
The Effectiveness of Creativity Training: A Quantitative Review

Ginamarie Scott, Lyle E. Leritz, and Michael D. Mumford

The University of Oklahoma

ABSTRACT: Over the course of the last half century, numerous training programs intended to develop creativity capacities have been proposed. In this study, a quantitative meta-analysis of program evaluation efforts was conducted. Based on 70 prior studies, it was found that well-designed creativity training programs typically induce gains in performance with these effects generalizing across criteria, settings, and target populations. Moreover, these effects held when internal validity considerations were taken into account. An examination of the factors contributing to the relative effectiveness of these training programs indicated that more successful programs were likely to focus on development of cognitive skills and the heuristics involved in skill application, using realistic exercises appropriate to the domain at hand. The implications of these observations for the development of creativity through educational and training interventions are discussed along with directions for future research.

Few attributes of human performance have as much impact on our lives, and our world, as creativity. Outstanding achievement in the arts and sciences is held to depend on creativity (Fiest & Gorman, 1998; Kaufman, 2002; McKinnon, 1962). Creativity has been linked to the development of new social institutions and the leadership of extant institutions (Bass, 1990; Mumford, 2002). Creativity, moreover, has been shown to play a role in entrepreneurial activities and long-term economic growth (Amabile, 1997; Simonton, 1999; Wise, 1992). On a more prosaic level, the “good” jobs available in modern information-based economies stress creative thought (Enson, Cottam, & Band, 2001; McGourty, Tarshis, & Dominick, 1996; Mumford, Peterson, & Childs, 1999) whereas creativity has been linked to well-being and successful adap-

tation to the demands of daily life (A. J. Cropley, 1990; Reiter-Palmon, Mumford, & Threlfall, 1998).

The varied effects of creativity on the nature and quality of our lives begs a question. How can we stimulate people’s creative efforts? In fact, a number of approaches have been used to encourage creativity, including (a) provisioning of effective incentives (e.g., Collins & Amabile, 1999; Eisenberger & Shanock, 2003), (b) acquisition of requisite expertise (e.g., Ericsson & Charness, 1994; Weisberg, 1999), (c) effective structuring of group interactions (e.g., King & Anderson, 1990; Kurtzberg & Amabile, 2001), (d) optimization of climate and culture (e.g., Amabile & Gyskiewicz, 1989; Anderson & West, 1998; Ekvall & Ryhammer, 1999), (e) identification of requisite career development experiences (e.g., Feldman, 1999; Zuckerman, 1974), and (f) training to enhance creativity (e.g., A. J. Cropley, 1997; Nickerson, 1999; Torrance, 1972).

Of these interventions, training has been a preferred, if not the favored, approach for enhancing creativity (Montouri, 1992). Both organizations and educational institutions have invested substantial time and resources in the development and deployment of creativity training. For example, Solomon (1990), drawing from survey data, found that 25% of the organizations employing more than 100 people offer some form of creativity training. Creativity training has been developed for occupations ranging from marketing (Rickards & Freedman, 1979), business management (Basadur, Wakabayashi, & Takai, 1992) and educational administration (Burstiner, 1973), to medicine

Correspondence and requests for reprints should be sent to Michael Mumford, Department of Psychology, The University of Oklahoma, Norman, OK 73019. E-mail: mmumford@ou.edu

(Estrada, Isen, & Young, 1994) and engineering (Basadur, Graen, & Scandura, 1986). Creativity training, moreover, executed as either distinct course segments or embedded exercises, is often a key component of educational programs for the gifted and talented (Kay, 1998; Renzulli, 1994). Creativity training, in fact, has been developed for virtually every student population including kindergarten students (Meador, 1994), elementary school students (Castillo, 1998; Clements, 1991), high school students (Fritz, 1993), college students (Daniels, Heath, & Enns, 1985; Glover, 1980), disadvantaged students (Davis et al., 1972), disabled students (Jaben, 1983, 1985a), athletes (Kovac, 1998), art students (Rump, 1982), science students (McCormack, 1971, 1974), and engineering students (Clapham & Schuster, 1992).

As might be expected, based on these wide-ranging applications, creativity training comes in many forms. Smith (1998), in a review of training program content, identified 172 techniques, or instructional methods, that have, at one time or another, been used to develop divergent thinking skills. Bull, Montgomery, and Baloché (1995), in a more focused review of college level creativity courses, identified some 70 techniques that were viewed as important components of instruction. Not only do these courses differ with respect to content, they also display some marked differences with respect to method of delivery. For example, Warren and Davis's (1969) program stresses guided practice whereas Fontenot's (1993) program places a greater emphasis on lecture and discussion. Clapham (1997) described a training program that is less than 1 hr long. Reese, Parnes, Treffinger, and Kaltsounis (1976) described a training program that extended over multiple semesters.

The widespread application of creativity training, coupled with the marked variability observed in content and delivery methods, leads to our two primary goals in this investigation. First, we hoped to provide a reasonably compelling assessment of the overall effectiveness of creativity training through a quantitative analysis of prior program evaluation efforts. Second, we hoped to identify the key characteristics of training content and delivery methods that influenced the relative success of these training efforts. Before turning to the findings emerging from this review, however, it would seem germane to provide some background concerning creativity, in general, and the major approaches used in creativity training.

Creativity Training

Metatheoretical Assumptions

Creativity ultimately involves the production of original, potentially workable, solutions to novel, ill-defined problems of relatively high complexity (Besemer & O'Quin, 1999; Lubart, 2001). What must be recognized here, however, is that the production of workable new solutions to novel, ill-defined problems in most "real-world" settings is influenced by a number of different types of variables (Mumford & Gustafson, 1988). For example, creativity can be understood in terms of the cognitive processes by which people work with knowledge in the generation of ideas (Baughman & Mumford, 1995; Bink & Marsh, 2000; Finke, Ward, & Smith, 1992; Qin & Simon, 1990; Sternberg, 1988; Weisberg, 1999). However, one might also understand creativity in terms of more basic associational and affective mechanisms (Eysenck, 1992; Kaufmann, 2003; Martindale, 1999; Vosberg, 1997). Still another way one might seek to understand creativity is through the dispositional and motivational characteristics that prompt people to engage in creative efforts (Collins & Amabile, 1999; Domino, Short, Evans, & Romano, 2002; McCrae, 1987). Alternatively, creativity might be viewed as one outcome of career strategies and successful exploitation of various environmental opportunities (Kasoff, 1995; Rubenson & Runco, 1992; Simonton, 1999).

Differences in the framework used to understand the creative act influence the kind of training strategies applied. Thus, scholars who see problem solving as a central aspect of creativity often use techniques based on the heuristics that allow people to effectively apply available expertise (Mumford, Baughman, & Sager, 2003). Scholars who see associational mechanisms as being a particularly important aspect of creativity, however, are more likely to apply imagery techniques in training (Gur & Reyher, 1976). In their review of college courses, Bull et al. (1995) identified a number of general approaches applied in the development of creativity training including (a) cognitive approaches, (b) personality approaches, (c) motivational approaches, and (d) social interactional approaches.

In addition to these differences in metatheoretical models, two other overarching assumptions shape the content and structure of creativity training. One of these differences derives from the framework underly-

ing course design. In some cases theoretical models bearing on some aspect of creativity provide the basis for development of an integrated, programmatic, set of training interventions. This model-based approach is evident in training programs derived from theories of lateral thinking (DeBono, 1971, 1985), productive thinking (Covington, Crutchfield, Davies, & Olton, 1970), and creative problem solving (Parnes & Noller, 1972; Treffinger, 1995). Other forms of creativity training, however, eschew general models relying on assemblies of theory independent techniques, such as brainstorming (Muttagi, 1981) or metaphor generation (Lackoff & Johnson, 1980).

The other noteworthy assumptional difference evident in creativity training efforts pertains to the assumed degree, or desirability of, domain specific training. Many training efforts are based on general models, or techniques, held to enhance creativity across a range of situations that require little modification to account for domain and population differences (Basadur, 1997; Isaksen & Dorval, 1992). Other efforts, however, tailor techniques and models to the unique demands made in a given performance domain. One illustration of this domain specific training approach may be found in Baer (1996). He developed creative thinking exercises specific to poetry writing, for example image construction training involved inventing words, or descriptions of things, that suggested other things. He found that this domain specific training appeared to result in more creative products, for poems but not stories, when this experimental group was compared to a control group where only standard language arts training was provided.

Divergent Thinking

Although creativity training programs differ with respect to domain specificity, use of substantive models, and metatheoretical assumptions made about the nature of the creative act, most creativity training shares a common foundation (Fasko, 2001). This foundation was laid down with the seminal work of Guilford and his colleagues (e.g., Christensen, Guilford, & Wilson, 1957; Guilford, 1950; Wilson, Guilford, Christensen, & Lewis, 1954). Here, of course, we refer to the notion of divergent thinking or the capacity to generate multiple alternative solutions as opposed to the one correct solution. Students of creativity continue to debate whether divergent thinking is

fully necessary and sufficient for creative thought—with many scholars stressing the need for supporting cognitive activities such as critical thinking and convergent thinking (Fasko, 2001; Nickerson, 1999; Treffinger, 1995). Nonetheless, the evidence accrued over the last 50 years does suggest that divergent thinking, as assessed through open-ended tests such as consequences and alternative uses, where responses are scored for fluency (number of responses), flexibility (category shifts in responses), originality (uniqueness of response), and elaboration (refinement of responses), does represent a distinct capacity contributing to both creative problem solving and many forms of creative performance (Bachelor & Michael, 1991, 1997; Mumford, Marks, Connelly, Zaccaro, & Johnson, 1998; Plucker & Renzulli, 1999; Scratchley & Hakstain, 2001; Sternberg & O'Hara, 1999; Vincent, Decker, & Mumford, 2002).

With the identification of divergent thinking as a distinct capacity making a unique contribution to creative thought, scholars interested in the development of creativity began to apply divergent thinking tasks in the design of training. One illustration of the approach may be found in Glover (1980). He based a training course for college students on known divergent thinking tasks beginning with lecture and discussion on the value of a task performance strategy, such as identifying alternative uses, and then providing practice in the application of this strategy. A similar approach was applied by Cliatt, Shaw, and Sherwood (1980) in developing creativity training for young children. Here questions intended to elicit alternative uses, story completion, and question generation provided the basis for training. In both cases, use of these divergent thinking tasks as a basis for training did, at least apparently, result in some performance gains.

Divergent thinking models have also provided a basis for the development of some systematic, and widely applied, training programs. Perhaps the best known of these systems is the Purdue Creative Thinking program, developed by Feldhusen and his colleagues (Feldhusen, 1983). This program consists of 28 audio taped lessons. These 14-minute instructional sessions present a key principal for enhancing fluency, flexibility, originality, and elaboration (3 to 4 min) followed by illustrations of this principal (8 to 10 min through stories about historic figures). Students subsequently work through a set of accompanying exercises intended to illustrate and provide practice in the applica-

tion of these principals. Some evidence for the effectiveness of this program in enhancing divergent thinking has been provided by Alencar, Feldhusen, and Widlak (1976) and Speedie, Treffinger, and Feldhusen (1971).

Problem Solving

Of course, divergent thinking, however important, is only one component of creative thought. Beginning with the work of Dewey (1910) and Wallas (1928), scholars have proposed various models intended to provide a more complete description of the processes involved in creative thought (e.g., Hennessey & Amabile, 1988; Isaksen & Parnes, 1985; Merrifield, Guilford, Christensen, & Frick, 1962; Osborn, 1953; Silverman, 1985; Sternberg, 1986). In a review of these process models, Mumford and his colleagues (Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991; Mumford, Peterson, & Childs, 1999) identified eight core processing operations: (a) problem construction or problem finding, (b) information gathering, (c) concept search and selection, (d) conceptual combination, (e) idea generation, (f) idea evaluation, (g) implementation planning, and (h) action monitoring. This synthetic model, in fact, appears to provide a reasonably coherent description of creative thought where multiple forms of expertise are brought to bear on complex, ill-defined problems with the new ideas that provide a basis for solution implementation emerging from the combination and reorganization of relevant concepts. Moreover, the evidence accrued in various experimental and psychometric investigations has demonstrated the importance of the various processes specified by this model. For example, problem finding (Getzels & Csikszentmihalyi, 1976; Okuda, Runco, & Berger, 1991; Rostan, 1994), conceptual combination (Baughman & Mumford, 1995; Finke, Ward, & Smith, 1992), and idea evaluation (Basadur, Runco, & Vega, 2000; Runco & Chand, 1994) have all been shown to be related to both creative problem solving and creative performance.

Processing models of the sort described previously, like divergent thinking, have also provided a basis for development of new training techniques. One illustration of this approach may be found in Davis's (Davis, 1969; Warren & Davis, 1969) attempt to improve early cycle processing activities (e.g., problem finding, information gathering, concept selection, and conceptual

combination) through the use of a checklist in which people were encouraged to take certain actions on the available material (e.g., change colors and shapes, change design styles, rearrange parts, add or subtract something). In the Warren and Davis study, this checklist technique was compared to (a) feature listing and (b) presenting various divergent thinking techniques. It was found that both the checklist technique and feature listing, a technique held to promote conceptual combination (Baughman & Mumford, 1995), lead to an increase in the number of ideas provided for improving a door knob vis-à-vis untrained controls or simply providing a list of divergent thinking techniques. Clapham (1997) and McCormack (1971, 1974) also provided evidence for the utility of checklist and feature listing techniques for enhancing creative problem solving.

In this regard, however, it is important to note that processing models, like divergent thinking concepts, have provided a basis for the development of a wide range of training techniques. For example, drawing from prior work examining the role of analogies in problem finding and conceptual combination (e.g., Baughman & Mumford, 1995), Castillo (1998) devised analogy identification strategies that appear to contribute to creative problem solving in elementary school students. Along similar lines, but focusing on concept selection as well as conceptual combination, Meador (1994) and Phye (1997) have shown that listing the similarities and differences among objects can contribute to creative thinking. Finally, Fraiser, Lee, and Winstead (1997), focusing on idea evaluation, used grid appraisal techniques to encourage the evaluation of creative ideas and spur their subsequent refinement.

In addition to providing a basis for the development of training techniques, models of creative problem solving have also been used to develop more systematic programs of instruction. Perhaps the best known process-based program is the Creative Problem-Solving program developed by Parnes and his colleagues (Noller & Parnes, 1972; Noller, Parnes, & Biondi, 1976; Parnes & Noller, 1972). This program presents six stages of creative problem solving, or problem-solving processes, including mess finding, problem finding, information finding, idea finding, solution finding, and acceptance finding, subsumed under three broader operations, problem understanding, idea generation, and action planning that call for both convergent and divergent operations (Treffinger, 1995). Within this framework, instruction proceeds

within a lecture and discussion framework where the nature of this model is described along with its implications for creative work. Topics covered include the nature of creative thought, key processes, blocks to creativity, strategies for removing these blocks, and techniques for applying these processes. These lecture and discussion sections are followed by exercises intended to illustrate key points and provide practice applying techniques that might enhance process application (Basadur et al., 1992; Fontenot, 1993; Treffinger, 1995).

A number of studies have been conducted seeking to provide evidence for the effectiveness of the Creative Problem Solving program. For example, Reese, Parnes, Treffinger, and Kaltsounis (1976) have shown that a variation on this basic approach resulted in gains in divergent thinking up to 2 years later as reflected in tasks calling for social problem solving, planning, and idea generation. Other work by Fontenot (1993), Basadur, Graen, and Green (1982), Basadur, Graen, and Scandura (1986), and Basadur and Hausdorf (1996) provided evidence indicating that this training may also contribute to performance on creative problem solving tasks as well as creativity relevant attitudes and behaviors.

Meta-Analyses

As alluded to previously, at least some evidence is available pointing to the effectiveness of some techniques and creativity training programs. An initial attempt to provide a more comprehensive assessment of the effectiveness of creative training may be found in Torrance (1972). He reviewed the results of some 142 studies, 103 of which used the Torrance tests of creative thinking as a criterion. The training interventions examined covered a range of programs and techniques where success was assessed based on a judgmental appraisal of whether the study met its initial objectives. The results obtained in this review indicated that 72% of the training interventions were successful with integrated programs, such as the Creative Problem Solving and Productive Thinking programs, proving most successful.

Of course, this kind of judgmental analysis is subject to a number of ambiguities. A more trenchant criticism, however, involves the failure of the evaluative effort to explicitly examine performance gains due to training. To address this concern, Rose and Lin (1984)

conducted a quantitative meta-analytic study of creativity training interventions that used the Torrance tests scored for fluency, flexibility, originality, and elaboration. They identified 46 studies that met the standards for inclusion in this meta-analysis. Subsequent analyses indicated that creativity training was effective yielding an effect size of .64. Somewhat stronger effects, however, were obtained for originality as opposed to fluency, flexibility, and elaboration.

Although, taken at face value, these studies seem to provide strong support for the effectiveness of creativity training, this conclusion has been questioned by some scholars (A. J. Cropley, 1997; Mansfield, Busse, & Krepelka, 1978; Nickerson, 1999). One set of criticisms pertains to the external validity of these findings. Clearly, the results obtained in these studies speak most directly to performance gains on divergent thinking tests. Thus, problem solving and performance criteria, indeed the criteria of ultimate concern, were not examined. Moreover, the bulk of the evidence examined in the Rose and Lin (1984) and Torrance (1972) studies was obtained in school settings—typically elementary school settings. As a result, it is unclear whether these findings can be extended to other settings and other populations.

In addition to these concerns about external validity, the internal validity of the studies providing a basis for these conclusions has been questioned. For example, because manipulations were administered by authority figures it is possible that conformity pressures might account for the obtained results (Cropley, 1997; Nickerson, 1999; Parloff & Handlon, 1964). Alternative interpretations of this sort become more plausible when it is recognized that posttests were often administered immediately after training, transfer problems were not developed, and the training often focused on material similar to, if not identical to, the posttest items. These internal validity issues, of course, suggest that design considerations must be taken into account in drawing conclusions about the validity, or effectiveness, of creativity training.

Aside from these internal and external validity concerns, it should also be noted that neither the Rose and Lin (1984) nor the Torrance (1972) studies examined the course content variables and course delivery methods contributing to the success of training interventions. This point is of some importance because identification of these relations provides a stronger foundation for drawing inferences about the likely suc-

cess of training interventions while providing practical guidance concerning the design and delivery of training (Messick, 1989). Accordingly, in this effort we hoped to conduct a quantitative, meta-analytic, review that would address the internal and external validity concerns arising from prior studies while providing a more comprehensive examination of potential influences on program success.

Method

Literature Search

Identification of the studies included in this meta-analysis began by identifying the studies included in prior meta-analytic efforts (Rose & Lin, 1984; Torrance, 1972). Available general reviews of creativity training and the development of creative capacities were also consulted to identify candidate studies (e.g., A. J. Cropley, 1997; Jausovec, 1994; Mansfield et al., 1978; Nickerson, 1999; Treffinger, 1998). Additionally, prior issues of journals, including the *Journal of Creative Behavior*, the *Creativity Research Journal*, *Roeper Review*, *Gifted Child Quarterly*, and the *Journal of Educational Psychology*, were consulted.

Following this initial review, a more complete search of relevant data bases was conducted. This search began with examination of *Psychological Abstracts*, *ERIC*, and the *Expanded Academic Database*. The *National Technical Information Service Database* was examined to obtain relevant technical reports and government documents. Theses and dissertations that examined creativity training were identified through a search of *Datrix II* and *Dissertation Abstracts International*. After the candidate studies identified in these searches had been obtained, the citations provided were used to identify additional candidates for inclusion in this meta-analytic effort.

To address the file drawer problem arising from publication requirements (Rosenthal, 1979; Rothstein & McDaniel, 1989), two additional steps were taken. First, the corresponding authors of each article identified in the initial literature review were contacted. The 149 corresponding authors thus identified were asked to provide any previously unpublished studies they had conducted that might be relevant to a meta-analysis of the creativity training literature. Second, some 50 con-

sulting firms and large companies known to be actively involved in creativity training were contacted and asked to provide any available course evaluation data along with relevant descriptive material.

Application of these procedures led to the identification of 156 studies that were candidates for potential inclusion in the meta-analysis. Five criteria were applied in selecting the studies that were actually to be included in the meta-analysis. First, the study was required to expressly focus on creativity training. Thus, studies that examined the effects of general educational courses (e.g., arts courses) on creativity were not considered. Second, the relevant article, or report, was required to provide a clear description of the procedures used in training, the population involved, and the strategies applied in training delivery. Third, the study was required to clearly describe the exact nature of the measures used to assess creative performance. Fourth, the study was required to provide the statistics needed to assess effect size using Glass's Delta. Thus, studies providing only global summaries of findings and studies based solely on difference scores were eliminated. Fifth, if several studies were based on the same data set, only one publication (the publication optimizing the previously noted criteria) was retained to avoid overweighting select studies. Application of these criteria led to the identification of 70 studies to be included in the meta-analysis. Citations for these studies are provided in the reference list.

Coding Effect Size

As noted previously, effect size estimates were obtained for each treatment-dependent variable pair using Glass's Delta (Glass, McGaw, & Smith, 1981). Glass's Delta obtains effect size estimates by calculating the difference between the means of the treatment and control groups on the dependant variable of interest and then dividing the observed difference by the control group's standard deviation. All studies included in the final sample were based on either a pretest or posttest control group design or a pretest or posttest no control group design. In the former case, Deltas were obtained by comparing the posttest scores of the treatment and control groups where the control group provides the estimate of within-group variation. In the later case, Deltas were obtained by comparing the posttest and pretest means where the pretest provided the estimate of within group variation. Applica-

tion of these procedures yielded 97 Delta (Δ) estimates based on 70 unique studies containing 4,210 participants.

The dependent variables applied in these studies were grouped into four general rubrics based on a review of the relevant literature. These dependent variable categories were (a) divergent thinking (e.g., fluency, flexibility, originality, elaboration; $\Delta n = 37$); (b) problem solving (e.g., production of original solution to novel problems; $\Delta n = 28$); (c) performance (e.g., generation of creative products; $\Delta n = 16$); (d) attitudes and behavior (e.g., reactions to creative ideas, creative efforts initiated; $\Delta n = 16$). Deltas applying to dependent variables lying in each of these categories were obtained along with an overall, cross-criteria Delta. Use of both criterion specific and overall Delta estimates was attractive because it helped insure that misleading conclusions would not arise from inappropriate aggregation of dependent variables (Bangert-Downs, 1986). Additionally, based on the observations of Rose and Lin (1984), separate effect size estimates were obtained for the fluency ($\Delta n = 32$), flexibility ($\Delta n = 22$), originality ($\Delta n = 31$), and elaboration ($\Delta n = 16$) criteria subsumed under the aggregate divergent thinking criteria. Deltas for these variables (e.g., fluency) were aggregated to obtain the effect size estimates used in the divergent thinking, and overall, indexes—a procedure justified based on known correlations among these indexes (Mumford & Gustafson, 1988) and the need to avoid undue weighting of divergent thinking in summary analyses.

Variable Coding

To examine the impact of relevant internal and external validity considerations on effect size, and take into account the influence of course content and delivery methods on variation in effect size estimates, a content analysis was conducted. In this content analysis, characteristics of the treatment providing the basis for effect size estimates were assessed, taking into account, as necessary given the coding variable at hand, broader study characteristics. Three judges were asked to conduct this analysis of training content following some 40 hr of training in application of the requisite coding procedures. These judges, all blind to the hypotheses underlying this study but familiar with the creativity literature, worked independently in the initial coding of the relevant study descriptions. The aver-

age interrater reliability coefficients obtained, using the procedures suggested by Shrout and Fleiss (1979), was .82. As recommended by Bullock and Svyantek (1985) after completing their independent appraisals, judges met and discussed differences in their appraisals of the coding variables with the resulting consensus appraisal providing the basis for the variable assessments applied in this study. An examination of the pattern of correlations observed among these ratings provided some evidence for their validity as indicated by the substantive meaningfulness of the observed relations.

External Validity

Some initial evidence bearing on the generality, or external validity, of creativity training is, of course, provided by the various dependent variables, or criteria, under consideration (e.g., divergent thinking, problem solving). Because, however, the external validity of creativity training has been questioned on other grounds, for example overreliance on student samples, a number of other external validity variables were examined, including (a) age (contrasting pre and postadolescent populations, or use of participants below 14 versus use of participants at, or above, 14); (b) setting (academic vs. occupational); (c) academic achievement of sample members; (d) use of a gifted sample; (e) gender mix (predominately men, 80% or more; women, 80% or more; mixed, 40% to 60%); and (f) year the study was conducted (before or after 1980).

Internal Validity

Whereas the external validity variables focused on effect size generality, the internal validity variables were intended to address certain criticisms of prior research on creativity training. One of these criticisms holds that larger effects are typically observed for less well-conducted studies (A. J. Cropley, 1997). Accordingly, the first set of internal validity variables examined (a) whether the study appeared in a peer reviewed or nonpeer reviewed publication; (b) the educational level of the investigator (doctorate versus nondoctorate); (c) use of a posttest only versus a prepost, or longitudinal, design; (d) interval to posttest following training; (e) needs assessment conducted; (f) task analysis conducted; (g) use of training exercises explicitly based on

posttest criteria; and (h) use of transfer tests in posttraining assessment.

The second set of internal validity variables was intended to assess the impact of demand characteristics. To address the potential influence of demand characteristics, the following variables were coded: (a) Was the instructor the person conducting the study? (b) Were prizes or money provided for creative responses? and (c) Did instructors actively praise or recognize creative response?

Course Content

The first set of course content variables examined the kind of metatheoretical models applied in development of the creativity training. Here course content was reviewed, and drawing from Bull et al. (1995), courses were evaluated as to whether or not they stressed (a) cognitive models, (b) social models, (c) personality models, (d) motivational models, (e) confluence models (supplemented cognitive models), or (f) other models (e.g., attitudes, blocks to creative thinking).

Following this initial assessment of course content, the cognitive skills to be developed in training were assessed with reference to the general model of creative problem solving processes developed by Mumford et al. (1991). Here judges were asked to review the instructional material and exercises being used in training. They were then asked to rate, on a 4-point scale, the extent to which exercises and instructional material would serve to develop creative problem-solving capacities including (a) problem finding, (b) information gathering, (c) information organization, (d) conceptual combination, (e) idea generation, (f) idea evaluation, (g) implementation planning, and (h) solution monitoring.

In addition to examining problem solving processes, judges were asked to review the instructional material and exercises to identify the techniques being applied. This list of techniques, drawn from Bull et al. (1995) and Smith (1998), was intended to cover the more widely applied general training techniques not linked to a single specific processing activity. Judges were asked to rate, on a 4-point scale, the extent to which application of each technique was emphasized in training. Among the 17 techniques to be considered were checklists, brainstorming, analogies, ideation, and illumination.

Delivery Method

The course design variables were intended to provide some evidence indicating how the basic parameters of instruction influenced the relative effectiveness of training courses. The course design variables drawn from Goldstein and Ford (2001) and Mumford, Weeks, Harding, and Fleishman (1988) examined time in training in days, and in minutes, whether or not whole (2), versus part (1), training was applied, whether or not training was distributed (1) or massed (2), whether (2) or not (1) the training taught discreet skills, whether (2) or not (1) the training was tailored to a specific performance domain, and whether (2) or not (1) a specific model of creativity (e.g., Parnes & Noller, 1972) was used in training design. In addition, judges were asked to rate, on a 4-point scale, the depth of the course material, the difficulty of the course, the amount of instructor feedback, the amount of training time devoted to practice, and the realism of the practice exercises.

After obtaining a description of overall course design, judges were asked to evaluate, on a 4-point scale, the extent to which practice exercises involved (a) classroom exercises; (b) field exercises; (c) group exercises; (d) realistic, domain-based, performance exercises; (e) computer exercises; (f) written exercises; (g) self-paced exercises; and (h) imaginative exercises. These judges were also asked to rate, again on a 4-point scale, the extent to which various instructional media (e.g., Goldstein & Ford, 2001) were employed in training. Among the 10 media to be appraised by judges were lecture, video, and audiotapes, text-based programmed instruction, and cooperative learning.

Results

External Validity

Effects. Table 1 presents the results obtained in assessing the effects of creativity training. As may be seen, the overall Delta obtained in aggregating effects across criteria (e.g., divergent thinking, problem solving) was 0.68. The associated standard error was 0.09. To insure that these effects were not the result of a few studies yielding unusual effects, these analyses were replicated eliminating outliers yielding Deltas larger than +2 or -2. Although the expected changes in estimates of cross-study variation oc-

Table 1. Overall Effects of Creativity Training Within and Across Criteria

	NE	Δ	SE	CI	SD	FS _N
Overall	70	.68	.09	.55-.81	.65	168
Overall with outliers removed	69	.64	.07	.53-.76	.59	152
Divergent thinking	37	.75	.11	.56-.93	.67	101
Divergent thinking with outliers removed	36	.68	.09	.52-.84	.55	89
Problem solving	28	.84	.13	.62-1.05	.67	90
Performance	16	.35	.11	.16-.54	.43	12
Attitude/behavior	16	.24	.13	.01-.47	.54	3

Note. NE = number of effect size estimates; Δ = average effect size estimate using Cohen's delta; SE = standard error of effect size estimates; CI = 90% confidence interval; SD = standard deviation in effect size estimates across studies; FS_N = fail safe N or number of studies needed to decrease effect sizes below .20.

curred with the elimination of outliers, the average effect size obtained ($\Delta = 0.64$; $SE = 0.07$) was similar. In the case of both analyses, analyses with and without outliers eliminated, fail-safe *N* statistics point to the robustness of these effects indicating that creativity training does lead to gains in performance. In fact, the fail-safe *N* statistic indicates that 168 null studies would be required to reduce the overall effect size below .20 (Orwin, 1983).

The question that arises at this juncture, of course, is whether these findings concerning the effectiveness of creativity training apply to the various criteria of interest. Accordingly, Table 1 also presents the Deltas obtained for studies employing divergent thinking, problem solving, performance, and attitudes and behavior criteria. Given the focus of creativity training on the development of creative thinking skills, it was not surprising that the largest effect sizes were obtained in studies employing divergent thinking ($\Delta = 0.75$; $SE = 0.11$) and problem solving ($\Delta = 0.84$, $SE = 0.13$) criteria. Studies applying performance criteria yielded smaller, albeit still sizable, effects ($\Delta = 0.35$;

$SE = 0.11$). Studies employing attitudes and behavior criteria also produced sizable but somewhat weaker effects ($\Delta = 0.24$; $SE = 0.13$). Given the many variables influencing creative performance and personal behavior aside from individual capabilities (Mumford & Gustafson, 1988), this pattern of results is not especially surprising. What is remarkable is that training evidenced at least some noteworthy effects on performance and attitudes and behavior. Again, this overall pattern of results was maintained when outliers were eliminated. Moreover, the fail-safe *N* statistics indicated that a number of null studies would be needed to change these findings particularly for the divergent thinking and problem-solving criteria.

The finding that creativity training has a particularly strong influence on divergent thinking and problem solving broaches a new question. What aspects of creative thought are influenced by training? One way this question might be addressed is by examining the impact of creativity training on various aspects of divergent thinking. Table 2 presents the results obtained when effect sizes in divergent thinking studies were as-

Table 2. Effects of Creativity Training on Components of Divergent Thinking

Components	NE	Δ	SE	CI	SD	FS _N
Composite only	4	.93	.16	.55-1.30	.32	15
Fluency	32	.67	.14	.44-.90	.77	75
Fluency with outliers removed	31	.61	.12	.40-.81	.68	64
Flexibility	22	.75	.15	.49-1.00	.70	60
Flexibility with outliers removed	21	.66	.13	.44-.87	.57	48
Originality	31	.81	.15	.56-1.06	.83	94
Originality with outliers removed	30	.72	.12	.51-.93	.67	78
Elaboration	16	.54	.14	.30-.78	.55	27

Note. Composite only = studies that only reported combined fluency, flexibility, etc.; NE = number of effect size estimates; Δ = average effect size estimate using Cohen's delta; SE = standard error of effect size estimates; CI = 90% confidence interval; SD = standard deviation in effect sizes across studies; FS_N = fail safe N or number of studies needed to decrease effect sizes below .20.

sessed with respect to fluency, flexibility, originality, and elaboration.

In keeping with the earlier observations of Rose and Lin (1984) originality produced the largest effect size obtained in this analysis ($\Delta = 0.81$; $SE = 0.15$). This result is noteworthy, in part, because it suggests that creativity training is effecting the critical manifestation of creative thought—the generation of original, or surprising, new ideas (Besemer & O'Quin, 1999). Creativity training, however, also appeared to have a rather broad impact on various manifestations of divergent thinking yielding sizable, and similar, effects with respect to fluency ($\Delta = 0.67$; $SE = 0.14$), flexibility ($\Delta = 0.75$; $SE = 0.15$), and, smaller, albeit still sizable effects with respect to elaboration ($\Delta = 0.54$; $SE = 0.14$).

Generality. Taken as a whole, the results obtained in these analyses paint a rather favorable picture of the effectiveness of creativity training. The question that arises at this juncture, however, is whether these findings generalize across people and settings as well as criteria. An initial answer to this question may be found in Table 3. Specifically, effect sizes are provided in Table 3 for each major criterion, and the overall index, for different levels of the various external variables under consideration.

As noted earlier, one question bearing on the external validity of creativity training derives from the widespread use of elementary school students in early studies (e.g., Torrance, 1972). To address this issue, studies were coded as to whether they involved people younger than 14 or 14 and older. As may be seen, in the overall analysis, similar effect sizes were obtained for younger ($\Delta = 0.67$; $SE = 0.10$) and older ($\Delta = 0.59$; $SE = 0.13$) populations with creativity training proving effective in both age groups. This pattern of effects held for the divergent thinking and problem-solving criteria. However, older populations evidenced stronger effects with respect to the attitude and behavior criteria ($\Delta = 0.31$; $SE = 0.13$ vs. $\Delta = -0.09$; $SE = 0.16$) whereas younger populations evidence stronger effects with respect to the performance criteria ($\Delta = 0.56$; $SE = 0.15$ vs. $\Delta = 0.18$; $SE = 0.13$).

The evidence accrued in this study also indicates generality across settings. The overall analysis indicated that creativity training was effective in both academic ($\Delta = 0.65$; $SE = 0.08$) and organizational ($\Delta = 1.41$; $SE = 0.37$) settings. In fact, it appears that creativity training may be more effective in organizational

than academic settings. Given the small number of organizational studies available, however, more research needs to be conducted before strong conclusions can be drawn in this regard.

Not only does creativity training appear useful in various settings and for different age groups, the value of this training holds for populations who differ in their intellectual capabilities. The overall effect sizes obtained in nongifted ($\Delta = 0.72$; $SE = 0.08$) and low achieving ($\Delta = 0.68$; $SE = 0.08$) samples indicated that these populations benefited from training. However, across criteria, gifted ($\Delta = 0.38$; $SE = 0.23$) students, but not necessarily high achieving students ($\Delta = 0.66$; $SE = 0.38$), appeared to benefit somewhat less from training, particularly with respect to divergent thinking and problem solving—perhaps because they already possess substantial skills in these arenas as independent creators. As might be expected, based on these observations, high achieving students, students who are typically good problem solvers, appeared to benefit more from training with respect to divergent thinking ($\Delta = 1.00$; $SE = 0.39$ vs. $\Delta = 0.72$; $SE = 0.12$) than problem solving ($\Delta = 0.25$; $SE = 0.47$ vs. $\Delta = 0.88$; $SE = 0.13$).

Although our foregoing observations underscore the value of creativity training in various populations, a surprising pattern of findings emerged for gender. In examining overall effects, studies that were based on a predominantly male sample yielded larger effects ($\Delta = 1.14$; $SE = 0.26$ vs. $\Delta = 0.42$; $SE = 0.26$) than studies that were more based on a predominantly female sample. Studies with a roughly equal proportion of men and women produced an effect size lying between these two extremes ($\Delta = 0.66$; $SE = 0.17$). This pattern of effects was particularly pronounced on the divergent thinking and problem-solving criteria. Although, at this point, the source of these differences is unclear, it is possible they might be linked to male risk taking and the tendency of women to focus internally when looking for ideas (Kaufman, 2001). Nonetheless, in evaluating this finding, it must be remembered that sizable effects were obtained for women, as well as men, indicating that women do benefit from creativity training.

A final question that might be asked with regard to generality pertains to the stability of these effects over time. To address this issue, studies were assigned to a before 1980 or a 1980-and-after category to reflect the emergence of cognitive approaches. In the overall analysis, studies published before 1980 yielded an effect

Table 3. External Validity Influences on the Effects of Creativity Training

	Overall					Divergent Thinking					Problem Solving					Performance					Attitude/Behavior				
	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD
Age																									
Below 14	41	.67	.10	.50-.84	.67	25	.70	.14	.47-.93	.79	14	.72	.19	.40-1.03	.57	7	.56	.15	.30-.83	.20	6	-.09	.16	-.36-.19	.36
Above 14	25	.59	.13	.37-.80	.60	12	.85	.20	.52-1.18	.34	11	.88	.21	.52-1.24	.83	9	.18	.13	-.05-.41	.50	9	.31	.13	.08-.53	.39
Setting																									
Academic	67	.65	.08	.52-.78	.64	36	.74	.11	.55-.93	.68	26	.80	.13	.57-1.02	.67	16	.35	.11	.16-.54	.43	15	.15	.11	-.03-.34	.42
Occupational	3	1.41	.37	.79-2.02	.37	1	.91	—	—	—	2	1.37	.47	.57-2.17	.43	0	—	—	—	—	1	1.56	—	—	—
Academic achievement																									
Below average	67	.68	.08	.54-.81	.66	34	.72	.12	.53-.92	.70	26	.88	.13	.66-1.10	.68	16	.35	.11	.16-.54	.43	14	.26	.15	.00-.52	.57
Above average	3	.66	.38	.02-1.29	.41	3	1.00	.39	.34-1.66	.12	2	.25	.47	-.55-1.05	.03	0	—	—	—	—	2	.08	.39	-.60-.77	.20
Giftedness																									
Nongifted	62	.72	.08	.58-.85	.64	32	.79	.12	.59-.99	.64	24	.94	.13	.72-1.16	.65	16	.35	.11	.16-.54	.43	14	.27	.15	.01-.53	.57
Gifted	8	.38	.23	-.01-.76	.73	5	.43	.30	-.07-.94	.88	4	.24	.32	-.30-.78	.47	0	—	—	—	—	2	.02	.39	-.66-.70	.14
Gender of sample																									
Predominantly male	6	1.14	.26	.69-1.58	1.03	4	1.24	.34	.64-1.84	1.26	3	.87	.34	.26-1.49	.72	2	.39	.20	-.86-1.65	.28	1	.20	—	—	—
Predominantly female	6	.42	.26	-.03-.86	.37	3	.63	.39	-.06-1.32	.36	3	.44	.34	-.17-1.05	.58	0	—	—	—	—	4	.21	.10	-.01-.43	.20
Roughly equal	14	.66	.17	.37-.95	.49	9	.88	.23	.486-1.28	.33	7	.39	.22	-.01-.79	.53	0	—	—	—	—	2	.08	.14	-.22-.39	.20
Publication date																									
Before 1980	19	.78	.15	.53-1.03	.59	12	.78	.20	.45-1.11	.68	7	1.06	.25	.63-1.50	.43	2	.44	.32	-.12-.99	.50	2	.39	.40	-.29-1.08	.12
During or after 1980	51	.64	.09	.49-.79	.67	25	.73	.14	.50-.96	.68	21	.76	.15	.51-1.01	.73	14	.33	.12	.12-.54	.44	14	.22	.15	-.04-.48	.57

Note. NE = Number of effect size estimates, Δ = Average effect size estimate using Cohen's delta, SE = Standard error of effect size estimates, CI = 90% Confidence interval, SD = Standard deviation in effect size estimates across studies.

size ($\Delta = 0.78$; $SE = 0.15$) comparable to that obtained for later studies ($\Delta = 0.64$; $SE = 0.09$). Of course, the apparent stability of these effects over time suggests that it is not inappropriate to combine studies conducted in different periods in this meta-analytic effort. These effects, however, also suggest that more recent conceptions of creativity have resulted in training that has proved to be as effective as earlier divergent thinking based approaches—a point underscored in Castillo's (1998) study examining the application of analogical models in creativity training.

Internal Validity

Although our foregoing observations argue for the general value of creativity training, a question raised by A. J. Cropley (1997) and Mansfield et al. (1978) is still not unanswered. Is it possible that these effects are inflated due to a lack of internal validity in creativity training studies? One might, of course, address this internal validity question with respect to the characteristics of the dependent variables, characteristics of study design, social/professional attributes of the authors, and characteristics of study development.

In this effort, characteristics of study development were examined in terms of needs analysis and task analysis. In accordance with the broader training literature (e.g., Goldstein & Ford, 2001), it was held that the systematic development of training interventions would influence the effectiveness of the resulting interventions. Because, however, all identified studies based interventions on either general models of creativity or application of certain techniques, the impact of these variables on study effects could not be assessed. The effect sizes obtained for the remaining variables are presented in Table 4.

Study quality. In examining social and professional markers of study quality, the overall analysis indicated that the educational level of the corresponding author did not exert much influence on the obtained effect size. Larger effect sizes were obtained for studies appearing in peer reviewed ($\Delta = 0.76$; $SE = 0.09$) as opposed to nonpeer reviewed ($\Delta = 0.41$; $SE = 0.16$) publications in the overall analysis. This trend was most clearly evident in the effect sizes obtained for studies using divergent thinking criteria and may reflect the tendency of authors to submit, and editors to accept, only studies yielding relatively large effect sizes when

investigators are working in relatively well-developed areas.

Study design. Characteristics of study design appeared to exert a larger, more consistent, influence on the effects obtained in studies seeking to evaluate the effectiveness of creativity training. In the overall analysis, larger effect sizes were obtained in (a) small sample ($\Delta = 1.00$; $SE = 0.10$) as opposed to large sample ($\Delta = 0.35$; $SE = 0.10$) studies; (b) studies examining only one treatment ($\Delta = 0.99$; $SE = 0.11$) as opposed to studies examining multiple treatments ($\Delta = 0.43$; $SE = 0.10$); (c) studies where no control group ($\Delta = 0.97$; $SE = 0.38$) was applied as opposed to studies applying a control group ($\Delta = 0.66$; $SE = 0.08$); and (d) studies using a posttest only ($\Delta = 1.01$; $SE = 0.14$) as opposed to studies using some form of a pre-post ($\Delta = 0.54$; $SE = 0.09$) design. Given the fact that this pattern of results held across all of the discrete criteria, it seems reasonable to conclude that studies applying poor designs did yield stronger, perhaps unduly strong, effects. What should be recognized here, however, is that when the effect sizes for studies employing stronger designs were examined, creativity training still exerted noteworthy effects across divergent thinking, problem solving, performance, and attitude and behavior criteria.

In examining the influence of dependent variables on the obtained effect sizes, it was found across all criteria that studies using multiple dependent variables ($\Delta = 0.76$; $SE = 0.08$) produced stronger results than studies using a single dependent variable ($\Delta = 0.11$; $SE = 0.21$). With respect to dependent variables, one might also argue that effect sizes can be inflated by use of assessments highly similar to training exercises. To examine the effects of "training to criterion," the similarity of training exercises to the dependent variables applied was evaluated. It was found in the overall analysis that, in spite overlap in training and criteria, the use of criterion measures similar to training exercises ($\Delta = 0.63$; $SE = 0.12$) did not result in markedly larger effect sizes than the use of criterion measures that displayed relatively little similarity to training exercises ($\Delta = 0.72$; $SE = 0.11$).

Creativity training has been criticized, not just for potential overlap in training and assessment methods, but also for failure to use designs demonstrating the robustness of training effects (Mayer, 1983; Treffinger, 1986). This criticism has been seen as sufficiently important to spur multiple studies intended

Table 4. *Internal Validity Influences on the Effects of Creativity Training*

	Overall					Divergent Thinking					Problem Solving					Performance					Attitude/Behavior					
	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	
Review																										
Nonpeer	16	.41	.16	.14-.68	.69	15	.32	.15	.07-.58	.60	3	.98	.39	.31-1.66	1.49	4	.57	.21	.20-.95	.25	6	.13	.22	-.26-.52	.66	
Peer	54	.76	.09	.61-.88	.62	22	1.03	.12	.82-1.24	.57	25	.82	.14	.59-1.05	.56	12	.27	.12	.06-.49	.46	10	.30	.17	.00-.61	.47	
Author education																										
Nondoctorate	39	.70	.11	.53-.88	.62	27	.62	.12	.41-.83	.59	15	.98	.17	.69-1.23	.72	6	.43	.18	.11-.75	.30	10	.11	.17	-.19-.40	.50	
Doctorate	31	.64	.12	.45-.84	.70	10	1.09	.20	.75-1.44	.79	13	.67	.18	.35-.98	.58	10	.30	.14	.05-.55	.51	6	.46	.21	.08-.83	.57	
Sample size																										
Below average	35	1.00	.10	.84-1.16	.59	19	.99	.14	.75-1.24	.64	19	1.03	.14	.78-1.27	.68	5	.39	.20	.04-.74	.26	3	.53	.31	-.01-1.07	.65	
Above average	35	.35	.10	.19-.512	.54	18	.48	.15	.23-.73	.62	9	.44	.21	.09-.79	.47	11	.33	.14	.09-.57	.50	13	.17	.15	-.09-.43	.51	
Number of criteria																										
One	9	.11	.21	-.23-.45	.44	0	—	—	—	—	0	—	—	—	—	5	-.01	.16	-.30-.28	.56	4	.26	.28	-.23-.75	.20	
More than one	61	.76	.08	.63-.89	.76	37	.75	.11	.56-.93	.67	28	.84	.13	.62-1.05	.67	11	.51	.11	.31-.70	.25	12	.23	.16	-.05-.51	.62	
Number of treatments																										
One	31	.99	.11	.82-1.17	.64	16	1.03	.16	.76-1.30	.71	16	1.08	.15	.82-1.35	.67	5	.45	.20	.10-.80	.30	7	.56	.18	.25-.87	.61	
More than one	39	.43	.10	.27-.59	.55	21	.53	.14	.30-.76	.53	12	.51	.18	.21-.81	.54	11	.30	.13	.07-.54	.49	9	-.01	.15	-.29-.26	.31	
Control group																										
Absent	3	.97	.38	.34-1.60	.23	1	.80	—	—	—	2	1.05	.48	.23-1.87	.25	0	—	—	—	—	0	—	—	—	—	
Present	67	.66	.08	.53-.80	.66	37	.74	.11	.55-.94	.68	26	.82	.13	.59-1.05	.69	16	.35	.11	.16-.54	.43	16	.24	.13	.00-.47	.54	

(continued)

Table 4. (Continued)

	Overall					Divergent Thinking					Problem Solving					Performance					Attitude/Behavior					
	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	NE	Δ	SE	CI	SD	
Evaluation structure																										
Posttest only	20	1.01	.14	.78–1.24	.77	9	1.29	.20	.96–1.63	.83	10	1.06	.21	.70–1.41	.89	5	.53	.19	.19–.87	.24	2	.73	.37	.09–1.38	.76	
All other designs	50	.54	.09	.40–.69	.55	28	.57	.11	.38–.76	.52	18	.72	.16	.45–.98	.50	11	.27	.13	.04–.49	.48	14	.17	.14	–.08–.41	.49	
Training to criterion																										
No	39	.72	.11	.54–.89	.67	26	.79	.13	.57–1.02	.69	14	.82	.18	.51–1.13	.77	7	.53	.16	.25–.81	.31	13	.22	.15	–.05–.49	.59	
Yes	31	.63	.12	.43–.82	.64	11	.63	.21	.29–.98	.64	14	.85	.18	.54–1.16	.59	9	.51	.14	–.04–.45	.48	3	.30	.32	–.26–.86	.18	
Time to posttest																										
Relatively short	24	.54	.14	.31–.77	.63	14	.73	.19	.40–1.07	.61	9	.67	.17	.37–.98	.35	6	.03	.19	–.33–.38	.53	4	.43	.25	–.02–.88	.76	
Relatively long	24	.65	.14	.42–.89	.72	13	.70	.20	.35–1.05	.84	11	.61	.16	.34–.88	.63	3	.41	.27	–.09–.91	.19	8	–.03	.18	–.34–.29	.32	
Transfer task																										
No	51	.74	.09	.59–.89	.63	29	.82	.12	.61–1.03	.64	24	.78	.14	.55–1.01	.69	5	.45	.20	.10–.80	.30	16	.24	.13	.00–.47	.54	
Yes	19	.51	.15	.26–.76	.70	8	.46	.24	.06–.86	.76	4	1.20	.33	.63–1.77	.48	11	.30	.13	.07–.54	.49	—	—	—	—	—	
Investigator is trainer																										
No	17	.80	.14	.56–1.03	.42	11	.64	.16	.36–.92	.37	6	1.11	.29	.61–1.60	.48	5	.47	.12	.26–.69	.31	—	—	—	—	—	
Yes	34	.66	.10	.49–.82	.63	18	.58	.13	.36–.80	.62	15	.85	.18	.54–1.16	.76	6	.54	.11	.34–.73	.21	9	.28	.24	–.16–.72	.71	
Prizes provided																										
No	68	.69	.08	.56–.82	.65	37	.75	.11	.56–.93	.67	27	.87	.13	.66–1.09	.65	15	.32	.11	.13–.52	.44	16	.24	.13	.00–.47	.54	
Yes	2	.26	.46	–.50–1.03	.60	—	—	—	—	—	1	–.16	—	—	—	1	.69	—	—	—	0	—	—	—	—	
Use of overt praise																										
No	61	.69	.08	.55–.83	.66	30	.78	.12	.57–.99	.66	26	.85	.13	.63–1.08	.69	13	.32	.12	.10–.53	.47	16	.24	.13	.00–.47	.54	
Yes	9	.61	.22	.25–.97	.65	7	.59	.26	.15–1.02	.76	2	.64	.48	–.18–1.46	.40	3	.47	.26	.02–.92	.20	0	—	—	—	—	

Note. NE = number of effect size estimates; Δ = average effect size estimate using Cohen’s delta; SE = standard error of effect size estimates; CI = 90% confidence interval; SD = standard deviation in effect sizes across studies.

to assess the long-term impact of creativity training. In one study along these lines, Glover (1980) re-administered divergent thinking tests nearly a year after initial training. He found that gains in fluency, flexibility, and originality were still observed a year later when the trained group was compared to pretest and no-training controls. In another study along these lines, Baer (1988) found that problem-solving training led to improved performance on transfer problems administered to middle school students 6 months after training.

The results obtained in this effort support these conclusions. First, in the overall analysis, it was found that studies using longer posttest intervals ($\Delta = 0.65$; $SE = 0.14$) produced effect size estimates comparable to those obtained from studies using shorter posttest intervals ($\Delta = 0.54$; $SE = 0.14$). Second, studies that used transfer tasks ($\Delta = 0.51$; $SE = 0.15$) yielded weaker, but not markedly weaker, overall effect size estimates than studies that did not use transfer tasks ($\Delta = 0.74$; $SE = 0.09$). In the case of studies focusing on problem solving, however, stronger effects were obtained in studies that used transfer tasks ($\Delta = 1.20$; $SE = 0.33$), than studies that did not use transfer tasks ($\Delta = 0.78$; $SE = 0.14$).

Alternative explanations. Although it appears that the effects of creativity training are reasonably robust, these findings cannot rule out competing explanations for the success of training. One common alternative explanation holds that the effects of creativity training might be attributed to demand characteristics (A. J. Cropley, 1997; Parloff & Handlon, 1964). One critical concern in this regard arises from the confirmatory bias likely to be associated with the investigator serving as the trainer. Although application of the procedure was relatively common, studies in which the in-

vestigator was the trainer ($\Delta = 0.66$; $SE = .010$) did not result in larger effect sizes than studies in which someone other than the investigator was the trainer ($\Delta = 0.80$; $SE = 0.14$). Another explanation, one also involving demand characteristics, does not seem plausible since providing prizes or money ($\Delta = 0.26$; $SE = 0.46$ vs. $\Delta = 0.69$; $SE = 0.08$) and instructors rewarding or praising creative responses ($\Delta = 0.61$; $SE = 0.22$ vs. $\Delta = 0.69$; $SE = 0.08$) tended to reduce, not increase, the impact of creativity training in both the overall and criteria specific analyses.

Course Content

Although the analyses conducted to this point indicate that creativity training has tangible effects on divergent thinking, problem solving, performance, and attitudes and behavior, little attention has been given to a noteworthy finding emerging in the internal and external validity analyses. More specifically, substantial variation was observed in the effect sizes resulting from creativity training. To account for this variability, the relation between the course content variables and the effect sizes resulting from the various training efforts were examined.

Theoretical approach. As noted earlier, the content of creativity training is typically based on some metatheoretical model concerning the kinds of variables shaping creative achievement. In this study, training efforts were evaluated as to whether or not they stressed a cognitive, social, personality, motivational, or confluence framework in the design of course content. Table 5 presents the correlations between these evaluations of theoretical approach effect size estimates. Also the results of a forced-entry regression

Table 5. Relationship of Metatheoretical Frameworks to Variation Across Studies in Effect Size

	Overall		Divergent Thinking	Problem Solving	Performance	Attitude/Behavior
	<i>r</i>	β	<i>r</i>	<i>r</i>	<i>r</i>	<i>r</i>
Techniques						
Cognitive	.31	.24	.38	.33	-.17	.31
Social	-.19	-.28	-.13	-.05	-.15	-.02
Personality	-.09	-.07	-.03	-.23	.15	.05
Motivational	-.16	-.10	.05	-.39	.24	-.15
Confluence	-.01	.14	—	-.05	.15	—
Other (e.g., attitudinal)	-.17	-.09	-.25	.07	-.16	-.04
Multiple correlation ($R = .40$)						

Note. Overall = overall, cross-criteria index; *r* = correlation coefficient; β = standardized regression coefficient.

analysis are presented—an analysis where the overall index was regressed on evaluations of metatheoretical framing. It is of note that these regressions were conducted only for the overall index due to concerns about stability in small samples.

The multiple correlation obtained when the overall index was regressed on evaluations of the framework applied was .40. Apparently, the framework selected as a basis for course development does influence the success of training. The correlation and regression coefficients indicated, furthermore, successful interventions tended to be based on a cognitive framework. In the overall analysis, use of a cognitive framework in the development of training content produced the only sizable positive correlation ($r = .31$) and regression weight ($\beta = .24$). This general conclusion held across criteria.

Processes. If it is granted that cognitive framing provides a particularly effective basis for the development of creativity training, the next question that comes to fore concerns the specific elements of cognition that contribute to training effects. Table 6 presents the results obtained when processing activities were related to indices of effectiveness.

In the regression analysis, the multiple correlation obtained for the overall index was .49. Thus, the development of course content around core processing activities apparently contributes to the success of creativity training. The correlational analysis using the overall index indicated that training focusing on problem identification ($r = .37$), idea generation ($r = .21$), implementation planning ($r = .19$), solution monitoring ($r = .17$), and conceptual combination ($r = .16$) were all positively related to program success. The re-

gression weights, however, indicated that problem identification ($\beta = .48$), idea generation ($\beta = .18$), and conceptual combination ($\beta = .14$) made the strongest unique contributions to training effects. When the effects of other variables were taken into account, however, idea evaluation ($\beta = -.20$) appeared to have a negative impact on training success. This finding, however, is not surprising given the observations of Mumford, Connelly, and Gaddis (2003) concerning the role of idea evaluation in stimulating conceptual combination and idea generation.

Broadly speaking, the pattern of relations obtained in examining the discrete criteria was consistent with these general trends. However, in accordance with our foregoing observations, an emphasis on idea evaluation was found to be positively related to the effect sizes obtained in problem solving ($r = .51$) and attitudes and behavior ($r = .56$) studies but negatively related to the effect sizes obtained in performance ($r = -.39$) studies. With regard to these differences, moreover, it should be noted that processing activities were more strongly related to the average effects obtained in problem solving ($r = .41$), performance ($r = .23$), and attitudes and behavior ($r = .44$) studies than divergent thinking ($r = .04$) studies—a result that is not easily attributed to limited variation in effect size estimates among the divergent thinking studies.

Techniques. Another way one might examine how content influences the success of creativity training is by examining how the application of various training techniques is related to study effect size. Table 7 presents the results obtained in examining the relation of the training techniques under consideration to the effect size estimates. As may be seen, the multiple

Table 6. Relationship of Core Processes to Variation Across Studies in Effect Size

Techniques	Overall		Divergent Thinking	Problem Solving	Performance	Attitude/Behavior
	<i>r</i>	β	<i>r</i>	<i>r</i>	<i>r</i>	<i>r</i>
Problem identification	.37	.48	.12	.55	.43	.57
Information gathering	.02	-.06	-.20	.14	.39	—
Information organization	.17	-.02	.01	.59	.49	.45
Conceptual combination	.16	.14	.14	.12	.07	.17
Idea generation	.21	.18	.11	.25	.27	.40
Idea evaluation	-.03	-.20	-.03	.51	-.39	.56
Implementation planning	.19	.05	.15	.50	.23	.57
Solution monitoring	.17	-.07	.00	.48	.28	.29
Multiple correlation ($R = .49$)						

Note. Overall = overall, cross-criteria index; *r* = correlation coefficient; β = standardized regression coefficient.

Table 7. Relationship of Training Techniques to Variation Across Studies in Effect Size

Techniques	Overall		Divergent Thinking	Problem Solving	Performance	Attitude/Behavior
	<i>r</i>	β	<i>r</i>	<i>r</i>	<i>r</i>	<i>r</i>
Divergent thinking	.02	-.01	.14	.09	.06	.49
Convergent thinking	.17	.12	.21	.44	-.38	.62
Critical thinking	.22	.26	-.01	.14	-.16	.44
Metacognition	.15	.07	-.07	.11	—	-.13
Ideation	.07	.13	.06	.09	-.01	.64
Elaboration	-.19	-.06	-.13	-.16	-.35	-.23
Illumination	-.27	-.38	-.37	-.18	—	-.47
Constraint identification	.15	.07	.16	.39	.28	.29
Strength/weakness identification	-.03	-.32	.18	.07	-.41	.20
Feature comparisons	-.04	.11	-.06	-.17	-.16	-.19
Feature listing	-.05	-.22	-.14	-.02	-.16	.00
Analogies	.06	.12	.12	.13	.28	.17
Checklisting	-.06	.00	.01	-.20	-.16	-.15
Brainstorming	.09	-.03	.01	.19	.08	.35
Imagery	-.21	.15	-.30	-.37	.00	-.49
Metaphors	-.18	-.22	-.11	-.34	.08	-.14
Expressive activities	-.27	-.24	-.02	-.42	-.44	-.12
Multiple correlation ($R = .56$)						

Note. Overall = overall, cross-criteria index; r = correlation coefficient; β = standardized regression coefficient.

correlation obtained when the overall index was regressed on technique application ratings was .56. In the overall analysis, the correlations and regression weights indicated that training courses stressing techniques such as critical thinking ($r = .22$, $\beta = .26$), convergent thinking ($r = .17$, $\beta = .12$), and constraint identification ($r = .15$, $\beta = .07$) produced the largest positive relations with effect size. Thus, use of techniques that stress analysis of novel, ill-defined problems contributes to success. In keeping with this conclusion, use of expressive activities ($r = -.27$, $\beta = -.24$), illumination ($r = -.27$, $\beta = -.38$), imagery ($r = -.21$, $\beta = .15$), elaboration ($r = -.19$, $\beta = -.06$) and metaphors ($r = -.18$, $\beta = -.22$) resulted in negative relationships with effect size estimates. Apparently, successful training courses devote less time and resources to techniques that stress unconstrained exploration.

This general pattern of relations was consistent with the correlations observed between technique use and the effect sizes obtained in studies using divergent thinking, problem solving, performance, and attitudes and behavior criteria. For example, in the case of problem solving, use of convergent thinking ($r = .44$) and constraint identification ($r = .39$) techniques were positively related to study effect size whereas use of ex-

pressive activities ($r = -.42$), imagery ($r = -.37$), and metaphors ($r = -.34$) were negatively related. Along similar lines, in the case of divergent thinking, use of convergent thinking techniques ($r = .21$), divergent thinking techniques ($r = .14$), and constraint identification ($r = .16$) were positively related to study effect size while use of imagery ($r = -.30$) and metaphors ($r = -.11$) were negatively related to study effect size.

Of course, these findings beg two questions. Why does a greater emphasis on exploratory techniques diminish training effectiveness? Why does a greater emphasis on more analytic techniques enhance training effectiveness? One potential answer to these questions may be found in Mumford and Norris (1999) and Mumford et al. (2003). They argued that training techniques, like attempts to develop processing capacities, provide heuristics, or strategies, for working with information in solving novel, ill-defined problems. Indeed some techniques such as checklists and feature comparisons, are quite explicit about the use of this approach (Clapham, 1996; McCormack, 1971; Warren & Davis, 1969). Techniques that provide structures for analyzing problems in terms of relevant strategies, or heuristics, typically more structured techniques, can therefore be expected to have a relatively powerful im-

impact on performance. On the other hand, more open exploratory techniques, techniques that provide less guidance in strategic approach, can be expected to have less impact on training outcomes—however useful these techniques may be in encouraging engagement in creative efforts.

Delivery Method

Course design. Table 8 presents the results obtained when study effect sizes were correlated with, and regressed on, the course design variables. As may be seen, course design apparently had a sizable impact on the effectiveness of creativity training. The multiple correlation obtained in examining the relation of the course design variables with effect size was .55.

As might be expected, given prior studies indicating that time on task contributes to learning and performance (Ericsson & Charness, 1994; Weisberg, 1999), the amount of practice provided ($r = .24, \beta = .32$) along with training time, as assessed in days ($r = .02, \beta = .26$) and minutes ($r = .14; \beta = -.39$), was positively related to training effects in the overall analysis. The negative regression weight obtained for the minutes variable when days were taken into account, is, of course, a reflection of the limits on effect size imposed by the use of short courses. In this regard, however, it should be noted that practice time and training time had less impact on the effect sizes obtained in studies using diver-

gent thinking criteria than studies using problem solving, performance, and attitudes and behavior criteria—a finding consistent with the earlier observations of Clapham (1997).

Earlier we noted that creativity courses tend to be based on either application of select training techniques or a theoretical model of creativity. Application of model based approaches in course design, as opposed to an ad hoc assembly of techniques, was found to be positively related to obtained effect sizes in both the overall ($r = .39; \beta = .46$) and the various criterion specific analyses. In keeping with the notion that creativity training should be framed with respect to viable general models, use of domain specific training strategies was not strongly related to obtained effect sizes in the overall analysis, although somewhat stronger, positive relations were obtained for studies using performance and attitudes and behavior criteria. Apparently, domain specificity is most useful when cognitive skills must be *applied* in a certain arena. In this regard, it should be noted that the realism of practice exercises, as reflected in their content mapping to “real world” domains, was positively related to effect size in the overall analysis ($r = .31; \beta = .00$) proving particularly important to training success in studies using problem solving and attitudes and behavior criteria. Thus, it appears that creativity training should be framed in terms of general principals with training being designed to illustrate the ap-

Table 8. Relationship of Course Design Variables to Variation Across Studies in Effect Size

Techniques	Overall		Divergent Thinking	Problem Solving	Performance	Attitude/Behavior
	<i>r</i>	β	<i>r</i>	<i>r</i>	<i>r</i>	<i>r</i>
Number of days in course	.02	.26	-.02	.25	.08	-.02
Number of minutes in course	.14	-.39	.13	.29	.28	.21
General model applied	.39	.46	.39	.54	.28	.65
Domain specific exercises	.05	-.08	-.08	-.05	.31	.66
Realistic practice	.31	.00	.09	.44	.42	.58
Amount of practice	.24	.32	-.03	.32	.22	.56
Depth of material	.24	-.01	.17	.27	.21	.46
Difficulty of material	.20	.05	.05	.30	.29	.35
Distributed versus massed training	-.07	.10	.18	-.10	-.46	—
Holistic learning	-.18	.00	-.02	-.29	-.35	-.47
Component skills trained	.15	.05	-.05	.26	.35	.47
Amount of instructional feedback	-.09	-.15	-.28	.25	.25	-.19
Multiple correlation ($R = .55$)						

Note. Overall = overall, cross-criteria index; *r* = correlation coefficient; β = standardized regression coefficient.

plication of these principals in a particular domain (Baer, 1996).

In fact, the Purdue Program was developed with this approach in mind. The Purdue program, however, was also designed in such a way as to challenge late elementary and middle school students in terms of the depth of topic coverage and the difficulty of the training material. In this study, depth ($r = .24$, $\beta = -.01$) and difficulty ($r = .20$, $\beta = .05$) yielded sizable positive correlations with effect size in the overall correlational analysis—a trend replicated in the criterion specific analyses. The weaker effects exerted by depth and difficulty in the regression analysis may be attributed to the relation of depth and difficulty with training time and practice time.

With regard to the style in which training material is presented, it appears that material should be presented in a fashion likely to facilitate the initial acquisition of relevant concepts and procedures (Mumford, Costanza, Baughman, Threlfall, & Fleishman, 1994). The negative correlation observed between practice type and overall effect size ($r = -.07$, $\beta = .10$) indicates that it was more effective to distribute than mass learning activities, particularly when the concern at hand was problem solving ($r = -.10$) and performance ($r = -.46$). However, massing was positively related to the effects obtained in divergent thinking training ($r = .18$) where short courses illustrating easily acquired techniques can be applied (Clapham, 1997). Along similar lines, in this overall analysis, it was found that training that presented material in a holistic fashion tended to be negatively related to effect size ($r = -.18$, $\beta = .00$)

whereas training that focused on the development of component skills ($r = .15$, $\beta = .05$) tended to be positively related to effect size with these effects again proving most pronounced for studies using problem solving and performance criteria.

A final design variable likely to be of concern is the amount of feedback provided by instructors during training. In the case of the problem-solving ($r = .25$) and performance ($r = .25$) criteria, instructor feedback was positively related to obtained effect size. In the case of the divergent thinking ($r = -.28$) and attitudes and behavior ($r = -.19$) criteria, instructor feedback was negatively related to obtained effect size. These relations, although complex, suggest that feedback is beneficial when performance shaping is required for product generation. When, however, the performance is less constrained, as is the case of divergent thinking and attitudes and behavior studies, then the imposition of external standards through feedback may inhibit creativity.

Media. Although our foregoing observations provide some guidelines for the design of creativity training, the approach used to deliver this training has not been addressed. Table 9 presents the results obtained when the overall index was regressed on the instructional media variables. The multiple correlation of .40 obtained in this analysis suggests that instructional media can have an impact on program success. In examining the regression weights obtained in this analysis, along with the associated correlation coefficients, it was found that two general

Table 9. Relationship of Instructional Media to Variation Across Studies in Effect Size

Techniques	Overall		Divergent Thinking	Problem Solving	Performance	Attitude/Behavior
	<i>r</i>	β	<i>r</i>	<i>r</i>	<i>r</i>	<i>r</i>
Lecture	.20	.30	.19	.15	.30	.66
Video or audio	.07	.17	.35	-.28	.17	—
Computer assisted	-.01	.00	-.03	—	—	—
Individualized coaching	.09	.02	.11	.31	.04	-.08
Programmed instruction	.07	.07	-.01	-.03	—	-.15
Discussion	-.04	-.14	.07	.03	.18	.59
Social modeling	.16	.07	-.13	.26	.17	-.10
Behavior modification	-.04	-.02	—	-.11	—	—
Cooperative learning	.21	.18	.06	.24	-.20	—
Case based	.25	.11	.07	.22	.31	.66
Multiple correlation ($R = .40$)						

Note. Overall = overall, cross-criteria index; r = correlation coefficient; β = standardized regression coefficient.

media deployment strategies contribute to the success of creativity training.

First, the use of media that provide information was found to be positively related to the success of creativity training. Thus, the use of lecture based instructional techniques was positively related to effect size in the overall analysis ($r = .20$, $\beta = .30$) as well as the effect sizes obtained in studies examining divergent thinking, problem solving, performance, and attitudes and behavior criteria. Along similar lines, use of audio-visual media, again a technique focused on information, was positively related to the effect sizes obtained in divergent thinking and performance studies. Thus, in accordance with the observations of Basadur et al. (1986), Clapham (1997), and Speedie et al. (1971), informing people about the nature of creativity and strategies for creative thinking is an effective, and perhaps necessary, component of creativity training.

Second, the use of media that encourage knowledge application was found to be positively related to the success of creativity training. Specifically, use of social modeling ($r = .16$, $\beta = .07$), cooperative learning ($r = .21$, $\beta = .18$), and case-based ($r = .25$; $\beta = .11$) learning techniques was found to be positively related to the effect sizes obtained in the cross-criteria analyses. Although these relations were evident in studies employing problem solving, performance, and attitudes and behavior criteria, they did not appear in studies employing divergent thinking criteria. This pattern of results suggests active application of techniques and principles may be more important when the concern at hand is product generation as opposed to idea generation.

Practice exercises. These observations about instructional media bring us to the relation between various forms of practice and the success of training. Table 10 presents the results obtained in examining the relation between the extent to which different types of exercises were applied and the effect sizes obtained in creativity training. Exercise type was found to be related to the success of training producing a multiple correlation of .42 in the regression analysis examining the overall criterion.

The most clear-cut finding to emerge in the overall analysis was that the use of domain-based performance exercises was positively related ($r = .31$, $\beta = .35$) to effect size. It is of note in this regard, however, that the use of domain based performance exercises was more important when the concern at hand was problem solving, performance, and attitudes and behavior criteria as opposed to divergent thinking criteria. This pattern of findings is, of course, consistent with our earlier observations concerning the value of domain-based practice. In keeping with this pattern of findings, use of field exercises and interactive class exercises was positively related to the effect sizes obtained in performance and attitudes and behavior studies.

The other noteworthy finding to emerge in examining the value of different exercises involved the use of imaginative exercises. In the overall analysis use of imaginative exercises ($r = -.27$, $\beta = -.25$) was negatively related to program success. These effects were particularly pronounced for studies based on divergent thinking, performance, and attitudes and behavior criteria. Apparently, creativity training requires struc-

Table 10. Relationship of Exercise Type to Variation Across Studies in Effect Size

Techniques	Overall		Divergent Thinking	Problem Solving	Performance	Attitude/Behavior
	<i>r</i>	β	<i>r</i>	<i>r</i>	<i>r</i>	<i>r</i>
Classroom exercises	.13	.10	.09	.01	.39	.32
Field exercises	.01	-.21	-.11	-.08	.31	.66
Self-paced exercises	.02	-.10	-.07	.00	—	-.01
Written exercises	.04	-.13	.14	-.14	.16	.10
Computer exercises	-.01	-.06	-.04	—	—	—
Imaginative exercises	-.27	-.25	-.27	.02	-.47	-.60
Performance/production exercises	.31	.35	.09	.44	.42	.58
Group exercises	.06	.00	.01	.20	.31	.59
Multiple correlation ($R = .42$)						

Note. Overall = overall, cross-criteria index; r = correlation coefficient; β = standardized regression coefficient.

tured, directed, practice in the application of relevant techniques and principals.

Discussion

Before turning to our broader conclusions, certain limitations of the present study should be noted. To begin, both the qualitative and quantitative review presented herein was focused on a relatively narrowly defined phenomenon—the effects of creativity training. As a result, broader developmental issues, such as life history, (Feldman, 1999), career experiences (Zuckerman, 1974), and environmental opportunities (Csikszentmihalyi, 1999), were not considered. Along similar lines, no attempt was made in this study to examine more complex, contextual, aspects of the instructional environment, such as curiosity, playfulness, and exploration (A. J. Copley, 1997; Nickerson, 1999). Clearly, however, a careful examination of these contextual influences, influences that, indeed, may condition the success of creativity training, would have proven premature given the diversity and complexity of creativity training as a phenomenon in its own right.

In this study, moreover, an attempt was made to draw relatively strong conclusions with respect to the effectiveness of creativity training using quantitative, meta-analytic procedures. As a result, relatively stringent criteria were applied in selecting the studies to be considered in this meta-analysis. Although application of this approach is commonly recommended in meta-analytic efforts (Rosenthal, 1979; Rothstein & McDaniel, 1989), this approach did result in the loss of studies in which relevant training methods were poorly described or inappropriate statistics were used to assess the effects of training—often studies based on difference scores. Finally, as is the case in all meta-analytic efforts, the validity of our conclusions is clearly dependent on a comprehensive sampling of relevant studies. Although an unusually extensive “file-drawer” search, as well as the use of fail-safe statistics served to address this concern, caution is still called for in generalizing our findings to all studies of creativity training, particularly studies that did not examine divergent thinking, problem solving, performance, and attitudes and behavior criteria.

Along similar lines, it should be recognized that not every external and internal validity issue was, or in-

deed could be, examined in every study. As a result, the number of studies bearing on these issues was not always large, thereby recommending some caution in appraising the effects of these variables. This limitation on the strength of the conclusions flowing from this effort is also evident in the course design and delivery variables. For example, so few studies employed computer assisted instruction, it is difficult to say with certainty how the use of this technique is related to training effects.

In this regard, however, it should be noted that the failure of studies to employ certain approaches or apply certain instructional strategies is of some interest in its own right. A case in point may be found in the limited use of computer assisted instruction. Given recent advances in computer-assisted instruction (Nieveen & Gustafson, 1999), as well as advances in our understanding of the cognitive mechanisms underlying creative thought (Brophy, 1988; Lubart, 2001), the merits of this approach to creativity training clearly warrant more attention. Another illustration of this point may be found in the fact that creativity training, by virtue of its focus on models and techniques, does not commonly apply instructional design techniques such as needs analysis and task analysis (Goldstein & Ford, 2001). Given the finding that realistic practice appears beneficial, however, it is possible that application of these techniques might prove beneficial in exercise design.

Even bearing these caveats in mind, however, we believe that the results obtained in this study do lead to some compelling conclusions about the effectiveness of creativity training as well as the course content and delivery methods that make effective training possible. Perhaps the most clear-cut conclusion to emerge from this study is that creativity training is effective. Not only was a large effect size obtained in the overall analysis but sizable effects were observed for each of the four major criteria applied in evaluating training—divergent thinking, problem solving, performance, and attitudes and behavior. Although the effect sizes obtained for studies employing performance and attitudes and behavior criteria were smaller than those obtained for the divergent thinking and problem solving, this result is readily attributable to the many complex influences on people’s attitudes and performance. Of course, prior studies by Rose and Lin (1984) and Torrance (1972) have provided evidence indicating that creativity training can enhance divergent thinking.

The results obtained in this study are noteworthy, however, not only because they confirm the findings obtained in earlier investigations, but also because they indicate that training may influence other criteria.

The value of creativity training, at least with respect to divergent thinking, problem solving, performance, and attitudes and behavior criteria is underscored by two other findings emerging in this study. First, although it has been argued that the *apparent* effects of creativity training might be attributed to various internal validity concerns (A. J. Cropley, 1997; Mansfield et al., 1999), the evidence accrued in this study does not support this proposition. No evidence was obtained in the internal validity analyses indicating that demand characteristics influence the effects of training. Moreover, although larger effects were obtained in poorly conducted studies, studies using a small sample, no control group, only one treatment, or a posttest only design, better designed studies still yielded sizable effects across all four criteria with these effects being maintained over time and on transfer tasks.

Second, the results obtained in this study indicate that well-designed training can evidence substantial external validity. Creativity training contributed to divergent thinking, problem solving, performance, and attitudes and behavior for younger and older students and working adults, and for high achieving and more "run of the mill" students. In fact, even in cases where the effects of training varied by subpopulation, specifically showing less effect for gifted students and women, training was still found to have sizable effects on the various criteria under consideration. Thus, creativity training appears beneficial for a variety of people, not just elementary school students or the unusually gifted.

Taken as a whole, these observations lead to a relatively unambiguous conclusion. Creativity training works. The question that arises at this juncture, however, is exactly how creativity training works. An initial answer to this question was provided in our examination of how the various metatheoretical models commonly applied in creativity training (Bull et al., 1985) were related to obtained effect sizes. Of the various metatheoretical models applied in creativity training, only use of a cognitive approach consistently contributed to study effects. Moreover, it was found that training stressing the cognitive processing activities commonly held to underlie creative efforts, specifically the core processes identified by Mumford et al. (1991), was positively related to study success. Of the

various processes included in this model, processes closely linked to the generation of new ideas, specifically problem finding, conceptual combination, and idea generation, proved to be the most powerful influences on the effectiveness of training. Thus, it appears that the success of creativity training can be attributed to developing and providing guidance concerning the application of requisite cognitive capacities.

Given these findings, however, one must ask still another question. What is being developed through these cognitive interventions? Because creativity training is often rather short it seems unlikely that training is serving to develop expertise (Ericsson & Charness, 1994). Instead, what appears more likely is that training provides a set of heuristics, or strategies, for working with already available knowledge (Kazier & Shore, 1995; Mumford & Norris, 1999; Mumford et al., 2003). Some support for this proposition may be obtained by considering how various training techniques were related to obtained effects. Specifically, techniques such as critical thinking, convergent thinking, constraint identification, and use of analogies, all techniques where people are shown how to work with information in a systematic fashion, were positively related to the success of training. In keeping with this observation use of more open exploratory techniques, techniques where less concrete guidance with regard to the application of information is provided (e.g., expressive activities, illumination, and imagery) were negatively related to obtained effects.

Although the success of creativity training appears linked to providing people with strategies, or heuristics, for working with information, two noteworthy provisos with regard to this general conclusion should be mentioned. First, in the various course content analyses, the success of divergent thinking studies was less effectively predicted than studies using problem solving, performance, and attitudes and behavior criteria despite adequate variation in effect size. One potential explanation for this pattern of results may be found in the delivery method variables. Here lecture-based instruction was found to exert particularly strong positive effects on divergent thinking. This finding suggests that simple demonstration of heuristics, or strategies, may, at times, be sufficient to stimulate divergent thinking, perhaps because these strategies and heuristics are readily grasped and contextual application is not required. Indeed, simple exposure to relevant heuristics, or strategies, for divergent thinking has

proven effective in many studies (e.g., Clapham, 1997; Warren & Davis, 1969).

Second, although the results obtained in this effort point to the value of cognitive approaches in creativity training, these results should not be taken to imply that other approaches have no value. Use of confluence models proved beneficial across criteria whereas use of motivational and personality approaches was positively related to the effects obtained in studies focusing on performance criteria. It is possible, moreover, that cognitive training, by demonstrating the effectiveness of various strategies for performing creative tasks may, through feelings of efficacy, motivate creative efforts just as the outcomes of creative efforts lead to an appreciation of creative work (Basadur et al., 1992; Davis et al., 1972).

If one grants the apparent value of cognitive approaches to creativity training then it seems germane to consider how the training should be delivered. In fact, the results obtained in this effort paint a rather coherent picture of the delivery procedures that contribute to the success of creativity training. First, training should be based on a sound, valid, conception of the cognitive activities underlying creative efforts. Second, this training should be lengthy and relatively challenging with various discrete cognitive skills, and associated heuristics, being described, in turn, with respect to their effects on creative efforts. Third, articulation of these principles should be followed by illustrations of their application using material based on “real-world” cases or other contextual approaches (e.g., cooperative learning). Fourth, and finally, presentation of this material should be followed by a series of exercises, exercises appropriate to the domain at hand, intended to provide people with practice in applying relevant strategies and heuristics in a more complex, and more realistic context.

Some support for these conclusions may be found in the more successful of the creativity training programs currently available. For example, the Purdue Creative Training program (e.g., Feldhusen, Treffinger, & Bahlke, 1970) explicitly describes creative thinking principles and then provides illustrations of their application in a “real-world” context. Along similar lines, the Creative Problem-Solving program (e.g., Parnes & Noller, 1972; Treffinger, 1995) begins by describing the key cognitive processes underlying creative thought. Subsequently, strategies for effectively applying these processes are described and illustrations of their application provided.

These observations about delivery method, along with our foregoing observations about course content, also point to a broader implication of the present study. More specifically, the success of training depends on a sound substantive understanding of the critical components of creative thought. One implication of this observation is that as research progresses, and leads to new developments in our understanding of creative thought, these advances might provide a basis for the development of new approaches or the refinement of existing approaches. Thus, recent work on conceptual combination (Baughman & Mumford, 1995; Ward, Smith, & Finke, 1999) might provide new strategies for creativity training—strategies stressing analysis for the linkage requirements among applicable concepts. Alternatively, creativity training might attempt to incorporate strategies that help people identify and appraise anomalies (Mumford, Baughman, Supinski, & Maher, 1996).

More generally, however, this observation suggests that creativity training should not be viewed as simply a particular program or the result of applying a fixed set of techniques. Instead, creativity training should be subject to revision and extension as we develop a better understanding of creative thought and better understanding of the approaches that might be used to enhance creative thought. Hopefully, this investigation, by identifying the kind of course content and course delivery methods that lead to successful training interventions will lay a foundation for future efforts along these lines.

References¹

- Alencar, E., Feldhusen, J. F., & Widlak, F. W. (1976). Creativity training in elementary schools in Brazil. *Journal of Experimental Education, 44*, 23–27.
- Amabile, T. M. (1997). Entrepreneurial creativity through motivational synergy. *Journal of Creative Behavior, 31*, 18–26.
- Amabile, T. M., & Gryskiewicz, N. P. (1989). The creative environment scales: work environment inventory. *Creativity Research Journal, 2*, 231–253.
- Anderson, N. R., & West, M. D. (1998). Measuring climate for work group innovation: Development and validation of the team climate inventory. *Journal of Organizational Behavior, 19*, 235–258.

¹Asterisked references indicate articles that provided one or more studies for inclusion in the meta-analysis.

- Bachelor, P. A., & Michael, W. B. (1991). Higher order factors of creativity within Guilford's Structure of Intellect Model: A reanalysis of a fifty-three variable data base. *Creativity Research Journal, 4*, 157-176.
- Bachelor, P. A., & Michael, W. B. (1997). The structure-of-intellect model revisited. In M. A. Runco (Ed.), *Handbook of creativity research: Volume one* (pp. 155-182). Norwood, NJ: Ablex.
- Baer, J. M. (1988). Long-term effects of creativity training with middle school students. *Journal of Early Adolescence, 8*, 183-193.
- *Baer, J. M. (1996). The effects of task-specific divergent-thinking training. *Journal of Creative Behavior, 30*, 183-187.
- Bangert-Drowns, R. L. (1986). Review of developments in the meta-analytic method. *Psychological Bulletin, 99*, 388-399.
- Basadur, M. (1997). Organizational development interventions for enhancing creativity in the work place. *Journal of Creative Behavior, 31*, 59-72.
- Basadur, M. S., Graen, C. B., & Green, S. C. (1982). Training in creative problem solving: Effects on ideation and problem finding and solving in an I/O research organization. *Organizational Behavior and Human Performance, 30*, 41-70.
- Basadur, M. S., Graen, G. B., & Scandura, T. A. (1986). Training effects on attitudes toward divergent thinking among manufacturing engineers. *Journal of Applied Psychology, 71*, 612-617.
- Basadur, M., & Hausdorf, P. R. (1996). Measuring divergent thinking attitudes related to creative problem solving and innovation management. *Creativity Research Journal, 9*, 21-32.
- Basadur, M., Runco, M. A., & Vega, L. A. (2000). Understanding how creative thinking skills, attitudes, and behaviors work together: A causal process model. *Journal of Creative Behavior, 34*, 77-100.
- *Basadur, M. S., Wakabayashi, M., & Takai, J. (1992). Training effects on the divergent thinking attitudes of Japanese managers. *International School of Intercultural Relations, 16*, 329-345.
- Bass, B. M. (1990). *Bass and Stogdill's handbook of leadership*. New York: Free Press.
- Baughman, W. A., & Mumford, M. D. (1995). Process-analytic models of creative capacities: Operations influencing the combination-and-reorganization process. *Creativity Research Journal, 8*, 37-62.
- Besemer, S. P., & O'Quin, K. (1999). Confirming the three factor creative product analyses matrix model in an American sample. *Creativity Research Journal, 12*, 287-296.
- Bink, M. L., & Marsh, R. L. (2000). Cognitive regularities in creative activities. *Review of General Psychology, 4*, 59-78.
- Brophy, D. R. (1998). Understanding, measuring, and enhancing individual creative problem solving efforts. *Creativity Research Journal, 11*, 123-150.
- Bull, K. S., Montgomery, D., & Baloche, L. (1995). Teaching creativity at the college level: A synthesis of curricular components perceived as important by instructors. *Creativity Research Journal, 8*, 83-90.
- Bullock, R. J., & Svyantek, D. J. (1985). Analyzing meta-analysis: Potential problems, an unsuccessful replication, and evaluation criteria. *Journal of Applied Psychology, 70*, 108-115.
- *Burstiner, I. (1973). Creativity training: Management tool for high school department chairmen. *Journal of Experimental Education, 41*, 17-19.
- *Carter, L. K. (1984). *The effects of multimodal creativity training on the creativity of twelfth graders*. Unpublished doctoral dissertation, Kent State University, Akron.
- *Castillo, L. C. (1998). The effect of analogy instruction on young children's metaphor comprehension. *Roeper Review, 21*, 27-31.
- Christensen, P. R., Guilford, J. P., & Wilson, R. C. (1957). Relations of creative responses to working time and instructions. *Journal of Experimental Psychology, 53*, 82-88.
- *Clapham, M. M. (1996). The construct validity of divergent scores in the structure-of-intellect learning abilities test. *Educational and Psychological Measurement, 56*, 287-292.
- *Clapham, M. M. (1997). Ideational skills training: A key element in creativity training programs. *Creativity Research Journal, 10*, 33-44.
- Clapham, M. M., & Schuster, D. H. (1992). Can engineering students be trained to think more creatively. *Journal of Creative Behavior, 26*, 165-171.
- *Claque-Tweet, C. (1981). *Implementation of creativity training in the elementary school curriculum through two varied techniques*. Dillon: Western Montana College. (ERIC Document Reproduction Service No. ED219334)
- *Clements, D. H. (1991). Enhancement of creativity in computer environments. *American Educational Research Journal, 28*, 173-187.
- *Cliatt, M. J., Shaw, J. M., & Sherwood, J. M. (1980). Effects of training on the divergent thinking abilities of kindergarten children. *Child Development, 51*, 1061-1064.
- Collins, M. A., & Amabile, T. M. (1999). Motivation and creativity. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 297-312). Cambridge, England: Cambridge University Press.
- Cropley, A. J. (1990). Creativity and mental health. *Creativity Research Journal, 3*, 167-178.
- Cropley, A. J. (1997). Fostering creativity in the classroom: General principals. In M. A. Runco (Ed.), *Handbook of creativity research: Volume one* (pp. 83-114). Norwood, NJ: Ablex.
- *Cropley, D. H., & Cropley, A. J. (2000). Fostering creativity in engineering undergraduates. *High Ability Studies, 11*, 207-219.
- Csikszentmihalyi, M. (1999). Implications of systems perspective for the study of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 313-338). Cambridge, England: Cambridge University Press.
- *Daniels, R. R., Heath, R. G., & Enns, K. S. (1985). Fostering creative behavior among university women. *Roeper Review, 7*, 164-166.
- *Davis, G. A. (1969). Training creativity in adolescence: A discussion of strategy. In R. E. Grinder (Ed.), *Studies in adolescence* (pp. 538-545). New York: MacMillan.
- *Davis, G. A., & Bull, K. S. (1978). Strengthening affective components of creativity in a college course. *Journal of Educational Psychology, 76*, 833-836.
- *Davis, G. A., Houtman, S. E., Warren, T. F., Roweton, W. E., Mari, S., & Belcher, T. L. (1972). *A program for training creative thinking: Inner city evaluation* (Rep. No. 224). Madison: Wisconsin Research and Development Center for Cognitive Learning. (ERIC Document Reproduction Service No. ED070809)

- *Davis, G. A., & Manske, M. E. (1966). An instructional method for increasing originality. *Psychonomic Science*, 6, 73–74.
- DeBono, E. (1971). *Lateral thinking in management*. New York: American Management Association.
- DeBono, E. (1985). *DeBono's thinking course*. New York: Facts on File Publications.
- Dellas, M. (1971). *Effects of creativity training, defensiveness, and intelligence on divergent thinking*. Paper presented at the meeting of the American Educational Research Association Convention, New York.
- Dewey, J. (1910). *How we think*. Boston: Houghton.
- Domino, G., Short, J., Evans, A., & Romano, P. (2002). Creativity and ego defense mechanisms: Some exploratory empirical evidence. *Creativity Research Journal*, 14, 17–26.
- Eisenberger, R., & Shanock, L. (2003). Rewards, intrinsic motivation, and creativity: A case study of conceptual and methodological isolation. *Creativity Research Journal*, 15, 121–130.
- Ekvall, G., & Ryhammer, L. (1999). The creative climate: Its determinants and effects at a Swedish university. *Creativity Research Journal*, 12, 303–310.
- Enson, J., Cottam, A., & Band, C. (2001). Fostering knowledge management through the creative work environment: A portable model from the advertising industry. *Journal of Information Sciences*, 27, 147–155.
- Ericsson, K. A., & Charness, W. (1994). Expert performance: Its structuring and acquisition. *American Psychologist*, 49, 725–747.
- Estrada, C. A., Isen, A. M., & Young, M. J. (1994). Positive affect improves creative problem solving and influences reported source of practice satisfaction in physicians. *Motivation and Emotion*, 18, 285–299.
- Eysenck, H. J. (1997). Creativity and personality. In M. A. Runco (Ed.), *The creativity research handbook: Volume one* (pp. 41–66). Norwood, NJ: Ablex.
- Fasko, D. (2001). Education and creativity. *Creativity Research Journal*, 13, 317–328.
- Feldhusen, J. F. (1983). The Purdue Creative Thinking program. In I. S. Sato (Ed.), *Creativity research and educational planning* (pp. 44–46). Los Angeles: Leadership Training Institute for Gifted and Talented.
- Feldhusen, J. F., Treffinger, D. J., & Bahlke, S. (1970). Developing creative thinking: The Purdue Creative Thinking program. *Journal of Creative Behavior*, 4, 85–90.
- Feldman, D. H. (1999). The Development of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 169–188). Cambridge, England: Cambridge University Press.
- Fiest, G. T., & Gorman, M. E. (1998). The psychology of science: Review and integration of a nascent discipline. *Review of General Psychology*, 2, 3–47.
- Finke, R. A., Ward, T. B., & Smith, S. M. (1992). *Creative cognition: Theory, research, and applications*. Cambridge, MA: MIT Press.
- *Firestien, R. L. (1990). Effects of creative problem solving ability: The Purdue Creativity project. *Small Group Research*, 21, 507–521.
- *Fontenot, N. A. (1993). Effects of training in creativity and creativity problem finding on business people. *Journal of Social Psychology*, 133, 11–22.
- Fraiser, M. M., Lee, J., & Winstead, S. (1997). Is the future problem solving program accomplishing its goals. *Journal for Secondary Gifted Education*, 8, 157–163.
- *Fritz, R. L. (1993). Problem solving attitude among secondary marketing education students. *Marketing Educators Journal*, 19, 45–59.
- *Gerrard, L. E., Poteat, G. M., & Ironsmith, M. (1996). Promoting children's creativity: Effects of competition, self-esteem, and immunization. *Creativity Research Journal*, 9, 339–346.
- Getzels, S. W., & Csikszentmihalyi, M. (1976). *The creative vision: A longitudinal study of problem finding in art*. New York: Wiley.
- Glass, G. V., & McGaw, B., & Smith, M. L. (1981). *Meta-Analysis in social research*. Beverly Hills, CA: Sage.
- *Glover, J. A. (1980). A creativity training workshop: Short-term, long-term, and transfer effects. *Journal of Genetic Psychology*, 136, 3–16.
- Goldstein, L. L., & Ford, J. K. (2001). *Training in organizations: Needs assessment, development, and evaluation*. Belmont, CA: Wadsworth.
- *Greene, T. R., & Noice, H. (1988). Influence of positive affect upon creative thinking and problem solving in children. *Psychological Reports*, 63, 895–898.
- *Griffith, T. J. (1988). *An exploration of creativity training for management students*. Unpublished doctoral dissertation, Boston University.
- Guilford, J. P. (1950). Creativity. *American Psychologist*, 5, 444–454.
- Gur, R. C., & Reyher, J. (1976). Enhancement of creativity via free image and hypnosis. *American Journal of Clinical Hypnosis*, 18, 237–249.
- Hennessey, B. A., & Amabile, T. M. (1988). The conditions of creativity. In R. J. Sternberg (Ed.), *The nature of creativity* (pp. 11–42). Cambridge, England: Cambridge University Press.
- *Hennessey, B. A., & Zbikowski, S. M. (1993). Immunizing children against the negative effects of reward: A further examination of intrinsic motivation training techniques. *Creativity Research Journal*, 6, 297–307.
- *Houtz, J. C., & Feldhusen, J. F. (1976). The modification of fourth graders' problem solving abilities. *Journal of Psychology*, 93, 229–237.
- *Hudgins, B. B., & Edelman, S. (1988). Children's self-directed critical thinking. *Journal of Educational Research*, 81, 262–273.
- Isaksen, S. G., & Dorval, K. B. (1992). An inquiry into cross-cultural creative training: Results from a five week study tour in Bergen and Bratislava. Paper presented at the 6th International Creativity Network Conference, Buffalo, NY.
- Isaksen, S. G., & Parnes, S. J. (1985). Curriculum planning for creative thinking and problem solving. *Journal of Creative Behavior*, 19, 1–29.
- *Jaben, T. H. (1983). The effects of creativity training on learning disabled students' creative expression. *Journal of Learning Disabilities*, 16, 264–265.
- *Jaben, T. H. (1985a). Effect of instruction for creativity on learning disabled students' drawings. *Perceptual and Motor Skills*, 61, 895–898.
- *Jaben, T. H. (1985b). Effects of instruction on elementary-age students' productive thinking. *Psychological Reports*, 57, 900–902.

- *Jausovec, N. (1994). Can giftedness be taught? *Roeper Review*, 16, 210–214.
- *Kabanoff, B., & Bottger, P. (1991). Effectiveness of creativity training and its relation to selected personality factors. *Journal of Organizational Behavior*, 12, 235–248.
- Kasoff, J. (1995). Explaining creativity: An attributional perspective. *Creativity Research Journal*, 8, 311–366.
- Kaufman, J. C. (2001). The Sylvia Plath effect: Mental illness in eminent creative writers. *Journal of Creative Behavior*, 35, 37–50.
- Kaufman, J. C. (2002). Dissecting the golden goose: Components of studying creative writers. *Creativity Research Journal*, 14, 27–40.
- Kaufmann, G. (2003). Expanding the mood-creativity equation. *Creativity Research Journal*, 15, 131–136.
- Kay, S. I. (1998). Curriculum and the creative process: Contributions in memory of a Harry Passow Roeper Review: *A Journal on Gifted Education*, 21, 5–13.
- Kazier, C., & Shore, B. M. (1995). Strategy flexibility in more and less competent students on mathematic word problems. *Creativity Research Journal*, 8, 77–82.
- *Khatena, J. (1971). Teaching disadvantaged preschool children to think creatively with pictures. *Journal of Educational Psychology*, 62, 384–386.
- *Khatena, J., & Dickerson, E. C. (1973). Training sixth-grade children to think creatively with words. *Psychological Reports*, 32, 841–842.
- King, N., & Anderson, N. (1990). Innovation in working groups. In M. A. West & J. L. Farr (Eds.), *Innovation and creativity at work* (pp. 81–100). New York: Wiley.
- *Kovac, T. (1998). Effects of creativity training in young soccer talents. *Studia Psychologica*, 40, 211–218.
- Kurtzberg, T. R., & Amabile, T. M. (2001). From Guilford to creative synergy: Opening the black box of team level creativity. *Creativity Research Journal*, 13, 285–294.
- Lackoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: University of Chicago Press.
- Lubart, T. I. (2001). Models of the creative process: Past, present, and future. *Creativity Research Journal*, 13, 295–308.
- *Macdonald, W. S., Heinberg, P., & Fruehling, R. T. (1976). Training of original responses and academic performance of fifth-grade students. *Psychological Reports*, 38, 67–72.
- Mansfield, R. S., Busse, T. V., & Krepelka, E. J. (1978). The effectiveness of creativity training. *Review of Educational Research*, 48, 517–536.
- Martindale, C. (1999). The biological bases of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 137–152). Cambridge, England: Cambridge University Press.
- Mayer, R. E. (1983). *Thinking, problem solving, and cognition*. New York: Freeman.
- McCormack, A. J. (1971). Effects of selected teaching methods on creative thinking, self-evaluation, and achievement of studies enrolled in an elementary science education methods course. *Science Teaching*, 55, 301–307.
- *McCormack, A. J. (1974). Training creative thinking in general education science. *Journal of College Science Teaching*, 4, 10–15.
- McCrae, R. R. (1987). Creativity, divergent thinking, and openness to experience. *Journal of Personality and Social Psychology*, 52, 1258–1265.
- McGourty, J., Tarshis, L. A., & Dominick, P. (1996). Managing innovation: Lessons from world class organizations. *International Journal of Technology Management*, 11, 354–368.
- McKinnon, D. W. (1962). The nature and nurture of creative talent. *American Psychologist*, 17, 484–495.
- *Meador, K. S. (1994). The effects of synectics training on gifted and non-gifted kindergarten students. *Journal for the Education of the Gifted*, 18, 55–73.
- Merrifield, P. R., Guilford, J. P., Christensen, P. R., & Frick, J. W. (1962). The role of intellectual factors in problem solving. *Psychological Monographs*, 76, 1–21.
- Messick, S. (1989). Validity. In R. L. Linn (Ed.), *Educational measurement* (pp. 13–105). New York: MacMillan.
- Montouri, A. (1992). Two books on creativity. *Creativity Research Journal*, 5, 199–203.
- Mumford, M. D. (2002). Social innovation: Ten cases from Benjamin Franklin. *Creativity Research Journal*, 14, 253–266.
- Mumford, M. D., Baughman, W. A., & Sager, C. E. (2003). Picking the right material: Cognitive processing skills and their role in creative thought. In M. A. Runco (Ed.), *Critical and creative thinking* (pp. 19–68). Cresskill, NJ: Hampton.
- Mumford, M. D., Baughman, W. A., Supinski, E. P., & Maher, M. A. (1996). Process-based measures of creative problem solving skills: IT information encoding. *Creativity Research Journal*, 9, 77–88.
- Mumford, M. D., Connelly, M. S., & Gaddis, B. H. (2003). How creative leaders think: Experimental findings and cases. *Leadership Quarterly*, 14, 306–329.
- Mumford, M. D., Costanza, D. P., Baughman, W. A., Threlfall, K. V., & Fleishman, E. A. (1994). The influence of abilities on performance during practice: Effects of missed and distributed practice. *Journal of Educational Psychology*, 86, 134–144.
- Mumford, M. D., & Gustafson, S. B. (1988). Creativity syndrome: Integration, application, and innovation. *Psychological Bulletin*, 103, 27–43.
- Mumford, M. D., Marks, M. A., Connelly, M. S., Zaccaro, S. J., & Johnson, J. F. (1998). Domain-based scoring of divergent thinking tests: Validation evidence in an occupational sample. *Creativity Research Journal*, 11, 151–163.
- Mumford, M. D., Mobley, M. I., Uhlman, C. E., Reiter-Palmon, R., & Doares, L. (1991). Process analytic models of creative capacities. *Creativity Research Journal*, 4, 91–122.
- Mumford, M. D., & Norris, D. G. (1999). Heuristics. In M. A. Runco & S. Pritzker (Eds.), *Encyclopedia of creativity: Volume two* (pp. 139–146). San Diego, CA: Academic Press.
- Mumford, M. D., Peterson, N. G., & Childs, R. A. (1999). Basic and cross-functional skills: Taxonomies, measures, and findings in assessing job skill requirements. In N. G. Peterson, M. D. Mumford, W. C. Borman, P. R. Jeanneret, & E. A. Fleishman (Eds.), *An occupational information system for the 21st century: The development of O*NET* (pp. 49–76). Washington, DC: American Psychological Association.

- Mumford, M. D., Weeks, J. C., Harding, F. D., & Fleishman, E. A. (1988). Individual and situational determinants of technical training performance. *Journal of Applied Psychology, 73*, 673–678.
- *Murdock, M. C., Isaksen, S. G., & Lauer, K. J. (1993). Creativity training and the stability and internal consistency of the Kirton adaption-innovation inventory. *Psychological Reports, 72*, 1123–1130.
- *Muttagi, P. K. (1981). Effect of brainstorming on creativity. *Indian Journal of Social Work, 42*, 41–53.
- *Nelson, A., & Lalemi, B. (1991). The role of imagery training on Tohono O'dham children's creativity scores. *Journal of American Indian Education, 30*, 24–31.
- Nickerson, R. S. (1999). Enhancing Creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 392–430). Cambridge, England: Cambridge University Press.
- Nieveen, N., & Gustafson, K. (1999). Characteristics of computer-based tools for education and training development: An introduction. In J. Van Denakker, R. M. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 155–174). Dordrecht, The Netherlands: Kluwer.
- Noller, R. B., & Parnes, S. J. (1972). Applied creativity: The creative studies project: The curriculum. *Journal of Creative Behavior, 6*, 275–294.
- Noller, R. B., Parnes, S. J., & Biondi, A. M. (1976). *Creative authorbook*. New York: Scribner.
- Okuda, S. M., Runco, M. A., & Berger, D. E. (1991). Creativity and the finding and solving of real world problems. *Journal of Psychoeducational Assessment, 9*, 145–153.
- Osborn, A. F. (1953). *Applied imagination: Principles and procedures for creative thinking*. New York: Schribner.
- Orwin, R. G. (1983). A fail-safe N for effect size. *Journal of Educational Statistics, 8*, 157–159.
- Parloff, M. D., & Handlon, J. H. (1964). The influence of criticalness on creative problem solving. *Psychiatry, 27*, 17–27.
- Parnes, S. J., & Noller, R. B. (1972). Applied creativity: The creative studies project: Part results of the two year program. *Journal of Creative Behavior, 6*, 164–186.
- *Peak, R., & Hull, C. (1983). *The effect of relaxation and imagination exercises on the creativity of elementary children*. Paper presented at the meeting of the Northern Rocky Mountain Educational Research Association, Jackson Hole, WY.
- Phye, G. A. (1997). Inductive reasoning and problem solving: The early grades. In J. G. Ryne (Ed.), *Handbook of academic learning* (pp. 451–471). San Diego, CA: Academic Press.
- Plucker, J. A., & Renzulli, T. S. (1999). Psychometric Approaches to the Study of Creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 35–61). Cambridge, England: Cambridge University Press.
- Qin, Y., & Simon, H. A. (1990). Laboratory replication of the scientific process. *Cognitive Science, 14*, 181–312.
- Reese, H. W., Parnes, S. J., Treffinger, D. J., & Kaltsounis. (1976). Effects of a creative studies program on structure of intellect factors. *Journal of Educational Psychology, 68*, 401–410.
- Reiter-Palmon, R., Mumford, M. D., & Threlfall, K. U. (1998). Solving everyday problems creatively: The role of problem construction and personality type. *Creativity Research Journal, 11*, 187–198.
- Renzulli, J. S. (1994). *Schools for talent development: A practical plan for total school improvement*. Mansfield Center, CT: Creative Learning Press.
- Rickards, T., & Freedman, B. (1979). A re-appraisal of creativity techniques in industrial training. *Journal of European Industrial Training, 3*, 3–8.
- *Riesenmy, M. R., Ebel, D., Mitchell, S., & Hudgins, B. B. (1991). Retention and transfer of children's self-directed critical thinking skills. *Journal of Educational Research, 85*, 14–25.
- Rose, L. H., & Lin, H. J. (1984). A meta-analysis of long-term creativity training programs. *Journal of Creative Behavior, 18*, 11–22.
- Rosenthal, R. (1979). The "file drawer problem" and tolerance for null results. *Psychological Bulletin, 86*, 638–641.
- Rostan, S. M. (1994). Problem finding, problem solving, and cognitive controls: An empirical investigation of critically acclaimed productivity. *Creative Research Journal, 7*, 97–110.
- Rothstein, H. P., & McDaniel, M. A. (1989). Guidelines for conducting and reporting meta-analyses. *Psychological Reports, 65*, 759–770.
- Rubenson, D. C., & Runco, M. A. (1992). A psychoeconomic approach to creativity. *New Ideas in Psychology, 10*, 131–147.
- Rump, E. E. (1982). Relationships between creativity, arts-orientation, and esthetic preference variables. *Journal of Psychology, 110*, 11–20.
- Runco, M. A., & Chand, I. (1994). Problem finding, evaluative thinking, and creativity. In M. A. Runco (Ed.), *Problem finding, problem solving, and creativity* (pp. 40–76). Norwood, NJ: Ablex.
- Scratchley, L. S., & Hakstain, A. R. (2001). The measurement and prediction of managerial creativity. *Creativity Research Journal, 13*, 367–384.
- Shrout, P. E., & Fleiss, J. L. (1979). Interclass correlations: Uses in assessing rater reliability. *Psychological Bulletin, 86*, 420–428.
- Silverman, B. G. (1985). The use of analogies in the innovative process: A software engineering protocol analysis. *IEEE Transactions on Systems, Man, and Cybernetics, 15*, 30–44.
- Simonton, B. K. (1999). Creativity from a historiometric perspective. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 116–136). Cambridge, England: Cambridge University Press.
- Smith, G. F. (1998). Idea generation techniques: A formulary of active ingredients. *Journal of Creative Behavior, 32*, 107–134.
- Solomon, C. M. (1990). Creativity training. *Personnel Journal, 69*, 64–71.
- Speedie, S. M., Treffinger, D. J., & Feldhusen, O. F. (1971). Evaluation of components of the Purdue Creative Thinking Study: A longitudinal study. *Psychological Reports, 29*, 395–398.
- Sternberg, R. J. (1986). Towards a unified theory of human reasoning. *Intelligence, 10*, 281–314.
- Sternberg, R. J. (1988). A three-facet model of creativity. In R. J. Sternberg (Ed.), *The nature of creativity* (pp. 125–147). Cambridge, England: Cambridge University Press.

- Sternberg, R. J., & O'Hara, L. A. (1999). Creativity and Intelligence. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 251–272). Cambridge, England: Cambridge University Press.
- Taber, T. H. (1983). The effects of creativity training on learning disabled students' creative expression. *Journal of Learning Disabilities, 16*, 264–265.
- Taber, T. H. (1985). Effect of instruction for creativity on learning disabled students' creative expression. *Perceptual and Motor Skills, 61*, 895–898.
- Torrance, E. P. (1972). Can we teach children to think creatively? *Journal of Creative Behavior, 6*, 114–143.
- Treffinger, D. J. (1986). Research on creativity. *Gifted Child Quarterly, 30*, 15–19.
- Treffinger, D. J. (1995). Creative problem solving: Overview and educational implications. *Educational Psychology Review, 7*, 191–205.
- Vincent, A. H., Decker, B. P., & Mumford, M. D. (2002). Divergent thinking, intelligence, and expertise: A test of alternative models. *Creativity Research Journal, 14*, 163–178.
- Vosberg, S. K. (1998). The effects of positive and negative mood on divergent thinking performance. *Creativity Research Journal, 11*, 165–172.
- Wallas, G. (1928). *The art of thought*. New York: Harcourt-Brace.
- Ward, T. B., Smith, S. M., & Finke, R. A. (1999). Creative Cognition. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 189–212). Cambridge, England: Cambridge University Press.
- *Warren, T. G., & Davis, G. A. (1969). Techniques for creative thinking: An empirical comparison of three methods. *Psychological Reports, 25*, 207–214.
- Weisberg, R. W. (1999). Creativity and knowledge: A challenge to theories. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 226–251). Cambridge, England: Cambridge University Press.
- *Williams, F. E. (1965). *Practice and reinforcement of training factors in creative performance*. Unpublished doctoral dissertation, University of Utah, Salt Lake City.
- Wilson, R. L., Guilford, J. P., Christensen, P. R., & Lewis, D. J. (1954). A factor analytic study of divergent thinking abilities. *Psychometrika, 19*, 297–311.
- Wise, G. (1992). Inventor and corporations in the maturing electrical industry. In R. J. Weber & D. W. Perkins (Eds.), *Inventive minds: Creativity in technology* (pp. 291–310). Oxford, England: Oxford University Press.
- Zuckerman, H. (1974). The scientific elite: Nobel Laureates' mutual influence. In R. S. Albert (Ed.), *Genius and Eminence* (pp. 171–186). New York: Pergamon Press.

Copyright of Creativity Research Journal is the property of Lawrence Erlbaum Associates and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.