An Empirical Examination of the Value of Creativity Support Systems on Idea Generation

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Abstract

Because organizations seek more innovative ways to compete, the ability of their employees to generate new and valuable ideas becomes a fundamental survival skill. To the extent that computer software might enhance the creative performance of individual users, organizations might ultimately apply such tools to enhance the creative performance of their employees. A controlled laboratory experiment was performed to determine whether two popular creativity support applications significantly enhanced the creative performance of individual users. The results suggest that responses generated with software support are significantly more novel and valuable than responses generated by pen and paper. The results also question the previous creativity research practice of not directly controlling for idea fluency prior to experimental manipulation. It is hoped the findings from this investigation can be used to improve individual creative performance, further research concerning factors relevant to creativity, and guide future ICSS development efforts.

Keywords: DSS, software quality, brainstorming, software packages, interface characteristics, user satisfaction

ISRL Categories: AF0802, CB09, EI0206.01, EI0207, HA03, HD01

Introduction

To respond effectively in today's quickly changing, highly complex business environment, management must depend on organizational members' mental capacities to generate new and meaningful ideas (Beckett, 1992; Herrmann,1993; Johnson, 1992; Kanter, 1982). Consequently, creativity has evolved into a fundamental organizational resource useful in establishing and maintaining competitive advantage (Coulson and Strickland, 1991; Everett, 1983; Gillam, 1993; Kiechel, 1983). Organizations such as Microsoft and Minnesota Mining and Manufacturing, for example, claim that cultivating creativity within their members has led to innovations otherwise not possible (LaBarre, 1994; Morgan, 1993). Moreover, between 1988 and 1992, the number of firms offering creativity training programs has increased eightfold to 33 percent (Thierauf, 1993). With industry leaders such as International Business Machines, Banc One, and Exxon Corporation regularly expending corporate dollars to nurture the creative spirit of their members, techniques aimed at enhancing creativity are flourishing (Couger, 1995; de Bono, 1993; Evans, 1991).

One relatively new set of tools intended to augment the creative process is Creativity Support Systems (CSS) (Abraham and Boone, 1994). These computer-based tools are generally aimed at enhancing boundary-breaking, insightful thought during problem solving (Evans, 1991; VanGundy, 1992; Winship, 1991). For example, some CSSs provide open-ended question-and-answer options for generating new points of view, while others provide more focused structures for exploring ideas (Marakas and Elam, forthcoming). In addition, some packages are designed to support individuals, while others are intended for group-oriented use (Dayton, 1991; Young, 1989).

Although the popularity of CSSs for individual use appears to be growing, only a few controlled examinations exploring their value have been performed (Rouse, 1989; Winship, 1991). For example, Proctor (1989) found that of 170 subjects using Individual-Level Creativity Support Systems (ICSS), over 50 percent claimed to have generated at least one useful insight not considered prior to using the ICSS. However, Proctor's investigation also found that a significant number of the subjects were not enthusiastic about the software. In addition, research by Watson (1989) and Roberts (1989) determined that students using an ICSS were able to generate more ideas faster than students brainstorming without software. While these findings have merit given the notion that a novel idea is more likely to emerge from many rather than fewer ideas, neither study directly considered the quality of ideas generated.

Notwithstanding the lack of clear empirical evidence concerning the value of an ICSS, there is also little theoretical justification (Abraham and Boone, 1994; Elam and Mead, 1990). Each ICSS appears to provide a different methodology for enhancing creativity with little more than anecdotal reasoning to justify the approach (Cohen, 1991; Young, 1989). However, if an ICSS were to directly enhance creative performance, the organizational benefits could be multifaceted. For example, organizational members could use the ICSS for reinforcing techniques learned in formal creativity training. Or, by matching ICSS tools to specific decision needs, the ICSS might enable management to better control creative performance. An organizational member unable to think in alternative ways on a particular issue might use the pattern switching or association tools of an ICSS to respond more variably.

To better understand the value of using an ICSS, this paper proposes a theoretical model reflecting a variety of factors believed directly relevant to an individual's creative performance. Hypotheses concerning the effects of ICSSs on creative performance are derived and investigated using a controlled laboratory experiment.

Theoretical foundation of the ICSS

Formally, an individual has performed creatively to the extent that the response produced is not only novel, but also meaningful and valuable for a given situation (de Bono, 1993; VanGundy, 1982). Conceptually, the extent to which one performs creatively is influenced by a variety of social, cultural, and historical factors (Ackoff and Vergara, 1981; Albert, 1983; Amabile and Tighe, 1993; Couger, 1995; Tardif and Sternberg, 1988). Within any given environment, however, additional factors such as individual ability, the nature of the decision task, the amount of training, and the technology used could also affect creative performance (Elam and Mead, 1990; Evans, 1991; Torrance, 1988; Young, 1989). A graphical depiction of these proposed relationships can be found in Figure 1.

Qualities relevant to an individual's creative ability include physiological characteristics of the brain (Restak, 1993); distinctive cognitive characteristics (Guilford, 1968); and special motivational considerations (Csikszentmihaly, 1988; Haines and Amabile, 1988). Generally, an individual's natural creative potential is biologically determined and established early in life. It is thought to directly affect creative performance and is not expected to vary significantly over time (Amabile, 1991; Cox, 1983; Torrance, 1988).

Through training, however, an individual's creative performance can be amplified or inhibited (de Bono, 1993; VanGundy, 1982; Walberg, 1988;). Creativity training represents the individual's past knowledge and developmental history concerning his/her creative behavior (Couger, 1995; Finke, et al., 1992; Jacobs, 1989). Depending upon the individual's background and training with respect to decision making, creative behavior may become more or less pronounced over time (Tardif and Sternberg, 1988; Walberg, 1988).

The nature of the decision task is another factor that affects creative performance (Elam and Mead, 1990; VanGundy, 1992). Categorically, creative responses result from two types of mental processes: generative and exploratory (Finke, et al., 1992). Within the generative

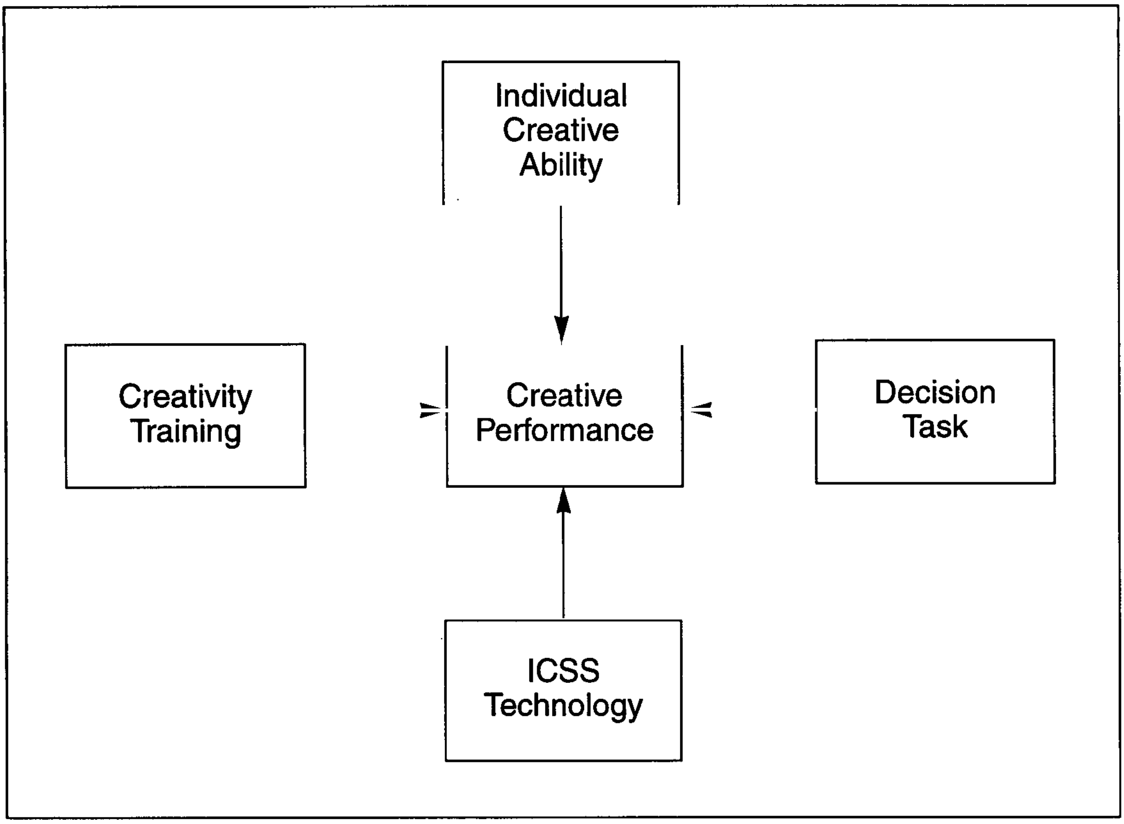

Figure 1. Theoritical Model of the Relationship Between Individual Creativity Support Systems and Creative Performance

mode, divergent ways of thinking, including remote association and pattern switching, produce novel, unique concepts (Ackoff and Vergara, 1981; de Bono, 1993; Young, 1989). In the exploratory mode, convergent thought such as elaboration or successive refinement reformulates a unique concept into a meaningful and valuable response (Ackoff and Vergara, 1981; Guilford, 1968; VanGundy, 1982). While both processes must occur for an individual to perform creatively (Guilford, 1968; Tardif and Sternberg, 1988), the nature of the decision task defines which mode is likely to dominate response formation (Finke, et al., 1992). Depending on whether the stated task is aimed at the generative or exploratory mode, the response produced would tend to be more novel or useful.

ICSSs are also thought to directly contribute to an individual's creative performance (Evans, 1991; Young, 1989). Theoretically, they influence performance by providing the necessary suggestions and cues for an individual to produce a creative response (Robbin, 1990). Moreover, these tools are believed to ward off debilitating distractions by focusing the individual's thoughts toward creativity (Cohen, 1991; Finn, 1993). However, while arguments suggest ICSSs ultimately enhance creative performance, it is also possible they have no impact or a negative impact on creativity. For example, operating a computer may make an individual so emotionally uncomfortable that his/her ability to think in any fashion is limited.

Hypotheses formation

Because creative performance has previously been operationalized in a variety of ways, it is useful to consider the expected impacts of ICSSs from multiple perspectives. One way is to consider the effect of ICSSs on idea fluency (Diehl and Stroebe, 1987; Young, 1989). Idea fluency refers to an individual's ability to generate a number of different ideas in response to a specific decision task (Guilford, 1968; Saletta, 1978). It is typically considered an objective, quantitative measure of creative performance and is widely used as a dependent variable in brainstorming research (Ackoff and Vergara, 1981; Couger, 1995; Roberts, 1989; Watson, 1989). Since ICSSs are specifically designed to provide cues that heighten an individual's creative performance, and idea fluency is considered an aspect of that performance, the following hypothesis is suggested.

H1: Use of ICSS technology will result in a greater number of ideas being produced for a given decision task than use of conventional software support or no software support.

Beyond providing mental triggers for quantitatively enhancing creative thought, an ICSS should also be capable of qualitatively improving creative performance. Not only would one expect more ideas to be produced from using an ICSS, but one would also expect these ideas to be more original and valuable than ideas produced by some other means. A formal statement reflecting this notion follows.

H2: Use of ICSS technology will result in more creative ideas being produced for a given decision task than use of conventional software support or no software support.

To the extent that a computer program can support creative thought, it theoretically has the potential to enhance creative performance in a precise way. Specifically, an ICSS focused on generative thinking (e.g., viewing a situation in a completely different way) should be able to spawn more novel responses than an ICSS focused on exploratory thinking (e.g., successively refining an established perspective). And, an ICSS that emphasizes exploratory thought over generative should produce creative outputs containing more situational value than novelty. Hypotheses to reflect these implied relationships follow.

H3: Use of a generative ICSS application will produce ideas for a given decision task that are more novel than those produced by an exploratory ICSS, conventional software support, or no software support.

H4: Use of an exploratory ICSS application will produce ideas for a given decision task that are more valuable than those produced by a generative ICSS, conventional software support, or no software support.

Methodology

The experiment entailed a 1 x 4 design where subjects completed the same task using one of four treatments: generative ICSS, exploratory ICSS, conventional software, and no software. Creativity training was held constant, and individual ability was monitored through testing before and after experimentation. The subjects' task responses were rated on creative merit by experts in the task domain. Details concerning subjects, software, variables, and procedures are provided in the following paragraphs.

Subjects

The subjects were 44 MBA students taking a graduate course in management information systems at a large metropolitan university. All were employed in a full- or part-time capacity. They volunteered to participate and were randomly assigned to treatments after receiving creativity training. None were familiar with any of the software applications used prior to receiving their respective treatments. But, all already knew how to operate a computer for word processing and spreadsheeting purposes.

Software selection

There were three different types of software used in the experiment. One, IdeaFisher, was selected to represent an ICSS with a generative focus. This software contained an idea bank with over 705,000 possible associations of topics, phrases, and words (Robbin, 1990). Using the idea bank, an individual could support the processes of divergent thinking and remote association by browsing through and pondering the listed topics and ideas. In addition, IdeaFisher provided a question bank of over 3,000 questions designed to support thought processes such as flexibility, memory retrieval, and pattern switching. While IdeaFisher did not claim to inhibit exploratory thought, the main thrust of the software appeared to focus on tools to generate novel ideas.

The second, Ideatree, was selected to represent an ICSS with an exploratory focus. Rather than ask open-ended questions or offer lists of generic ideas, this package provided a means for users to embellish, emphasize, and polish ideas. Specifically, the software enabled a user to type concepts into "idea-boxes," which could then be linked laterally or hierarchically. While the boxes had a limit on the space available for phrasing, the user was free to append additional comments to any idea-box through a word-processing option (Cohen, 1991). Although Ideatree did not actively inhibit generative thought, it focused on detailing, arranging, and coordinating ideas to make them more meaningful and valuable.

The third, Harvard Graphics, was used as a software-control mechanism for any impacts that may result simply from computer use and not creativity support. This conventional application was selected because it mimicked some features offered in formal ICSSs. For example, it readily allowed users to create and arrange boxes, charts, and text-based outputs.

Variables and measures

The independent variable manipulated was the type of creativity support each individual used to generate creative responses. The dependent variable was the subjects' creative performance on a decision task. Creative performance was operationalized into idea fluency, novelty, value, and a creative performance score. Fluency was defined as the number of ideas generated by each subject. Novelty was defined as the extent to which each response was rated as new, unique, and different. Value was defined as the extent to which each response was rated as realistic or worthwhile. And the creative performance score was generated by averaging novelty and value ratings across subjects' responses.

A creativity inventory (from Hellriegel and Slocum, 1991) was given to each subject before and after the experiment. The inventory consisted of 36 items designed to assess an individual's perceived self-confidence, need for individuality, abstract thinking ability, analysis capability, desire for task achievement, and degree of environmental control. Because these have been consistently cited as characteristics of a creative person (Amabile and Tighe, 1993; Barron and Harrington, 1981; Tardif and Sternberg, 1988; Torrance, 1988), the inventory appeared to provide a general determination of each subject's ability to perform creatively. Besides having face validity, the inventory seemed relatively simple to administer. It was split into two 18-question instruments so that three questions about each characteristic were present on each version. The response options were constructed so that higher scores reflected individuals more predisposed to perform creatively.

A software satisfaction survey was also given to each subject in the software treatments. The survey consisted of 11 items constructed to determine a subject's attitude toward computers (four items); deference toward the software used (two items); sense of the software's applicability and decision support (three items); and perception of its ease-of-use and operability (two items). The survey also contained two open-ended questions to gather additional opinions about the software each subject used.

Decision task

The task required subjects to devise solutions to the homeless problem faced by cities and society. This task was chosen based on Haines and Amabile (1988), which suggested that to decrease the potential for response bias, tasks requiring no specific knowledge or training should be used in creativity experimentation. Because homelessness reflects a problem that any person living in a large metropolitan area would have general awareness of and one where common knowledge would suffice for solution formation, the task seemed to meet these criteria. In addition, the task seemed distinctive enough to hold the subjects' attention but indefinite enough to support generative and exploratory thought equally well (Finke, et al., 1992).

Judges

The judges were selected for their expertise in governmental policy issues such as homelessness. One was an attorney specializing in human rights, and the other was a former community council president with a master's degree in public administration. The judges made their assessments independently and rated the ideas relative to each other rather than to a standard they might hold from their work domains. Expert-level performance standards are typically too high for members of the general population to consistently meet (Amabile and Tighe, 1993). Therefore, a negative rating bias might be introduced if an expert were to apply a domain-determined standard. The judges were asked to rate each idea on a scale of one (no merit for the factor) to 10 (maximum merit for the factor).

Experimental procedures

The experiment occurred over two sessions. In Session 1, the creativity training session, subjects were given an introduction in how to think more creatively. The session began with a lecture on how important creativity is for business decision making. Examples of how organizations have used creativity to become more successful were given. Subjects were also given a description of how the creative process occurs and were made aware of biases both individuals and organizations have with respect to creativity. Ways to overcome these obstacles were suggested, and discussion was encouraged. The session lasted approximately an hour and included one exercise in brainstorming and one in elaboration. The purpose of the session was to establish a consistent knowledge base concerning creativity.

After the discussion, each subject was given the first half of the creativity inventory to determine his/her baseline ability to respond creatively. The preinventory measure was given at the end of the training session so that a distinction could later be made between training and experimental effects. Had the preinventory been given before training, establishing whether training or treatment produced a given outcome would be difficult.

The second session occurred one week after the first. In Session 2, subjects in each software treatment received an initial overview of how their application functioned. Specifically, the idea and question bank features of IdeaFisher (novel-thought support tools) were taught to subjects in the generative treatment. Subjects in the exploratory treatment were taught the idea-box and note-pad options of Ideatree (refining-thought support tools). And conventional subjects received instruction in the organization chart and text-writing options of Harvard Graphics because these features appeared to mimic the ICSS box and screen features.

The software applications were menu-driven, offered online help, and appeared straightforward to use. For example, to use the idea bank feature in IdeaFisher, one would highlight listed ideas and then copy them to a supporting "screen-pad" with the click of a mouse. No specific creativity training examples were used in Session 2. But, various suggestions for how to use the chosen functions were taken from each application's training manual. The training for each software application took approximately 40 minutes to complete. When a subject acknowledged comfort in operating the features pertinent to his/her application, that subject was given a sheet of paper containing the decision task. Subjects were told to generate as many different ideas as possible in the period allotted using the software they had just learned.

Subjects in the control treatment were each given a pen, blank paper, and the sheet containing the assigned task. They, too, were told to generate as many different ideas as possible in the timeframe allotted. All subjects in all treatments were allowed 30 minutes to complete the assigned task. All subjects were allowed to ask questions concerning the tools they used such as "How do I change screens?" for the software treatments, or "Can I write on the back of the paper?" for the control treatment. Tool-focused questions were allowed to subvert confusion effects that might occur from subjects not remembering how to use their applications. But no questions concerning the assigned task were allowed. At the end of the allotted time, subjects were asked to either save their ideas on disk or turn them in on paper. All subjects then completed the second half of the creativity inventory, and subjects in the software treatments also completed the software satisfaction survey.

Data compilation techniques

Once the experiment was complete, the subjects' ideas were typed into a common word-processing format. A common format was used so that any visual differences in the outputs generated (such as handwriting or font style) would not influence the judges' decisions. The process of differentiating ideas from the responses given by the subjects occurred as follows. For the most part, the subjects either numbered their ideas, separated them by spacing between blocks of text, placed them into different boxes with any text-based elaboration attached on the electronic note-pad, or simply used phraseology such as "another idea would be." Where a response contained a lengthy explication of similar content or was not distinctly separated, the entire response was included as a single idea. Given that the judges were experts capable of appropriately assessing any elaboration and that nuances in word and grammar choice more accurately reflect a respondent's true intention, the ideas were transcribed as written with only spelling errors and basic punctuation corrected. Moreover, because the judges were asked to rate the ideas relative to one another, all ideas, even those of one subject that may have appeared similar in content to the ideas of another subject, were given to the judges.

Each expert was given a list of 149 ideas and asked to rate each on novelty and value. Two versions of the idea lists, one the reverse order of the other, were used so that fatigue or learning effects could be detected. The experts were provided as much time as they wanted and were encouraged to take breaks to avoid fatigue. Because so many ideas were generated, and because the experts were professionals with pressing responsibilities outside the cause of research, they only went through the rating process once.

Results

Because of the volume of data analyzed, the results have been divided into the following sections: Creative Ability, Judges' Reliability, Idea Fluency, Creative Performance, Generative and Exploratory Support, and Software Satisfaction. A summary of the statistics used for testing the hypotheses can be found in Table 1.

Creative ability

A formal extreme-scores test revealed that one pair of inventory scores from the control treatment was an outlier (Hildebrand and Ott, 1991). After viewing this subject's responses to both versions of the creativity inventory and the experimental task, it was decided to drop the subject from the study. A total of 43 subjects were left in the analysis. Table 2 presents the means and standard deviations for the creativity preinventory and post-inventory scores.

Multivariate analysis of variance techniques were used to compare subjects' inventory scores before and after the experimental manipulation. No significant differences were found between the mean scores at the .10 probability level.[1] No systematic bias was revealed, and creative ability did not appear influenced by the treatment conditions.

Judges' reliability

Interrater reliability was determined for each measure of creativity assessed by the judges

[1] Because of the exploratory nature of this investigation, the .10 probability level, a more inclusive criterion, was selected for hypothesis testing (Cohen, 1977).

Table 1. Summary of Key Statistics for Performance and Satisfaction Measures

Variable/ Statistic/ Effect Tested	Performance				Satisfaction				
	Wilks' lambda	F Ratios			Wilks' lambda	F Ratios			
		Creative Performance	Novelty	Value		Computer Comfort	Software Likability	Ease of Use	Decision Support
Creative Ability	3.26	6.88	3.48	6.02	-	-	-	-	-
Fluency	40.91	78.75	51.38	70.01	-	-	-	-	-
Treatment	2.54	3.90	2.56	4.00	2.15	-	6.31	7.36	-
Treatment x Fluency	-	-	-	-	-	-	-	-	-

Note: Only values that tested significant at the .10 probability level or below are reported.

Table 2. Means and Standard Deviations of Creativity Inventory Scores and Number of Ideas Generated

Instrument/ Group	n	Creativity Preinventory	Creativity Post-Inventory	Number of Ideas
Control	9	45.89 (8.30)	46.44 (5.25)	2.22 (1.13)
Generative	11	43.09 (5.17)	44.82 (7.29)	3.73 (2.53)
Exploratory	11	43.82 (7.80)	44.82 (5.25)	3.91 (1.44)
Conventional	12	45.92 (7.91)	42.50 (9.47)	3.25 (1.48)
Overall	43	44.65 (7.22)	44.51 (7.07)	3.30 (1.65)

Notes: All measures are means except where noted. Standard deviations appear in parentheses. The higher the value, the more the individual is predisposed to perform creatively.

(Huck, et al., 1974). The coefficient of correlation for novelty was .88 and for value, .74. The high degree of agreement on novelty is logical with expert-level raters (Amabile and Tighe, 1993). The more moderate agreement on value is logical given the experts were involved in different aspects of the problem domain.

Idea fluency

Hypothesis testing began by investigating H1, the impact of the experimental treatments on the number of ideas generated by each subject. The means and standard deviations for this measure can be found in Table 2.

In preparing to perform a one-way analysis of variance, preliminary tests showed that the homogeneity of variance assumption was violated (Bartlett-Box $F = 2.22$, $p < .10$), while frequency distributions and normal plots on the number of ideas generated indicated the presence of a bimodal distribution. Specifically, clustering existed around the low and high values for idea fluency.

Although the creativity inventory results indicated that subjects were dispersed throughout the treatments in an unbiased manner, the inventories did not directly account for a subject's ability to generate ideas. In the psychological literature, idea fluency has been characterized as a creative ability that remains relatively constant over time (Guilford, 1950; Torrance, 1988; and Wallach, 1983). Consequently, rather than have a random sample free of systematic bias, the treatment groups contained individuals who appeared to vary in their ability to generate ideas.

To statistically adjust these conditions so that the hypotheses could be appropriately tested, an additional independent factor entitled Fluency—with two levels (high and low)—was formed (Dillon and Goldstein, 1984). Subjects were placed into the high-fluency category if they generated more than the mean number of responses (i.e., four or more) and into the low-fluency category if they generated three or fewer responses. Because the subjects were dispersed throughout the treatment conditions in such a fashion that discernible fluency levels could be formed, the analysis continued.[2]

Creative performance

A creative performance score was generated by averaging each subject's total novelty and value rating scores.[3] By using an averaging process, both qualitative and quantitative aspects of a subject's performance could be simultaneously considered. Because creative ability was only indirectly controlled before the experimental manipulations, hypothesis testing began again using analysis of covariance techniques. Specifically, an assessment of H1 and H2 was made using the creative performance score as the dependent variable, the treatment condition and degree of fluency present as independent factors, and the creative ability preinventory score as a covariate. Adjusted mean scores for creative performance can be found in Table 3.

The ability covariate was significantly and positively related to creative performance ($F_{1,34}$ = 6.88, $p < .01$). Two main effects were significant: treatment ($F_{3,34}$= 3.9, $p = .02$) and fluency ($F_{1,34}$ = 78.75, $p < .01$). No significant interaction effects were noted. In addition, fluency accounted for the largest percent of variance explained—57 percent—while treatment accounted for 9 percent, and creative ability accounted for 5 percent.

The main effect of fluency revealed that highly fluent subjects generated ideas considered significantly more creative than those produced by less fluent subjects. And the Scheffe univariate adjusted mean comparisons for interpreting the treatment effect indicated that subjects in the software conditions performed significantly more creatively than subjects in the no software condition ($t = -3.10$, $p = .01$). However, no significant performance differences were noted between the software conditions.

H1 was not supported by these findings because the Treatment x Fluency interaction was not significant. Hence, subjects using ICSS software did not generate more ideas than subjects using conventional software or no software. The findings did show partial support for H2, however, given that subjects using software outperformed subjects using a pen and paper.

Generative and exploratory support

Multivariate analysis of covariance techniques were used to examine H3 and H4, with the novelty and value measures as dependent variables, the treatment condition and degree of fluency present as independent variables, and the creative ability preinventory score as a covariate. Adjusted means for both novelty and value can be found in Table 3.

[2] Interestingly, creativity research has rarely attempted to directly control for idea fluency before experimental manipulation (Ackoff and Vergara, 1981; VanGundy, 1992). Typically, research efforts have not only operationalized idea fluency as a dependent measure of creative performance, but they have also used bias controls for creative ability that only indirectly consider an individual's propensity to generate ideas quickly (Barron and Harrington, 1981; Domino, 1970; Joseph and Pillaj, 1986). Without establishing a subject's fluency level prior to treatment and controlling for this potential bias throughout experimentation, any results produced could be due to an individual's propensity to generate ideas (either innately present or otherwise learned) and not the intended experimental manipulation.

[3] Total novelty and value rating scores were generated by *summing* each judge's ratings on value and novelty for each subject's response set. These totals were then divided by the number of ideas the given subject generated to derive a mean novelty and value score for each subject. These mean scores were then averaged across judges to create a total novelty and a total value rating score for each subject.

Table 3. Adjusted Means for Creativity, Novelty, and Value

Dependent Measure/ Independent Factor	n	Creativity	Novelty	Value
Control				
High Fluency	2	14.69*	13.47*	16.59*
Low Fluency	7	7.94	6.46	9.86
Treatment Total	9	11.31**	9.69***	13.14**
Generative				
High Fluency	5	24.20*	24.13*	24.62*
Low Fluency	6	8.61	7.18	9.80
Treatment Total	11	16.40	15.66	17.21
Exploratory				
High Fluency	6	23.36*	19.95*	27.22*
Low Fluency	5	12.33	11.11	13.94
Treatment Total	11	17.85	15.53	20.58
Conventional				
High Fluency	4	21.17*	18.18*	24.16*
Low Fluency	8	9.74	8.13	11.73
Treatment Total	12	15.45	13.16	17.95
Overall				
High Fluency	17	20.85*	18.93*	23.15*
Low Fluency	26	9.65	8.22	11.29
Sample Total	43	15.25	13.58	17.22

Notes: All measures are means except where noted. Higher scores represent better performance.
* High fluency outperformed Low fluency at a .01 probability level.
** The Computer groups outperformed the Control group at a .01 probability level.
*** The Computer groups outperformed the Control group at a .02 probability level.

The test for covariation was significant (Wilks' lambda = 3.26, $p = .05$), with creative ability positively related to both novelty ($F_{1,34} = 3.48$, $p = .07$) and value ($F_{1,34} = 6.02$, $p = .02$). The overall multivariate test for fluency was significant (Wilks' lambda = 40.91, $p < .01$) as were the subsequent univariate comparisons for its effect on novelty ($F_{1,34} = 51.38$, $p < .01$) and value ($F_{1,34} = 70.01$, $p < .01$). Thus, highly fluent subjects produced ideas that were judged significantly more novel and valuable than those produced by less fluent subjects.

The overall multivariate test for treatment was also significant (Wilks' lambda = 2.54, $p = .03$), with the univariate comparisons for its effect on novelty ($F_{3,34} = 2.56$, $p = .07$) and value ($F_{3,34} = 4.00$, $p = .01$) significant. In addition, Scheffe mean comparisons suggested that subjects in all three software conditions produced ideas judged significantly more novel ($t = -2.40$, $p = .02$) and more valuable ($t = -2.86$, $p = .01$) than those produced in the no software condition. But, subjects in the software treatments did not significantly outperform each other on novelty or value. No interactions were noted in this analysis.

In general, these findings do not support H3 and H4 since the generative application did not outperform the exploratory on the perceived novelty of ideas produced, and the exploratory application did not outperform the generative on perceived value.

Software satisfaction

To investigate subjects' satisfaction concerning the software they used, composite measures of computer comfort, software likability, better decision support, and ease of use were formed by averaging subjects' responses across related items. The means and standard deviations of these measures can be found in Table 4.

With no significant covariation, the composite satisfaction measures served as dependent variables, with the treatment condition and degree of fluency present as independent factors in a multivariate analysis of variance. Overall, the main effect of treatment was significant (Wilks' lambda = 2.15, $p = .02$), indicating subjects' satisfaction varied depending on the software they used. Univariate comparisons revealed significant differences in perceptions of software likability ($F_{2,31} = 6.31$, $p < .01$) and ease of use ($F_{2,31} = 7.36$, $p < .01$). Specifically, individual mean comparisons showed that subjects using the generative application liked it significantly *less* than subjects using either the conventional ($t = 3.44$, $p = .01$) or exploratory ($t = 4.27$, $p = 02$) application. The generative application was also rated significantly *more* difficult to use than either the conventional ($t = 3.36$, $p = .01$) or exploratory ($t = 3.27$, $p = .01$). Satisfaction with the conventional or exploratory applications did not differ. Moreover, fluency did not affect software satisfaction, perceptions of computer comfort or better decision support did not vary between the software conditions, and no interactions were noted.

Conclusion

Although using experimental and statistical techniques to control for the decision task, creativity training, and creative ability precluded a comprehensive examination of Figure 1, an indication that software support directly enhances an individual's creative performance was noted. Moreover, since the number of ideas generated did not differ between treatment conditions, and all subjects in the software conditions had prior experience with computers, it is unlikely that using technology, per se, produced the performance enhancements. Rather, the finding that satisfaction with the generative software was relatively low while performance was high suggests the applications might have been providing decision support and not simply charming subjects into performing more creatively.

However, because performance did not differ between the software conditions, this experiment cannot explain exactly how the software enhanced creative performance. Both generative and exploratory thought seemed equally well supported, though the software features examined were expected to provide differential support. One potentially valuable use for ICSS technology may be to frame thought in a particular manner so that the ideas produced reflect specific qualities. However, if all support features improve novelty and value equally well, then discerning which feature to use when becomes arbitrary. Moreover, because low ratings on likability and usability did not appear to negatively affect performance, further study of the impact of ICSS design on creative performance seems appropriate.

Another limitation to this investigation is the one-time examination of the technology. While the performance difference noted was favorable to the technology, the efficacy of an ICSS to enhance creativity over time was not examined. And potential relationships between ICSS technology, creativity training, and the decision task were not fully explored. For example, although the technology appeared to enhance performance when training was held constant, ICSS may directly affect training efforts. Or, a more analytic decision task may hinder the ability of ICSS to enhance creative performance.

Despite its limitations, a few useful insights have been gained from this investigation. First, an empirical demonstration of ICSS technology's positive effect on creative performance offers an encouraging confirmation for its popularity. Second, a formal consideration of factors relevant for creativity enhancement provides a focus for managerial efforts to improve creative

Table 4. Means and Standard Deviations for Software Satisfaction

Fluency/ Satisfaction/ Treatment		High	Low	Total
	Generative	2.35	2.46	2.41
		(0.91)	(0.83)	(0.87)
Computer Comfort	Exploratory	2.33	2.50	2.42
		(1.06)	(0.66)	(0.86)
	Conventional	2.38	2.03	2.21
		(0.66)	(0.31)	(0.49)
	Overall	2.29	2.35	2.31
		(0.60)	(0.83)	(0.71)
	Generative	2.90	3.08	2.99*
		(1.57)	(0.80)	(1.19)
Software Likability	Exploratory	2.17	2.00	2.09
		(0.52)	(0.79)	(0.66)
	Conventional	1.88	1.56	1.72
		(0.63)	(0.68)	(0.66)
	Overall	2.16	2.33	2.24
		(0.95)	(0.98)	(0.96)
	Generative	3.33	3.61	3.47
		(0.82)	(0.65)	(0.74)
Decision Support	Exploratory	3.00	3.20	3.10
		(0.79)	(0.65)	(0.72)
	Conventional	3.41	2.58	2.99
		(1.19)	(0.46)	(0.83)
	Overall	3.07	3.22	3.14
		(0.69)	(0.84)	(0.76)
	Generative	2.70	3.42	3.06*
		(1.92)	(0.67)	(1.30)
Ease of Use	Exploratory	1.58	1.80	1.69
		(0.67)	(0.84)	(0.76)
	Conventional	1.75	1.69	1.72
		(0.50)	(0.59)	(0.55)
	Overall	2.26	2.00	2.15
		(1.00)	(1.20)	(1.10)

Notes: All values are means except where noted. The standard deviations appear in parentheses. The lower the value, the more positive the perception.
*Significant at a probability level below .01.

performance. Third, the inclusion of idea fluency as an independent factor affecting creative performance suggests a more thorough approach to researching creativity. These insights may not only allow for better designs and applications of ICSS, but may also ultimately improve the ability of organizations to creatively respond to their environments.

Acknowledgements

The author would like to thank Thomas Abraham, Larry W. Boone, Beata Lobert, and Patrick Lyons for their suggestions and support during the initial design and data collection phases of this project. The author would also like to thank the reviewers for their very helpful guidance in developing this research project into a paper.

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