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Abstract: Problem construction has been suggested as the first step in creative problem solving, but our understanding of the underlying process is limited. According to a model of problem construction (Mumford, Reiter-Palmon, & Redmond, 1994), problem construction ability, active engagement in problem construction, and the presence of diverse and inconsistent cues influence creative problem solving. To test these hypotheses, 195 undergraduates were asked to solve 6 real-life problems and complete a measure of problem construction ability. Active engagement in problem construction was manipulated by instructions to the participants. Cue consistency was manipulated by the information presented in the problem situation. The quality, originality, and creativity of the solutions were evaluated. Results indicated that problem construction ability was related to higher quality solutions as well as solutions rated as more original. Problem construction ability also interacted with cue consistency such that individuals with high problem construction ability produced solutions of higher quality and originality when faced with inconsistent cues. The implication of these findings to our understanding of creative problem solving and the problem construction process are discussed.

According to Dillion (1982) and Getzels (1975, 1979), problems can be classified based on the degree to which the problem itself, the method for solution, and the solution are already known to the problem solver or others. They further argued that problems that allow for creative solutions differ from routine ones in that they tend to be ill-defined. Ill-defined problems are ambiguous and include conflicting assumptions and information that may lead to different solutions (Schraw, Dunkle, & Bendixen, 1995), or situations where it is not even clear if a problem even exists (Dillion, 1982). These types of problems require the individual to structure and define the problem prior to solving the problem. Problem construction, or problem finding, is the process of defining the goals and objectives of the problem solving effort and designing a plan to structure and direct problem solving (Mumford, Reiter-Palmon, & Redmond, 1994). Several terms have been used to describe these processes (Runco, 1994a), among them *problem finding* (Getzels, *1975),problem identification* (Subotnik & Steiner, 1994), and *problem construction* (Mumford et al., 1994). Those terms have all been used interchangeably in the literature. However, the term *problem construction* will be used here because it implies more activity on the part of the problem solver. The problem solver is not just passively identifying or defining a problem that is already there; he or she is actively participating in the act of constructing the problem.

Getzels (1982) provided one of the best and simplest examples for problem construction and its effect on problem solving:

> An automobile is traveling on a deserted country road and blows a tire. The occupants of the automobile go to the trunk and discover that there is no jack. They define their dilemma by posing the problem: "Where can we get a jack?" They look about, see some empty barns but no habitation, and recall that, several miles back they had passed a service station. They decide to walk back to the station to get a jack. While they are gone, an automobile coming from the other direction also blows a tire. The occupants of this automobile go to the trunk and discover that there is no jack. They define their dilemma by posing the problem: "How can we raise the automobile?" They look around and see, adjacent to the road, a barn with a pulley for lifting bales of hay to the loft. They move the automobile to the barn, raise it on the pulley, change the tire, and drive off. (p. 38)

As this example demonstrates, the structure provided by problem construction supplies the context for the application of other processes of creative problem solving, and therefore may have a marked impact on creativity (Getzels, 1979; Kay, 1991; Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991; Runco & Okuda, 1988; Sternberg, 1986).

In their classic study of art students, Gemls and Csikszentmihalyi (1975, 1976) obtained behavioral measures of problem construction prior to and while painting. They found that these measures were strongly correlated with assessments of originality and aesthetic value of the resulting paintings. These measures were also linked to long-term artistic success measured 7 and 18 years later (Csikszentmihalyi, 1990). Okuda, Runco, and Berger (1991) investigated the role of problem construction in "real world" creative activities in children. They asked students to complete a measure of problem finding or problem construction in which students were asked to come up with their own problems and solve them as well as standard measures of the potential for creative thinking (divergent thinking). They found that problem construction skills predicted participation in creative activities above and beyond divergent thinking skills. Similarly, Rostan (1994) found that critically acclaimed professionals in art and science differed from competent artists and scientists in the proportion of time spent on a problem-finding task in a laboratory study. This study underscores the effect of the general skill of problem finding on real world achievement.

Other studies indicate that individuals display reliable differences in their ability to construct problems. Smilansky (1984), for example, found that individuals display differences in the ability to construct or define problems that cannot be accounted for by intelligence. More recent work by Redmond, Mumford, and Teach (1993) and Mumford, Baughman, Threlfall, Supinski, and Costanza (1996) showed that measures of individual differences in problem construction ability predicted performance on creative problem-solving tasks, yielding correlations in the .40s with indices of solution quality and solution originality.

Problem Construction Processes

Taken as a whole, the studies reviewed earlier indicate that the problem construction process may indeed play an important role in creative problem solving. However, none of these studies provide us with a real understanding of how people go about constructing problems nor an understanding of the cognitive processes that are involved. Mumford et al. (1994) proposed a model that describes the specific cognitive operations underlying problem construction. They suggested that problem construction processes operate on a form of knowledge called *problem representations.* Problem representations *are* schematic, or categorical knowledge structures derived from previous problem-solving efforts (Gick & Holyoak, 1980, 1983; Holyoak, 1984; Novick, 1480). These representations include information about (a) the goals or outcomes associated with the problem-solving effort, (b) key information required to define and solve the problem, (c) procedures and operations needed to solve the problem, and (d) constraints involved in problem solving (Barsalou, 1991 ; Wolyoak, 1984; Mumford et al., 1994).

Mumford et al. (1994) suggested that problem representations are activated through attention to cues in environmental events. A representation is activated if it has been associated with these cues in the past

(Holyoak, 1984). As the complexity and diversity of the cues increases, the number of activated representations increases accordingly. However, given a large number of activated problem representations, the individual needs a way to reduce this to a more manageable number. One straightforward and common strategy to screen the problem representations is to use the most highly activated problem representation. This strategy is very attractive because it minimizes time and effort involved in the problem construction process. This usually occurs when the problem representation shares many cues with the stimulus set (the problem).

However, there are situations where automatic application of the most highly activated representation is not possible. Particularly when the problem is novel or when there is not a good match between the stimulus set and the one problem representation, using multiple problem representations to construct the problem may be necessary. When this occurs, individuals will search through multiple problem representations and use a subset of the activated representations to understand and structure the problem. After a limited set of representations has been selected, the individual will search through them to identify those goals, procedures, information, and constraints that are relevant to the current effort. These elements will then be combined and reorganized into a new representation of the problem situation, which will serve to structure the situation and guide problem solving. According to this model, problem construction activities become more important, and their influence on the solution increases, as the degree of structure given in the problem decreases. That is, problem construction is particularly important in creative problem solving in ill-defined or novel situations.

Some initial support for the model suggested by Mumford et al. (1994) was provided by Redmond et al. (1993) in a study investigating creativity in marketing. They asked marketing students to formulate advertising campaigns for a three-dimensional holographic television. An active processing manipulation was used to force the participants to engage in the problem construction process, and not apply a problem representation automatically. Active processing was induced by instructing half of the participants to restate the problem before solving it, whereas participants in the nonactive processing manipulation were instructed to read the problem and immediately solve it. Participants in the active processing condition generated solutions that were of higher quality and originality than participants who were instructed to start work directly after reading the problem. The model of problem construction suggested by Mumford et al. (1994) predicts that when problem construction occurs in an effortful manner it will result in a more original and higher quality solution.

One intriguing implication of the model, however, has not been explored in prior studies. More specifically, the inclusion of multiple, diverse cues in the stimulus material should activate multiple problem representations that, according to this model, will serve to encourage problem construction. Our first objective in this study was to test this proposition, while experimentally controlling the effects of active processing.

> *Hypothesis 1:* Participants who are presented with diverse or inconsistent cues in the problem situation are more likely to engage in problem construction, which will result in higher quality and more original solutions.
>
> *Hypothesis la:* Because diverse cues serve to trigger active problem construction, an interaction between active processing and cue consistency is expected, such that when

cues are consistent, active processing will be related to higher quality and originality of the solution; however, no differences due to problem construction are expected when cues are diverse.

Recent work by Runco (1994b) suggested that the application of this process may be related to ability. He argued that individuals differ in their tolerance for contradictory or diverse information and that these differences may be related to individual differences in problem construction ability. Thus, the effect of diverse or inconsistent cues activating multiple representations may interact with problem construction ability.

Hypothesis 2: Problem construction ability will interact with cue consistency such that individuals with high problem construction ability will be able to provide solutions of higher quality and higher originality when facing diverse or inconsistent cues.

Method

Sample

The sample consisted of 195 undergraduates attending a large southeastern university. The 114 women and 80 men (1 participant failed to indicate gender) participated in the study for extra credit or as a requirement for psychology classes. Most sample members were in their sophomore or junior year.

Experimental Task

Participants were asked to solve six different problems in three domains. The domains were selected to allow familiarity with the problems and reflect problems that the student population may encounter. Because several studies revealed that expertise may effect the number and organization of problem representations (Greeno, 1977; Lesgold, 1984), problems were selected to be both realistic and familiar to the participant population. Problems were adapted from counseling case books and discussions with counselors at the university. Review of problems by undergraduate students ($N = 10$) revealed that they judged the problems to be realistic and familiar, as determined by interviews after they read the problems. The three domains selected were school, social relations, and leadership. Problems were designed to be ill-defined and ambiguous by allowing for multiple goals to exist and multiple plausible solutions. An example of one problem in the school domain is presented in Appendix A.

Procedure

The problem-solving exercises were administered in a group testing session and participants were randomly assigned to the manipulated conditions, with roughly equal numbers in each condition. Prior to solving the six problems, participants completed several measures and demographic information. Participants were asked to complete Guilford's (1967) Consequences A test, in which they generated possible consequences for new and unique situations. Two different situations were given, each with a time limit of 2 min. The Consequences test was scored for ideational fluency, defined as the total number of alternatives generated and used as a measure of divergent thinking. The test battery also included a measure of category combination (for examples of this test, see Mobley, Doares, & Mumford, 1992). The category combination measure presented participants with words from three different categories. Participants were then asked to generate a label that would combine the three word lists and generate exemplars of the new category. The category label and exemplars were then rated in accordance with the procedure established by Mobley et al. for quality and originality with interrater reliabilities ranging from .74 to .79. A creativity score was derived using the product of the quality and originality scores for both category label and exemplars. Label creativity, exemplar creativity, and ideational fluency were used as covariates. Because divergent thinking as measured by ideational fluency has been used extensively in the study of creativity and is suggested to contribute to originality (Runco, 1991), ideational fluency was used as covariate. Category combination (measured by label creativity and exemplar creativity) was included because it was felt that these reorganization skills may contribute directly to solution quality and originality & Mumford, 1995; Mobfey et al., 192). In addition to the covariates, participants were asked to complete a problem construction ability task modeled after Baer's (1988) problem-finding task.

Participants then proceeded to the problem-solving task, where they were asked to solve six problems in random order. After they completed solving the problems, participants answered a short post experimental questionnaire designed to assess the manipulations. Participants were asked two questions to assess the degree to which they engaged in problem construction activities as intended by the active processing manipulation. Participants were asked how much time they spent defining each problem and the number of different ways they looked at the problem before attempting to solve it. Finally, to d8termine whether participants attended to the consistent or inconsistent cues and considered them important and relevant for problem solution, participants were asked to write down all the information they could remember about each problem scenario.

Independent Variables

Problem construction ability. To test the effect of problem construction ability, participants were blocked on this variable using a median split. Problem construction ability was measured using different problems and stimulus material than the problem-solving task. The problem construction measure was a variation on Baer’s (1988) problem-finding task. Participants were presented with a situation and were asked to write all the different ways they could think of to restate the problem (but were not asked to solve the problem). Two different problem-finding tasks were used. An example of the problem-finding task is presented in Appendix B.

The problem restatements were rated on quality and originality using the rating scales developed by Redmond et al. (1993) and are presented in Appendix C. The quality and originality of the problem restatements were assessed using a procedure adapted from Hennessey and Amabile's (1988) consensual rating technique. In accordance with the procedure suggested, three judges familiar with relevant research in creativity, cognition, and problem solving were asked to rate the quality and originality of problem restatements obtained from 10 sample problems. These judges were then brought together for a panel meeting to discuss discrepancies in the ratings. Quality was defined as providing a plausible and viable restatement of the problem presented. Originality was defined as a novel response that was not structured by the stimulus context. These rating scales were then applied to actual data collected for this study. The trained judges were then given the stimulus material and the problem restatements generated by the participants and were asked to evaluate the quality and originality of each set of problem restatement.

Raters were not given information about the hypotheses, experimental conditions, or expected outcomes. When judges were asked to rate the quality of the problem restatement, an interrater agreement coefficient (Shrout & Fleiss, 1979) of .66 was obtained. The interrater agreement for originality was .64. These interrater reliabilities are sufficient for research purposes and are similar to those obtained in other studies using the similar measures and procedures (Mobley et al., 1992; Runco & Chand, 1992). Problem construction ability was defined as both quality and originality of the problem restatement. For the purpose of this study, and in accordance with the recommendations of Harrington, Block, and Block (1983), the quality and originality scores were multiplied to obtain a creativity score, and the median split was then performed on this score.

Active processing. The first manipulation was a replication of the manipulation used by Redmond et al. (1993) to induce active processing. Participants in the active processing manipulation were asked to write down all possible problem restatements after they have read the problem scenario. Only then were they instructed to solve the problem. Participants in the control condition did not receive these instructions, and were asked to proceed immediately with solving the problem.

Cue consistency. According to the model proposed by Mumford et al. (1994). activation of a wide range of problem representations will result if the individual attends to a wide range of diverse and possibly inconsistent (with prior knowledge or information) cues. Fewer or even only one problem representation will be activated when cues are consistent with prior knowledge and information. The second manipulation, intended to activate a wider range of problem representations, was achieved by providing participants with cues that were discrepant or inconsistent with the rest of the information provided in the problem scenario. In the consistent cues condition, these cues were replaced with cues that were consistent with the rest of the information presented in the problem. The problems in the two conditions were otherwise identical. Figure 1 provides a sample of a problem presented in this study with both consistent and inconsistent cues.

Dependent Variables

The quality, originality, and creativity of the problem solutions were the dependent variables in this study. The quality and originality of the solutions were assessed by using rating scales constructed according to Hennessey and Amabile's (1988) consensual rating technique. In accordance with the procedure suggested, three judges familiar with relevant research in creativity, cognition, and problem solving were asked to rate the quality and originality of problem solutions obtained from 10 sample problems. These judges were then brought together for a panel meeting to discuss discrepancies in the ratings. Based on the outcome of this discussion, revised definitions of solution quality and originality were formulated. Quality was defined as providing a viable solution to the problem that was coherent and feasible. Originality was defined as a novel response that was not structured by the stimulus context. These rating scales were then applied to actual data collected for this study and are presented in Appendix D. The trained judges were then given the stimulus material and the solutions generated by the participants and were asked to evaluate the quality and originality of each solution. Raters were not given information about the hypotheses, experimental conditions, or expected outcomes. The interrater reliability (Shrout & Fleiss, 1979) for quality was .69 and for solution originality the interrater reliability was .65. These values indicate sufficient reliabilities for research purposes and are similar to those obtained in other studies requiring ratings of this nature (Redmond et al., 1993).

Separate quality and originality scores were obtained for each participant by averaging the scores of quality and originality for each problem across raters. Additionally, a creativity index was obtained in accordance with the recommendations of Haningtm et al. (1983) for each of the problems. This was accomplished by using a multiplying average quality and originality ratings.

Because we suspected that problem type or problem domain (i.e., leadership, school, social) may influence the responses, separate quality and originality scores were obtained by averaging scores for the two problems in each domain. Split half reliabilities were computed for each of the domains (leadership, social, and school) and for each dependent measure and ranged from .60 to .71, further supporting the combination of the two problems in each domain.

Analyses

Before conducting the primary analyses, two sets of analyses were conducted to demonstrate the effectiveness of the manipulations and to assess the unidimensionality of the dependent measures. The effectiveness of the manipulations was tested by contrasting the responses of participants in the two conditions on the appropriate items in the post experimental questionnaire. The unidimensionality of the dependent measures was assessed by reviewing the correlations between ratings of quality and originality for all three problem types.

A series of analysis of covariance tests were used to analyze the effects of the manipulations and problem construction ability on the quality, originality, and creativity scores of problem solutions. The covariates examined in all analyses included divergent thinking fluency as measured by the Consequences A test and category combination as measured by label creativity and exemplar creativity (Mobley et al., 1992). A covariate was retained in a given analysis only if it accounted for a significant portion of the variance ($p < .05$) and satisfied the homogeneity assumption.

The effects of three independent variables on solution quality, originality, and creativity for each problem were examined. The three independent variables were active processing or no active processing, consistent or inconsistent cues, and high or low problem construction ability.

Results

Methods

To test the effectiveness of the active processing manipulation and to ensure that participants in the active processing condition did in fact engage in active processing, responses for each of the two questions in the post experimental questionnaire assessing active processing were compared. The responses for each question assessing active processing were summed across all six problems. Planned comparisons were used to compare the means of the two groups. Participants in the two conditions did not differ with respect to the time spent defining each problem $F(1, 182) = 1.78$. However, a significant effect was found for the number of different ways in which they looked at the problem before solving it, $F(1,182) =$

14.1, $p < .01$. Participants in active processing condition looked at the problem in more ways ($M = 2.37$, $SD = 0.52$) then participants who were not exposed to the active processing manipulation ($M = 2.11$, $SD = 0.37$).

To determine the effectiveness of the cue manipulation, the number of consistent cues remembered was compared to the number of inconsistent cues remembered. The reason for the selection of this manipulation check is that the problem construction model suggests that in order for inconsistent cues to activate a wide variety of problem representations, these cues have to be attended to and seen as relevant to the problem. Whether a participant could recall a particular cue was seen as a test for whether they attended to that cue and how relevant it was seen. Moreover, because they are inconsistent with the rest of the information provided in the problem, the inconsistent cues should be remembered more easily than the consistent cues that fit with the rest of the information. Planned comparisons were used to determine mean differences between the inconsistent cues condition and the consistent cues condition and a marginally significant main effect was found, $F(l, 177) = 3.36$, $p < .07$. Participants in the inconsistent cues condition remembered more cues ($M = 0.66$, $SD = 0.44$) than participants in the consistent cues condition ($M= 0.55$, SD = 0.40).

Correlations Among the Dependent Variables

These analyses indicate that the manipulations of cue consistency and active processing had the desired effect. Therefore, it would be appropriate to examine the effects of these variables on the measures of creative performance, quality, and originality. Before examining the primary findings on quality and originality, it may prove useful to first review the relations among the ratings of quality and originality obtained for the three problems. Table 1 presents the means, standard deviations, and correlations for all dependent variables, covariates, and problem construction ability. Regarding the correlations among the different problem types, it may be seen, quality and originality ratings obtained for the same problem tended to be strongly related to each other ($.78 < rs < .80$). This pattern of results may be attributed to (a) overlap in rating stimuli, (b) failure of the raters to distinguish between quality and originality, or (c) an intrinsic relation between the causes of quality and originality. The remaining correlations were in the .47 to .66 range. However, in accordance with expectations, quality ratings (average $r = .62$) and originality ratings (average $r = .57$) were more closely related within a set than across sets (average $r = .52$).

Quality

The results obtained in the three analyses examining quality in leadership, social, and school problems are presented in Table 2. When the quality of the solutions to the leadership problems and the social problems was examined, only one covariate was found to make a significant contribution: exemplar creativity, $ts(177) = 2.97, 2.92$, respectively, $ps < .05$. Exemplar creativity has been shown to be a good measure of the category combination and reorganization process, with a strong influence on the creativity of the final product (Baughman & Mumford, 1995; Mobley et al., 1992). It is not surprising that this covariate was related positively (ßs = .19 and .21 for leadership and social problems, respectively) with the quality of the solution. It is also of interest to note that the ideational fluency measure failed to reach significance in all three analyses. The failure of the ideational fluency as a measure of divergent thinking to reach significance is consistent with recent theoretical and empirical research suggesting that divergent thinking is more highly related to exploration of the implications of a new idea than initial idea generation (Mumford, Baughman, & Sager, in press).

When the effect of exemplar creativity was controlled, problem construction ability was significantly related to solution quality for the leadership problems, $F(l, 177) = 5.16$, $p < .05$, for the social problems, $F(l, 177) = 4.61$, $p < .05$, and for the school problems, $F(l, 178) = 5.82$, $p < .05$. As expected, individuals with higher problem construction ability produced better quality solutions for leadership problems ($M = 3.24$, $SD = .58$ vs. $M = 2.92$, $SD = .60$), for social problems ($M = 3.28$, $SD = .57$ vs. $M = 3.00$, $SD = .55$), and for school problems ($M = 3.2$, $SD = .49$ vs. $M = 2.99$, $SD =$ S7). High problem construction ability may lead individuals to think about multiple possible ways to construct the problem and may lead to a better problem-solving plan, therefore contributing to eventual solution quality (S. L. Friedman, Scholnick, & Cocking, 1987). Main effects on quality were not obtained for the two manipulations in this study: active processing and cue consistency.

An interesting finding was that of a significant interaction between cue consistency and problem construction ability for the quality of the solutions for the leadership problems, $F(l, 177) = 5.15$, $p < .05$, and social problems, $F(1, 177) = 4.45$, $p < .05$. This interaction was marginally significant for the school problems, $F(l, 178) = 2.84$, $p < .09$. A post hoc Scheffé was performed for the significant interactions and was found significant ($p < .05$) for both the leadership and social problems. The results for the leadership problems suggest that individuals with high problem construction ability who solved problems with inconsistent cues produced solutions of higher quality ($M = 3.37$, $SD = .56$) than individuals with low problem construction ability in either cue condition ($M = 2.98$, $SD = .46$ for consistent cues and M = 2.85, $SD = .72$ for inconsistent cues). When solving the social problems, problem construction ability had no effect when the cues presented in the problem were consistent ($M = 3.06$, $SD = .43$ for low problem construction ability vs. $M = 3.19$, $SD = .58$ for high problem construction ability). However, when the cues presented in the problem were inconsistent, high problem construction ability lead to significantly higher quality solution ($M = 3.37$, $SD = .53$) than low problem construction ability ($M = 2.92$, $SD = .65$). A similar pattern of results was obtained for the school problems. This pattern suggests that the elicitation of multiple and diverse problem representations will contribute to the quality of the solution only if the individual has high problem construction ability. It is possible that the reason for these results is that high problem construction ability allows the individual to integrate these diverse representations into a new coherent whole and therefore allows for higher quality solutions. If the individual is relatively low on this ability, the presence of diverse and inconsistent cues does not contribute to higher quality of the solution, because the person is not able to integrate all the diverse information presented.

Originality

The results of the analysis of covariance for originality are presented in Table 3. As in the analyses for quality, only the exemplar creativity variable reached significance in the analysis of covariance for any of the problem types and was retained for further analysis. Exemplar creativity was a significant covariate only for the leadership problems (ß = .26, $t = 3.56$, $p < .05$). This finding is consistent with earlier observations that category combination is an important component in creative production (Baughman & Mumford, 1995; Mobley et al., 1992). Again, ideational fluency failed to reach significance as a covariate for all three problem types.

A review of the results presented in Table 3 reveals that only one significant main effect emerged for the originality ratings. Problem construction ability was significant for the social problem, $F(l, 178) = 6.05$, $p < .05$. As expected, individuals with higher problem construction ability received higher originality ratings than individuals with lower problem construction ability ($M = 3.27$, $SD = .59$ vs. $M = 3.03$, $SD = .60$). Problem construction ability approached statistical significance for the school problems, $F(l,178) = 2.85$, p<~ .09. When inspecting the cell means, a similar pattern of results emerged. individuals with high problem construction ability obtained higher originality scores than those with lower problem construction ability ($M = 3.15$, $SD = .54$ vs. $M = 3.0$, $SD = .59$). Another marginally significant main effect was found for the active processing manipulation for the leadership problems, $F(l, 177) = 3.62$, $p < .06$. Individuals who were required to engage in problem construction activities before solving the problem produced more original solutions ($M = 3.26$, $SD = .65$) than individuals who did not engage in active problem construction ($M = 3.08$, $SD = .65$).

A two-way interaction between problem construction ability and cue consistency was obtained for both the leadership problems, $F(l, 177) = 5.39$, $p < .05$, and the school problems $F(l, 178) = 4.16$, $p < .05$. A post hoc Scheff*é* test revealed that the locus of that interaction was the difference between individuals with high problem construction ability and low problem construction ability in the inconsistent cues condition. In contrast, differences between high and low problem construction ability for consistent cues were not significant. A review of the cell means for the leadership problems indicated that individuals with high problem construction ability who solved problems with inconsistent cues produced more original solutions than individuals with low problem construction ability who solved the same problems ($M = 3.4$, $SD = .68$ vs. $M = 2.97$, $SD = .61$). For the school problems, individuals with high problem construction ability solving a problem with inconsistent cues generated more original solutions ($M = 3.22$, $SD = .52$) than individuals with low problem construction ability solving the same problem ($M = 2.9$, $SD = 50$). This pattern of relations suggests that providing diverse information that should elicit multiple problem representations was beneficial (i.e., increase originality of the solutions) only for a subset of individuals, those who have high problem construction ability.

Creativity

The final dependent variable examined in this study was the multiplicative index of the quality and originality ratings created as an index of creativity (Harrington et al., 1983; Mumford & Gustafson, 1988). The results for this analysis are presented in Table 4. Because the creativity score was derived from the quality and originality ratings, one would expect to find that exemplar creativity was the only significant covariate. Exemplar creativity was significant for both the leadership and social problems ($t = 3.57$ and 2.77, $p < .05$, ß = .26 and = .20, respectively). Similarly, problem construction ability was a significant main effect for the school problems, $F(1, 178) = 3.87$, p < .05, and a marginally significant main effect for the leadership problems, $F(1, 177) = 3.17$, p < .08, and for the social problems, F(1, 177) = 3.2, $p < .08$. A marginal main effect for active problem construction was observed for the leadership problems, $F(l, 177) = 3.3$, $p < .07$. Also, in accordance with the findings for the quality and originality, a two-way interaction was obtained between cues and problem construction ability for the leadership problems, $F(1, 177) = 5.34$, $p < .05$, as well as a marginally significant interaction for the school problems, $F(1, 178) = 3.47$, $p < .07$. Because these results show the same pattern as the results for quality and originality, we will not discuss their implications separately.

Discussion

The most straightforward conclusion that can be drawn from this study pertains to the role of problem construction in creative production. Based on earlier theoretical work (Mumford et al., 1991; Sternberg, 1986), and in accordance with previous research findings (Okuda et al., 1991; Redmond et **al.,** 1993), we found that participants with higher problem construction ability were able to provide more creative solutions to complex, ill-defined problems. The findings in this study suggest that the general ability of problem construction (i.e., the ability to define problems in multiple, creative ways) is related to more creative solutions.

Perhaps even more interesting was the finding that problem-finding ability was related to problem quality for all problem types. Since the publication of Guilford's (1967) influential model suggesting that divergent thinking should be considered when studying creativity, much of the focus in the study of creativity has shifted toward measures of divergent thinking, fluency, and originality. The findings presented here highlight the role of metacognitive skills in creative production. Although metacognition has received ample attention in the problem-solving literature (Berardi-Coletta, Buyer, Dominowski, & Rellinger, 1995; Murnford & Fleishman, 1994), it has not been studied extensively with regard to creative problem solving (Jausovec, 1994; Kaizer & Shore, 1995). This study suggests that problem construction ability, as partly metacognitive skill, may play an important role in arriving at solutions of higher quality. Being able to look at the problem from multiple perspectives, being able to identify multiple possible goals and objectives, and the ability to integrate sometimes conflicting goals should lead to better solutions, and not just more original solutions.

Not only do our findings indicate that problem construction ability is important for creative problem solving; they also provide information on the conditions under which problem construction ability plays a significant role in creative production. It appears that problem construction ability is essential for the generation of high quality, highly original solutions when problems contain diverse information that may be inconsistent with other presented information. These inconsistencies elicit multiple problem representations, and to form a plan for problem solving people have to first integrate these problem representations into a coherent new representation (Mumford et al., 1994; Mumford, Baughman, Threlfall, et al., 1996). Previous studies have found that creativity was associated with a tendency to consider apparently irrelevant information (Alissa, 1972), moderately remote associations (Cough, 1976), identification of multiple categories that apply to the problem (Davidson & Sternberg, 1985), and an environment that provides multiple diverse cues (F. Friedman, Raymond, & Feldhusen, 1978). These findings led to the belief that the availability of knowledge and wide range of information will facilitate creative problem solving (Langley & Jones, 1988; Mumford, Baughman, Costanza, Uhlman, & Connelly, 1993; Weisberg, 1988). However, later work by Runco (1994b) suggested that this universal claim may not be appropriate, and that although some individuals may benefit from these conditions, and enhance the creativity of the resulting solutions, others may not. This study provides additional evidence for the possibility of differential effects of the environment. More specifically, this study suggests that although a wide range of information can be beneficial for creative problem solving, this is not so for all individuals. Whether the availability of knowledge or a diverse set of categories will act to enhance creative problem solving or not depends on the level of information processing skill the person possesses. The findings of this study indicate that people need a basic level of information processing capacity (in this case, problem construction ability) before they can capitalize on the availability of opportunities provided by diverse or conflicting information and the availability of multiple problem representations.

This finding is even more important given assertions from Dillion (1982) and Cetzels (1979) that novel, ill-defined, complex problems allow more room for creative problem solving than routine, well-defined problems. Ill-defined problems are characterized by diverse, and in many cases, inconsistent information (Schraw et al., 1995). Those factors that allow for greater creativity to take place are theelcments that may inhibit creative problem solving for some people. This also places greater emphasis on the role of the problem construction process and how it may contribute to creative problem solving. According to these findings one important function of the problem construction process is to integrate diverse information to form a coherent, workable problem representation.

Our attempt to enhance the application of the problem construction process through instructions for active processing was not successful. This finding was somewhat puzzling because this manipulation was used successfully in a previous study (Redm4 et al., 1993) and because the post experimental questionnaire revealed that participants in the active processing condition defined the problem in more ways than participants in the control condition. A possible explanation for these results is in the different tasks that were used in the two studies. Redmond et al. asked participants to design advertising campaigns for a new product. In this study, participants were asked to solve real-life problems. These problems were selected specifically to ensure that all participants had some level of exposure to similar type problems. Because the problems in this study were more involving, participants may have been able to access problem representations without the call for active processing (Csikszentmihalyi & Sawyer, 1995). Some support for this hypothesis is found in a study designed to assess affective reaction and emotional involvement to different problem types (Scherer, Butla, Reiter-Palmon, & Weiss, 1994). Further studies are needed to determine whether the affective actions of the participants to the type of problem they are asked to solve indeed impacts the quality and originality of the solution.

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Appendix A: Example of Problem Scenario

(Underlined words were included only in consistent cues manipulation, italicized words were included only in the inconsistent cues manipulation).

You are a twenty year old college junior, majoring in biology.

In high school you were a very good student and were concerned with getting good grades and being successful in school. Even though you spent a lot of time studying you were involved in different clubs and had an active social life.

In selecting a college and your major, you delayed the decision until the last minute. You had been uncertain regarding a career and were not sure what you wanted to study. Given your good grades in high school and your high SAT scores, your choice of colleges was wide open. You ended up applying to the first three schools that came to your mind when the application deadline approached. When the time came to select a college, your parents were very enthusiastic and seemed to be more interested in the colleges that you visited than you were. You elected to major in biology because science has always been an easy subject for you. You also figured that biology might be a good major in terms of opening up several career options.

You are an <u>average</u> *(good)* student, your GPA is <u>2.9</u> (3.9) and you spend a lot of time studying and worrying about your performance in school. You are unhappy with your GPA level. You are still unsure about your career choice. You are entertaining thoughts about applying to graduate school, and although your grades are high enough to get accepted, you are unsure about whether this is what you want.

You are unhappy about your learning experience in college and you feel that you are not getting what you thought you would get out of college. At some point you thought about taking a year off from school to use the time to travel, work, and get a better sense of direction. Your parents were dead set against the idea and were afraid that you would drop out of school. You have therefore decided to continue with your college education.

What would you do in the situation described?

Appendix B: Instructions and Sample Problem for Problem Construction Task

This is a test to find out how many different ways you can think of to state a problem. After reading a problem description, you should try to find as many different ways to state the problem as you can. State each problem in the form of a question (e.g., "How can we" or "How can l?) and then write the problem.

Here is a sample item.

Problem description: Mice are in my basement.

Sample problem statements:

1 . How can I build a better mousetrap?

2. How can we get rid of the mice?

3. How can I not be bothered by the mice?

Appendix C: Rating Scales for Problem Constructions

Please rate all problem restatements together as a group.

Quality. The degree to which the problem restatement are plausible and viable restatements of the problem presented.

> 1 very low quality, problem restatements are not plausible.
>
> 2 low quality, most problem restatements are not plausible.
>
> 3 average quality, some problem restatements are plausible.
>
> 4 high quality, most problem restatements are plausible.
>
> 5 very high quality, all problem restatements are plausible.

Originality. The degree to which the problem restatements are free from the problem situation presented and go beyond it. The degree to which the problem restatements are not obvious from the situation. The degree of novelty and uniqueness in the problem restatements. The degree to which the problem restatements cover multiple different views of the problem.

> 1 very low originality, problem restatements directly tied to the problem, only one way of viewing the problem.
>
> 2 low originality, problem restatements tied to the problem, few different but obvious ways of viewing the problem.
>
> 3 average originality, problem restatements somewhat tied to the problem, one non-obvious way of viewing the problem.
>
> 4 high originality, problem restatements somewhat free from the problem, few nonobvious ways of viewing the problem.
>
> 5 very high originality, problem restatements free from the problem, multiple different non-obvious ways of viewing the problem.

Appendix D: Rating Scales for Problem Solutions

Quality. The degree to which the solution is a plausible and appropriate solution to the problem presented. The degree of logic and coherence in solution.

1 very low quality, solution not plausible or appropriate

2 low quality, solution somewhat plausible, little logic and coherence

3 average quality, solution plausible, somewhat appropriate, some logic

4 high quality, solution plausible, appropriate, and logical

5 very high quality, solution very plausible and appropriated, very logical.

Originality. The degree of extrapolation from the stimulus context (the problem scenario presented). The degree to which the solution is not structured by the problem and has gone beyond the rote. The degree of novelty and uniqueness of the solution.

1 very low originality, no extrapolation, highly structured by the problem.

2 low originality, little extrapolation, structured by the problem.

3 average originality, some extrapolation, somewhat structured by the problem.

4 high originality, moderate degree of extrapolation, little structure by the problem.

5 very high originality, large degree of extrapolation, not structured by the problem.

Table 1. *Means, Standard Deviations, and Correlations for Dependent Variables, Covariates, and Problem Construction Ability*

	M	*SD*	SLQ	SQS	SQSC	SOL	SOS	SOSC	SCL	SCS	SCSC	PCA	DT	CLC	EC
SLQ	3.08	.63	—	.65***	.67***	.80***	.57***	.60***	.94***	.64***	.66***	.34***	–.12*	.22***	.30***
SQS	3.14	.58		—	.55***	.58***	.78***	.47***	.65***	.94***	.53***	.30***	–.07	.19**	.29***
SQSC	3.09	.56			—	.64***	.60***	.80***	.66***	.54***	.94***	.19**	–.05	.18**	.22***
SOL	3.17	.65				—	.60***	.64***	.94***	.63***	.68***	.26***	–.07	.24***	.30***
SOS	3.14	.61					—	.47***	.61***	.93***	.50***	.24***	–.09	.14*	.21**
SOSC	3.08	.58						—	.64***	.49***	.94***	.18**	–.11	.15*	.19**
SCL	10.09	3.92							—	.67***	.69***	.31***	–.09	.24***	.32***
SCS	10.11	3.55								–	.54***	.28***	–.08	.20**	.28***
SCSC	9.77	3.33									—	.18*	–.08	.18*	.21**
PCA	10.60	3.44										—	–.11	.24***	.34***
DT	6.16	2.16											—	–.06	.05
CLC	10.83	3.88												—	.62***
EC	10.41	4.11													—

Note: SLQ = Solution Quality Leadership; SQS = Solution Quality Social; SQSC= Solution Quality School; SOL = Solution Originality Leadership; SOS = Solution Originality Social; SOSC = Solution Originality School; SCL = Solution Creativity Leadership; SCS = Solution Creativity Social; SCSC = Solution Creativity School; PCA = Problem Construction Ability; DT = Divergent Thinking; CLC = Category Label Creativity; EC = Exemplar Creativity.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 2. *Analysis of Covariance for Quality*

Source of Variance	Leadership			Social			School		
	MS	*df*	*F*	*MS*	*df*	*F*	*MS*	*df*	*F*
Cues	0.07	1	0.19	0.00	1	0.00	0.00	1	0.02
AP	0.07	1	2.16	0.38	1	1.28	0.14	1	0.63
PC	1.85	1	5.16*	1.38	1	4.61*	1.73	1	5.82*
Cues × AP	0.09	1	0.24	0.10	1	0.34	0.03	1	0.09
Cues × PC	1.85	1	5.15*	1.34	1	4.45*	0.84	1	2.84
AP × PC	0.06	1	0.18	0.11	1	0.36	0.39	1	1.31
Cues × AP × PC	0.14	1	0.39	0.22	1	0.72	1.09	1	3.66
Within	0.36	177		0.30	177		0.30	178	

Note: AP = Active processing; PC = problem construction ability.
*p < .05.

Table 3. *Analysis of Covariance for Originality*

Source of Variance	Leadership			Social			School		
	MS	*df*	*F*	*MS*	*df*	*F*	*MS*	*df*	*F*
Cues	0.00	1	0.00	0.07	1	0.19	0.05	1	0.14
AP	1.39	1	3.62	0.34	1	0.94	0.24	1	0.71
PC	0.40	1	1.03	2.19	1	6.05*	0.95	1	2.85
Cues × AP	0.10	1	0.27	0.66	1	1.82	0.19	1	0.56
Cues × PC	2.07	1	5.39*	0.33	1	0.92	1.39	1	4.16*
AP × PC	0.03	1	0.07	0.07	1	0.18	0.18	1	0.53
Cues × AP × PC	0.06	1	0.15	0.20	1	0.56	0.08	1	0.24
Within	0.38	177		0.36	178		0.33	178	

Note: AP = Active processing; PC = problem construction ability.
*p < .05.

Table 4. *Analysis of Covariance for Creativity*

Source of Variance	Leadership			Social			School		
	MS	*df*	*F*	*MS*	*df*	*F*	*MS*	*df*	*F*
Cues	3.34	1	0.25	1.79	1	0.15	0.11	1	0.01
AP	44.27	1	3.30	17.43	1	1.48	8.47	1	0.77
PC	42.49	1	3.17	37.65	1	3.20	42.63	1	3.87*
Cues × AP	4.52	1	0.34	6.30	1	0.54	3.15	1	0.29
Cues × PC	71.61	1	5.34*	21.01	1	1.79	38.23	1	3.47
AP × PC	2.26	1	0.17	7.76	1	0.66	16.75	1	1.52
Cues × AP × PC	0.38	1	0.03	6.09	1	0.52	14.03	1	1.27
Within	13.41	177		11.77	177		11.02	178	

Note: AP = Active processing; PC = problem construction ability.
*p < .05.