate to this hypothesis. Both of these measures were taken 2 weeks after training.

This was the second most weakly supported hypothesis of the six. Only Creativity on Well-Defined Problems was significant ($p \leq .05$) overall. Moreover, on this measure, the experimental group mean was signifi-

TABLE 6
PRACTICE OF IDEATION IN PROBLEM SOLVING
METHOD OF MEASUREMENT

Measures ^a	Questionnaire				Interview			
	Change Noticed in Being				Change Noticed in Being			
	More Openminded to New Ideas and Approaches		More Openminded to New Ideas and Approaches		Less Likely to Jump to Conclusions as to what Is the Real Problem		More Likely to Pause to Try Unusual or Creative Approaches to Solving Problems	
	By self	By others	By self	By others	By self	By others	By self	By others
Group means								
1. Experimental	+3.6	+1.5	+3.0	+0.63	+2.1	+.52	+1.8	+0.67
2. Placebo	+1.8**	+1.0*	+0.7**	+0.30*	+0.1**	+.19	+0.6	+0.07**
3. Untreated	+1.2**	+0.9*	+1.2**	+0.17**	+0.4**	+.04**	+0.2*	+0.00**
Tests of statistical significance ($\alpha = .05$)								
Group 1 vs 2	** $p = .001$	* $p = .045$	** $p < .001$	* $p = .050$	** $p < .001$	ns($p = .067$)	ns($p = .076$)	** $p = .002$
Group 1 vs 3	** $p = .001$	* $p = .022$	** $p < .001$	** $p = .007$	** $p < .001$	** $p = .005$	* $p = .026$	** $p = .001$
Group 2 vs 3	ns	ns	ns	ns	ns	ns	ns	ns
$F(2,42)$	14.4**	3.5*	13.3**	5.2**	20.4**	5.1**	3.5*	13.5*

^a All measures taken 2 weeks after return to work.

* $p \leq .05$.

** $p \leq .01$.

TABLE 7
PROBLEM-FINDING PERFORMANCE

Measures ^a	Method of measurement			
	Tape-recorded, thinking-out-loud ^b task: Wishes generated for a new product of the future			Questionnaire
	Creative quality (based on Jackson & Messick's 4 criteria of a creative product)	Quantity (total number of wishes generated)	Amount of time (in seconds) spent in divergent, problem- finding thought during task	Number of different problem definitions developed prior to choosing one as best
Group means				
1. Experimental	1.8	24.3	177.7	8.4
2. Placebo	1.1*	13.9*	121.4**	2.6**
3. Untreated	1.0**	12.2**	120.6**	2.5**
Tests of statistical significance (^a $\alpha = .05$)				
Group 1 vs 2	* $p = .015$	* $p = .020$	** $p = .009$	** $p = .002$
Group 1 vs 3	** $p = .004$	** $p = .007$	** $p = .012$	** $p = .002$
Group 2 vs 3	ns	ns	ns	ns
$F(2,42)$	5.4**	6.3**	4.8**	12.0**

^a All measures taken immediately after training/placebo/nonplacebo.

* $p \leq .01$.

** $p \leq .05$.

cantly ($p \leq .05$) higher than that of the untreated group but not significantly ($p = .061$) higher than that of the placebo group.

Summary of Results

A summary of the results² is shown in Table 8. As shown in this table, 31 out of a total possible of 44 supportive contrasts with the experimental group were significant ($p \leq .05$). None of the 22 contrasts between placebo and untreated groups was significant. Moreover, five of the six hypotheses were supported by at least one significant contrast.

In terms of empirical support, two hypotheses (1A: Preference for Ideation in Problem Finding and 3B: Problem-Solving Performance) received the weakest support; two hypotheses (1B: Preference for Ideation in Problem Solving and 2B: Practice of Ideation in Problem Solving) received strong support, and two hypotheses (2A: Practice of Ideation in Problem Finding and Problem-Finding Performance) received complete support.

DISCUSSION

This study suggests that 2 days of training (16 hr) in a "complete process of creative problem solving" emphasizing the ideation-evaluation process in all stages (see Fig. 1) can make a measurable impact on individuals' attitudes and behaviors. The impact is evident and systematically measurable not only immediately after the training, but also at least 2 weeks after return to the work setting. Overall, the results strongly supported four of the six hypotheses. In particular, this study suggests that individuals receiving such training in an applied research setting, especially if they are relatively low in ideation tendency, show significant differences compared to controls in (1) preference for ideation in problem *solving* (H_{1B}), but maybe not in problem *finding* (H_{1A}); (2) practice of ideation in both problem *finding* and problem *solving* (H_{2A} and H_{2B}); and (3) problem-*finding* performance (H_{3A}), but maybe not in problem-*solving* performance (H_{3B}).

The effects of the training appear to be fairly generalized. There is evidence of changes in cognitive (e.g., time spent in different modes of thinking), attitudinal (e.g., openness to ideas), and behavioral (e.g., number of negative judgments made on ideas, not jumping to conclusions) processes. All three arenas appear actively involved in this training. Because the effects of training are more likely to endure when multiple aspects of behavior are influenced, the authors are encouraged by this generalizability.

The authors also believe it is significant that some changes in the be-

² For completeness, tables for hypotheses 1A and 3B are available on request from the senior author.

TABLE 8
PROPORTION OF INDIVIDUAL MEASURE COMPARISONS SUPPORTING EACH HYPOTHESIS^a

In an applied research setting, given a sample that has a relatively low ideation tendency, training in a "complete process of problem solving" emphasizing the ideation-evaluation process in all stages (Fig. 1) will lead to an increase in

	Preference for ideation in problem finding (H _{1A})	Preference for ideation in problem solving (H _{1B})	Practice of ideation in problem finding (H _{2A})	Practice of ideation in problem solving (H _{2B})	Problem-finding performance (H _{3A})	Problem-solving performance (H _{3B})
Immediately after training	0/6 (One method)	4/6 (One method)	4/4 (One method)	NA	8/8 (Two methods)	NA
Two weeks after return to work setting	NA ^b	NA	NA	14/16 (Two methods)	NA	1/4 (One method)

^a Expressed as the fraction of the total, the number of comparisons providing a significantly higher mean score vs placebo/nonplacebo at $\alpha = .05$.

^b NA, not applicable (i.e., no measures available).

havior patterns of trainees were great enough to be readily observable by co-workers even back on the job. Thus, the training appears to translate (at least in the short run) into actual changes in job behavior. This relationship was stronger for the practice of ideation than for problem-solving performance. Measures relying on co-workers' judgments of on-the-job practice of ideation demonstrated positive results for 14 out of 16 comparisons. On the other hand, of the four available comparisons using superiors' judgments of problem-solving performance, only one of the four comparisons was positive. It may be possible that the effects of the training on this construct dissipated fairly quickly once the training was over, or that the impact was so small as not to be noticeable, or that other exogenous factors intruded to neutralize impact of the training on performance. The first possibility mentioned above might be the most plausible since hypothesis 3A, which also concerned a performance construct (problem-finding performance) *was* supported and was evaluated immediately after the training. Future research should be designed to check this by measuring all the constructs both immediately after training and later back in the work setting. Additionally, as mentioned earlier, it may be that a longer duration, more intensive training design is needed to affect performance on the job. The evidence of effects after 2 weeks back on the job, however, is encouraging. It suggests that the training has at least some lasting (2 weeks) effects.

One interesting anomaly in the results is that preference for ideation in problem finding was virtually not affected by the treatment, yet practice and performance in problem finding showed strong effects. It may be the case that one is able to get participants to *do* problem finding (cognitive and behavioral) yet still not *like* problem finding (attitudinal). Problem finding for many people in our culture appears to be a somewhat unfamiliar chore, especially for people who tend to operate more in problem-solving or solution-implementation modes (e.g., business people and engineers in more applied work). Thus, perhaps participants do not *like* problem finding, but maybe they can be induced to practice it and improve performance in it. Furthermore, since preference for ideation in problem *solving* was strongly affected, it may be that it is more difficult to change preference for ideation in the problem-finding stage than in the problem-solving stage. Longer, more intensive training may be needed to change preferences for ideation in problem finding. This may be especially true for participants with a relatively lower ideation tendency.

Future Directions for Research

One direction is to test the elements of Fig. 1 more completely, particularly the evaluation and implementation stages. Furthermore, the creativity talent identification research, both cognitive and personality,

could be integrated into empirical tests of the model. For example, it remains to be seen whether this training influences different personality or cognitive traits differentially, or whether one can identify more creative people by their behavior during such training, or whether greater gains in organizational creativity could be realized by focusing training only on people possessing certain traits.

A second research direction involves generalizability. One of the limitations of this study is that it concerns only one organizational sample. Future studies should cover different types of organizations (e.g., hospitals, government, and education institutions); different organizational functions (e.g., marketing, finance, market research, and manufacturing); and other organizational levels, such as upper, middle, and lower management and nonmanagement salaried and hourly paid workers.

A third research direction would be to attempt to clarify and replicate the training effects discovered in this study. For example, increasing base size and strengthening the internal consistency and reliabilities of measures, especially for some of the on-the-job observation measures, is in order. Further, developing improved methods to measure all hypothesized constructs would appear to be a most fruitful opportunity for some creative methodological work.

A fourth research direction would be to negotiate opportunities to study portability of effects for longer periods, say 6 months or a year.

Finally, an interesting line of research would be to explore the relative contributions of ideation and evaluation at each of the three stages of the process (Fig. 1). Also, one might question whether these relative contributions differ by task. For example, perhaps in high-pressure, high-implementation-oriented jobs, the contribution or importance of evaluation is relatively higher than ideation. Perhaps there are optimum ideation evaluation ratios which differ by stage for any job or organization.

Summary

This study leads the authors to feel that creativity-training research is still very primitive, but are very encouraged by these results. There is much to feel encouraged about. For example, the effects found were evident even with the small sample. Further, theoretical models integrating diverse elements appear feasible. Also, several new speculations have been raised by the data and the literature search which could lead to new insights. Finally, several future directions for research have been identified. In conclusion, it appears that creativity, in the narrow sense of this research, can be influenced by training. At present, linking it to problem-solving performance in an organization is problematic. This may require a better understanding of moderators of ideation-performance links. For example, organizational factors such as organization type, kind of task,

value and reward system, time pressures, and nature of immediate work group and working relationship with supervision may significantly affect the usefulness of increased ideation. It appears, however, to be a question that merits additional research.

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