Research in Creativity and GSS

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Abstract

Recent IS literature points to a growing interest in the subject of creativity. After some isolated attempts in the 1980's by researchers, systematic efforts by Couger and others have yielded much useful creativity research in the 1990s pertinent to the field of information systems. Much less work relevant to creativity has been done in the topic area of Group Support Systems (GSS); we review this research and prepare the ground for stimulating more extensive studies.

1 Introduction

It is difficult to browse through a journal these days—academic or popular—without encountering a business-related article that dwells on the subject of *creativity*. Until recently—at least among Information Systems (IS) researchers—creativity was at best a curiosity to be enjoyed privately rather than an object of serious research. Indeed, the many misconceptions surrounding the topic, and especially the widely-held belief that it was much too intangible to yield to systematic investigation, had kept it away from the cross-hairs of most IS scholars. Also, the subject had not received much attention from researchers in the other management disciplines. Since IS researchers often follow their lead, building on theories developed in those other areas, creativity as an IS research topic had remained largely unexplored.

This state of affairs was turned around following a Delphi study of CIOs in the United States by Professor Daniel Couger in 1988, which led to his identifying *creativity* as a key issue in IS (Couger, 1996). Spurred on by this finding Couger established a research center for systematically investigating creativity in an IS context. This program has proved to be very fruitful, resulting in over twenty-two refereed articles on the subject (Couger, 1996). In addition, Couger established a creativity and innovation mini-track at the annual HICSS conference, which by 1996 had produced thirty-two articles. Couger listed and classified these articles in his 1996 HICSS paper (Couger, 1996), and created a framework for future research in creativity and innovation in IS.

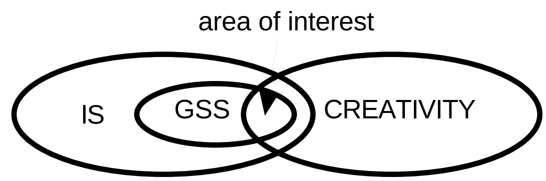

Figure 1. Focus of this research

One area of IS research that potentially would most benefit from studies in creativity is the field of Group Support Systems (GSS; Bostrom, Watson, and Kinney, 1992; Valacich and Jessup, 1993). The focus of this article is creativity related issues in the context of GSS (Figure 1). We provide a brief overview of creativity research in general, and then delve into creativity research in the IS field, considering first individual creativity support and then group creativity support. Finally, we provide suggestions for future research in this sub-field for four key creativity factors.

2 Creativity

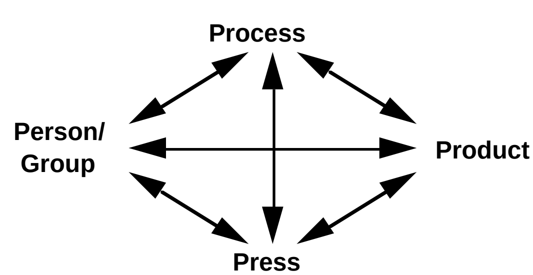

Figure 2 (adapted from Fellers & Bostrom, 1993).

Creativity researchers classify their work in terms of whether it addresses the creative **person**, creative **product**, creative **process**, or the creative **press** (environment and context). As can be seen in Figure 2 (adapted from Fellers and Bostrom, 1993), these four

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factors (the “four P’s”) mutually influence each other and are hence intimately related.

Creativity—true to the nature of the subject—has been defined in numerous ways. Almost all definitions, however, imply that creativity includes or involves a combination of originality and usefulness (aesthetic or practical) producing outcomes (products) that generate at least a modicum of surprise in observers. Since it began flowering in the early 1950’s, research in creativity has proven to be very fecund. With an emphasis on works of art (i.e., creative **products**) early research focused on creative individuals (i.e., creative **persons**), and drew the interest of psychologists. Attention then turned to the processes underlying the emergence of creative thoughts and ideas. Wallas (1926) earlier had proposed that creative thinking followed a 4-step process:

preparation —> incubation —> illumination —> verification

More recently, the work of Amabile (1996), among others, has led to inclusion of the environmental context or **press** as an important factor in influencing creativity.

Prior research in the area of creativity has tended to focus on only one or two of these four factors. For example, some researchers have focused on characteristics of the environment or press (e.g., Amabile, 1983; Csikszentmihalyi, 1988), while others have focused on the attributes of the individuals (e.g., Sternberg, 1988; Torrance, 1988). We believe in it is important to consider the effects of each of these factors and their interrelationships in doing creativity related research, although the focus from a GSS perspective will be primarily on the process. Given a context and a predetermined group of individuals, the deliberate use of processes or techniques is the principal means of producing desired creative products. Process is perhaps the key factor that can be manipulated when using GSS to support creative tasks. Consequently, this factor is discussed in some detail below.

2.1 The creative process

Wallas’s model of the creative **process** has served as the basis for variations and refinements suggested by several researchers over the years. The importance of the work of Wallas and others lay in the fact that creativity was no longer treated as a mysterious and mystical quality but as a set of processes that even less creatively endowed individuals potentially could employ to produce reasonably creative products.

Models of the creative process and models of the choice processes (decision making or problem-solving) are similar. They are stepwise models that contain a series of steps or stages through which an individual or group proceeds. These steps need not follow a strict sequence, nor are all steps required in any particular instance. Recursive and iterative use of steps are allowed and commonly noted. Both approaches are content independent, and thus, can be applied to a variety of tasks and situations. The primary difference between the two is their focus on different outcomes. Creativity models focus on the uniqueness and usefulness of the ideas generated out of each step while choice models tend to focus on the accuracy or quality of the final choice (solution or decision path). We will be using in this article a model that captures the essence of most multi-step creative process model.

Creative Problem Solving (CPS) is a comprehensive methodology developed largely through the efforts of Alex Osborn and Sidney Parnes, Chairman of the Creative Education Foundation in Buffalo, New York. CPS (cf. Isaksen and Treffinger, 1985) is not so much a predefined technique to be followed in a lockstep fashion as a framework consisting of six steps within which more specific techniques can be incorporated. The six steps are: Opportunity Finding; Fact Finding; Problem Finding; Idea Finding; Solution Finding; Application Finding. Each step consists of a divergent phase and a convergent phase. Specific creativity techniques may be used for divergence and convergence. CPS is a useful base model for classifying and discussing creativity research that investigates process.

Opportunity Finding involves identify broadly various potential areas or general situations for improvement. In the divergent phase, a number of opportunities are identified and in the divergent phase, one of these is selected for further elaboration in the next step (i.e., Fact Finding). *Fact Finding* involves identifying all that is known about the selected opportunity and also noting items about which data is required to be obtained. This step is used as a springboard for the next step, *Problem Finding*, in which a variety of very specific problem statements are formulated. A single problem statement is the selected in the convergent phase of this step. The problem having been identified, in the next step—*Idea Finding*—a variety of ideas are generated for solving the problem. In the following step, *Solution Finding*, a set of criteria are identified for selecting a subset of ideas, and in the final step, *Application Finding*, a practical procedure for implementing the chosen solution is formulated. .

One of the chief merits of the CPS method lies in the fact that it forces users to carefully identify the right problem to be addressed, rather than jump into solving a problem that has been only implicitly stated. Further, the

CPS methodology does not stop merely at generating ideas, but coaxes the user to follow a set of steps that lead to specifying exactly how the solution will be implemented in the real world. Adaptive Structuration Theory (AST) developed by DeSanctis and Poole (1994) establishes the importance of structural mechanisms that help shape individual and social processes. CPS provides an overall map for identifying such structural mechanisms based on desired outcomes from each step during creative problem solving. There is little research as yet on structuring mechanisms in creativity research in general and creativity and IS research in particular.

3 Creativity and IS

Direct reference to creativity in IS research until about 1990 was rare. Research on creativity in information systems received a major impetus when Couger established a research program and Center for Research on Creativity and Innovation (CRCI) at the University of Colorado at Colorado Springs (Couger, 1996). This program has produced over 20 refereed articles and inspired *IS-creativity* research at other institutions as well. In one article, Couger, Higgins, and McIntyre (1993), reviewed the literature on creativity, presented the 4P's model, and described in depth how creativity techniques could be applied in the context of information systems. Couger also established the Creativity and Innovation Track at HICSS where a number of articles on this theme have been published. These are listed in Couger (1996).

Creativity research within the IS field has generally taken two paths: following one path are studies of creative processes in IS development (CREATIVITY in and for IS) and following the other are investigations of IS support for creative processes (IS for CREATIVITY). Some studies address both issues. The context of the research that Couger (1996) overviews predominantly has been IS development and the IS organization. All four components of the 4P framework have been addressed by different studies. Nearly all creativity research involving GSS has been of the second kind — IS support for creativity.

A key goal of information systems is to support decision making and problem solving in organizations. Information Reporting Systems (IRS), decision support systems (DSS), and executive information/support systems (EIS/ESS) deliberately target this goal, and DSS are designed with the explicit objective of supporting the exploration of alternatives by asking "What if?" types of questions. In this sense, such IS could be treated as providing support for creative problem solving. Indeed, a reductionist argument would be that any tool that supports problem solving supports creative problem solving. This support, however, is far too limited, and the designers of such systems generally do not pay attention to the finer points of creative problem solving when developing such systems. Instead, they might focus, for instance, on providing appropriate modeling capabilities or on user interface issues. In the following sections, we look at systems that explicitly support individual and group creativity.

All the software tools currently available attempt to support some limited aspect of the creative problem solving process. Some employ the training wheels metaphor by guiding the user through a structured process (such as CPS) in order to complete a task (process structuring). MindLink Problem Solver (1995) steps the user through a process called Synectics (Gordon, 1961) which involves, among other things, the generation of imagery to assist in shifting perspective. Others provide a variety of sources of cognitive stimulation. For instance, IdeaFisher (IdeaFisher, 1993) consists a bank of associatively linked concepts that augments a user's process of free association. Another tool called CyberQuest (Dickey, 1990) provides cognitive and emotional stimulation through images, sounds, and smells. Yet others help the user to change perspectives. Some combine elements of each. The Creative Whack Pack available both in the form of cards as well as software based is on the ideas of Von Oech (1990). The emphasis here is on shifting perspectives through examples provided. Tools such as Inspiration (1994) are based on the concept of Mindmapping (Buzan, 1991) where one can brainstorm by rapidly develop visual maps showing the relationships among concepts relating to an issue as they occur in the mind. Mindmapping breaks the linearity of conventional, verbal forms of idea generation and serves as an ongoing visual stimulus during the idea generation process.

There is much room for enhancement of these tools by incorporating other creativity enhancing techniques in them. Some researchers have suggested DSS design modifications to support creativity (e.g., Elam and Mead, 1990). However, empirical examination of these suggestions is rare. Also, specific GSS tool design to support creativity has received only a very limited discussion (e.g., Nagasundaram and Bostrom, 1995).

3.1 IS to support individual creativity

While our focus is on group creativity support, individual creativity research is very relevant to group creativity research. Nagasundaram and Dennis (1993) have argued that creativity is primarily a cognitive phenomenon. Creative ideas are generated from individual cognitive processes even if they occur within the context of a group. The group serves as an additional structuring mechanism that could either promote or retard individual creativity. GSS design, then, would focus on retaining or emphasizing the positive effects of groups and minimizing or eliminating their deleterious effects.

There are not very many studies of IS support for individual creativity. In an early IS article dealing with creativity, Young (1983) appealed for the development of what he called "right-brained" decision support systems. Young based his article on the popular notion (or gestalt) that the left cerebral hemisphere is given to analytic, symbolic, systematic thinking while the right hemisphere uses more holistic, visual, and intuitive processes. He asserted that the DSS at the time of his writing over-emphasized analytical problem solving, and stressed the need for DSS that assisted the intuition.

There is indeed research suggesting that successful executives rely heavily on their intuitive abilities in making business decisions. As a consequence, perhaps, DSS that rely on formal models and which provide no support for human intuition have not become popular with managers. Vendors appear to have got the message for currently available tools targeted at managers tend to rely less on mathematical modeling than on features such as data visualization and drilling, which are more in the nature of intuition-supporting features.

Proctor (1988) used two different software packages with business practitioners—Brain and Oracle—to determine whether software could aid creative thinking. Brain stimulated users by presenting random words, while Oracle helped users challenge their assumptions regarding a given situation. There was no control group. Users reported that the use of either software resulted in their gaining at least one new insight that they believed could readily implemented in their work context. The Oracle package that helped challenge assumptions had a slight performance edge over the package called Brain which provided stimulation through random words. While this brief study suggests that software could support creativity, it lacked adequate experimental controls to provide strong evidence.

Elam and Mead (1990) used three different treatments—two using creativity software support and a control treatment that used no software to test whether the use of software caused the process and outcomes of problem solving to differ. The software instituted a systematic process where the human problem solver responded to prompts provided by the software. The software guided the problem solver with questions, but provided no explicit cognitive stimulation for creative idea generation. In general, the software prompted the user (in different ways and to different extents) to establish **outcomes**, perform **fact finding, problem finding, idea finding, solution finding,** and **application finding,** without actually suggesting techniques by which each of these steps could be performed. Version One of the software instituted the following problem solving process through prompts provided to the user:

describe problem —> gather facts —> assess relevancy —> organize facts —> develop explanation —> test explanation —> identify solutions

In terms of the CPS methodology, step 1 of the above process matches with Problem Finding, the next three steps with Fact Finding, the step 5 with Idea Finding, and the last two steps with Solution Finding.

Version Two used the somewhat different process, given below:

gather candidate facts —> determine objectives —> assess relevancy —> identify objectives —> inventory resources —> generate ideas —> edit and translate ideas —> make decisions —> test decisions

Again, stated in terms of the CPS methodology, step 1 and 5 are Fact Finding, steps 2 and 3 Opportunity/Problem Finding, step 6 Idea Finding, step 7 Solution Finding, and the last two steps Application Finding.

Those using the second version of the software produced results that were judged to more creative than either the first version or the manual problem solving group. Indeed, those using the first version scored less than even the manual group on creativity.

As we can see, the Version One of the software employed only four of the six steps of the CPS methodology, whereas all six were incorporated into Version Two. Also, in Version one, Problem Finding preceded Fact Finding, whereas in Version Two, Fact Finding helped flesh out the situation and helped in the formulation of the problem in the subsequent steps. Further, Version Two concluded with Application Finding, an essential step in the development of implementable solutions whereas this step was missing from Version One. This could partially explain the results obtained. Indeed, a component-level analysis of this kind, that involves the identification of steps and available mechanisms in a technique of technology is required for understanding the effects of creativity tools.

Marakas and Elam (in press) partially replicated the Elam and Mead study using the first version of the same software. The treatments were modified somewhat crossing software use (software or no software) with problem solving process training (training or no training). The **software/training** condition produced results judged to be most creative, while the **no software/no training** condition produced the least creative results. Among the other two conditions, the **no software/training** condition produced more creative results than the **software/no training** condition. In general, it appeared that creativity training was the more critical determinant of creative performance than the use of software.

Durand and Van Huss (1992) compared idea generating performance using a software package called IdeaGenerator with a process that used no software. Participants were asked to read two cases and suggest suitable solutions, using the software for one case, and none for the other. Dependent measures were quantity of alternatives generated, originality, depth, detail, and an overall assessment of creativity. The results indicated that the software helped generate more alternatives, but that the ideas so generated were less creative than when no software was used. This effect was observed for both high creative and low creative individuals.

Results such as this bring up the issue of fit between task, person, and process used. For instance, if a word processor were used for a creative task, perhaps it would help in generating a lot of output, without necessarily having an impact on creativity. Likewise, another tool that supports a structured thought process designed for generating novel ideas, could result in fewer ideas that are nevertheless novel.

MacCrimmon and Wagner (1994) reviewed research on creativity and develop concepts relevant to the design of decision support systems (DSS). Their model of creative problem solving consists of three stages: problem structuring; idea generation; and, idea evaluation. These correspond to the CPS steps of Problem Finding, Idea Finding, and Solution Finding. The developed a program called GENI (for GENerating Ideas) to support the three stages of problem solving based on the principle of facilitating new "connections" among concepts and ideas. Four types of connections are supported: relational combinations; ends-means chains; idea transformations; and, metaphoric connections, in addition to brainstorming.

The researchers used a version of GENI that focused on only Idea Finding to test the proposition that a set of idea generation procedures based on "connection" processes embedded in software can help increase the yield of ideas. The control groups used a word processor to generate ideas. The results suggest that GENI outperformed the word processor on a measure aggregating five dimensions: novelty, non-obviousness, relevance, workability, and thoroughness. The effect was strongest for the best performing individuals in experiment. The subjects also overwhelming indicated a preference for using the software for generating ideas over the word processor and pencil and paper despite their relative unfamiliarity with the software and a degree of restrictiveness that it enforced.

Massetti (1996) was interested in studying the effects of using different kinds of individual creativity support software (ICSS) on the number, creativity, value and novelty of ideas generated. She investigated two treatment conditions, labeled, **generative** and **exploratory,** and two control conditions, one using software, and one that used no software. In her experimental treatments, she used IdeaFisher©, a product that used an associative idea bank of concepts and questions, as a “generative ICSS”; and IdeaTree©, a tool which provided users the ability to build associative maps of concepts (without providing the concepts themselves), as an “exploratory ICSS”. In her software control condition, she used Harvard Graphics©, a graphics package as a control for the effects of using software that was somewhat similar to the other two. The task used asked participants to generate solutions to the problem of homelessness in society. Massetti hypothesized that the use of ICSS software would produce ideas that were greater in number and creativity; and specifically, the use of **generative**, software would produce more **novel** ideas, while the use of **exploratory** software would produce more **useful** ideas. In general, the use of any software tended to improve performance (creativity judged as a combination of novelty and value of ideas generated) over pen and paper, but the greatest determinant of creative performance was an individual’s innate fluency in generating ideas.

Massetti’s research highlights the importance of investigating the fit between individual characteristics and creativity tool. Studies by Kirton (1989) suggest that individuals differ not only in their extent of creative ability, but also the style in which they are creative, **adaptors** and **innovators**, representing the two extreme ends of a one-dimensional spectrum. Adaptors prefer to effect change within an existing framework, while innovators prefer changing the fundamental assumptions of any particular situation. Given a specific need, say for adaptive change, innovators might require additional support to help them remain within a given context while generating ideas.

Wagner (1996), in a conceptual article explores reasoning mechanisms that could support creativity and identifies five based on the kinds of outcomes that they can potentially generate: deduction, induction, abduction, specialization/generalization, and elementary memory associations. He bases his argument on a Turing-like definition of creativity which asserts that a process can be considered creative if the outcomes of the process are judged by an external observer to be creative. He describes software that he has developed that uses such reasoning methods and produces results that appear creative—much like artificial intelligence programs that appear to make intelligent suggestions. He concludes that creative behavior involves elementary reasoning processes which are programmable in software.

Table 1. Summary of individual creativity support studies

Study	Method	Person	Process	Product	Press	Result
Young ('83)	concept.		•			
Proctor ('88)	Lab	control	IV=software	DV=new insights	control	software generated new insights
Elam & Mead ('90)	Lab	control	IV=software	DV=creativity of ideas	control	depends on software
Marakas & Elam (press)	Lab	control	IV=software & training	DV=creativity of ideas	control	training enhances creativity
Durand and Van Huss ('92)	Lab	control	IV=software	DV=quantity and creativity of ideas	control	software enhanced quantity but reduced creativity
MacCrimmon & Wagner ('94)	Lab	control	IV=software	DV=creativity of ideas	control	CSS enhances creativity
Massetti ('96)	Lab	covariate =idea fluency	IV=software	DV=novelty & usefulness of ideas	control	software enhances creativity; individual attrib. key determinant
Wagner ('96)	concept.		•	•		

Summary. Key aspects of the above studies are summarized in Table 1. These studies point to the process-structuring ability provided by an ICSS. The results suggest that the software used helps enforce a sequence of well-demarcated phases that support creative thinking. The above research, however, does not attempt to identify the specific structures and mechanisms in the software and relate them via theories of creativity to the outcomes observed. While the Elam and Mead, and Marakas and Elam studies treat creativity as a monolithic measure, Massetti separately measures two key components of creative products, namely novelty and usefulness. MacCrimmon and Wagner measure creativity along five dimensions from which they compute an aggregate score. There is scope for examining other attributes of creative products besides these. The dimensions of person and press also have been left unexplored. In particular, a lot more research needs to focus on individual attributes.

Creative **intent**, is another key issue that has not merited attention in the literature. While any process can generate creative output serendipitously, for an idea generation process to be considered creative, there must at least be an intention to generate creative thoughts. In addition to intent, some kind of creativity enhancing technique or structure should be employed during the process. Explicit instructions to participants in a idea generation process to be creative may itself be a key factor in generating creative output. This fact may be a confound in studies that did not make the creative intent explicit. Massetti's study (1996) made the creative aspect of the task explicit to participants, while no mention of creativity was made to participants by either Elam and Mead (1990), or Marakas and Elam (in press).

3.2 IS to support group creativity—GSS

There is very little GSS research that has focused explicitly on creativity, although several studies have attempted to measure the creativity of ideas generated by the process. The first creativity-specific GSS article was by Duncan and Paradice (1992). They reviewed the creativity and group behavior literature on problem solving processes identified four stages: Problem preparation; Problem design/structuring; Search/choice; and Verification/intelligence. With reference to the CPS process, stage 1 covers Opportunity and Fact Finding, stage 2 equates with Problem Finding, stage 3 with Idea and Solution Finding, and stage 4 with Application Finding. The authors conclude that creativity support is especially needed during the problem formulation phase and identify possible applications.

In stage 1 (problem preparation), GDSS should help users explore the problem space. It should provide ready access to wide variety of information; analytical methods for identifying and defining problems; environmental scanning tools; and tools for the development of cognitive maps. In stage 2 (problem design/structuring), tools to support problem design, cognitive mapping and problem structuring should be available. In stage 3: (search/choice), there should be provision for the storage of multiple versions of solutions and the Ability for

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individual group members to work on their own in parallel with the group process. Finally, in stage 4 (verification/intelligence), there should be tools to support validation of the solutions development.

Fellers and Bostrom (1993), reviewed the 4P's creativity model and suggested ways for GSS to play a role in relation to each of the P's. They pointed out that CPS techniques embedded in GSS can continually teach creativity each time the GSS is used, and over time help generate and maintain a creative climate in an organization.

Evaristo and Eierman (1993) integrated creativity problem solving models developed by Wallas (1926), Simon (1966) Newell and Simon (1972), Amabile (1983), and Findlay and Lumsden (1988) and raised questions regarding the nature of support provided by a GSS for the creative process.

Lobert (1993), performed an experiment to determine whether the use of a GSS could eliminate the need for idea incubation. The group task required preparation of a proposal for a new IS module at a university. Creativity was measured qualitatively with a creativity assessment questionnaire. While the use a GSS resulted in more creative project proposals, results relating to incubation were inconclusive.

Nagasundaram and Bostrom (1994, 1995a) noted that much of GSS research relating to idea generation had focused on the quantity of ideas generated using various idea generation techniques. This had led to the conclusion GSS were superior to verbal methods because they resulted in a greater number of ideas generated. The authors proposed an expansion of research to include other issues. This included a focus on the nature of ideas generated and an investigation into the underlying mechanisms in GSS that resulted in differences.

Nagasundaram and Bostrom (1995b) used two different creativity techniques, brainstorming and guided fantasy, both manually and with a GSS. Ideas generated were measured in terms of their paradigm-relatedness which is a measure of the extent to which the product remains close to or represents a drastic shift from the paradigm of the problem context. A paradigm-preserving (PP) concept stays within the bounds of the problem context while a paradigm-modifying (PM) concept shifts away from the context. For instance, suppose that a city has a problem of growing traffic and roads that are not wide enough to gracefully accommodate the traffic. An underlying assumption is that traffic is growing and will continue to grow. A PP solution to the problem would be to widen the roads or add new roads, thereby accommodating the growth. A challenge to this assumption would be to explore whether traffic could be reduced or eliminated and some corresponding PM solution would be to promote telecommuting, give early retirement to workers, or use Star Trek-style molecular transportation.

There were significant effects for technology, with the GSS use leading to a greater quantity of ideas. Manually generated ideas were more paradigm-modifying than those generated with the GSS.

Table 2. Summary of group creativity support studies

Study	Method	Person	Process	Product	Press	Result
Duncan & Paradice ('92)	concept.		•			
Fellers & Bostrom ('93)	concept.	•	•	•	•	
Evaristo & Eierman ('93)	concept.		•			
Nagasundaram & Bostrom ('94/'95a)	concept.	•	•	•		
Lobert ('93)	lab	control	IV=GSS/No GSS & incubation/no incubation	DV=creativity of proposals	control	GSS increases creativity; effects of incubation inconclusive
Nagasundaram & Bostrom ('95b)	lab	control	IV=GSS/No-GSS & creativity technique	DV=paradigm relatedness & quantity of ideas	control	GSS increases idea quantity; Manual more paradigm-modifying
Ocker et al. ('95)	lab	control	IV=IBIS & computer conferencing	DV=creativity of design solutions	control	computer conferencing increases creativity

They observed that current GSS provide little active support for divergence other than by exposing participants to each others' ideas. Other software tools such as IdeaFisher use data banks semantically related phrases to help a user shift perspective. GSS provide tools for participants to numerically evaluate ideas, but no active support is provided to turn impractical ideas into useful ones.

Ocker, Hiltz, Turoff, and Fjermestad (1995) studied two groups of software design teams, one using the EIES computer conferencing (distributed, asynchronous) system. The Issue Based Information Systems (IBIS) method was used for structuring the group problem solving process. The groups using computer conferencing were judged as producing more creative design solutions than the other groups (using Teresa Amabile's method of expert judges using their implicit, individual criteria).

Summary. Key aspects of the above research is summarized in Table 2. A significant proportion of articles have been conceptual. In the experiments, as in the individual creativity support studies, the independent variable invariably is from the process dimension. This follows from the accepted perspective that the software used helps enforce systematic, sequential, creative thinking. The Nagasundaram and Bostrom studies raise the issue of more specific structures and measures product in terms of a new measure, paradigm-relatedness. There is little research addressing dimensions of person and press.

While conceptual research tends to look at the entire creative process (for instance, involving all the steps in the CPS model), empirical studies tend to limit themselves to one or a few phases, typically the Idea Finding phase. Future research should explore other steps in the CPS model.

3.3 Related GSS research

A significant research thrust within the area of GSS has been with respect to idea generation. This research has been reviewed and summarized elsewhere (McLeod, 1992; Benbasat and Lim, 1993; Dennis, Haley and Vandenburg, 1997). The studies are relevant to creativity, since creative processes generally involve idea generation. Most of the research in GSS idea generation, however, does not explicitly reference creativity. All idea generation processes are not necessarily creative, in that they are not necessarily intended to produce creative ideas. The use of a GSS may result merely in giving all participants an opportunity to air their thoughts and opinions, or share some facts about a situation, and then use this as the basis for a decision. The studies reviewed here relate to creativity.

Nagasundaram and Dennis (1993) suggest that GSS idea generation should be investigated as primarily a cognitive rather than a social phenomenon. Ideas are generated when structures present in GSS interact with the cognitive mechanisms of the human information processing system (IPS), during an creative idea generation process. They presented an agenda for research that emphasized **cognitive stimulation** during the idea generation process.

For an individual engaged in idea generation in a group context, the presence of other group members could both be a help and a hindrance. The old adage, "two heads are better than one" suggests that individuals can solve complex problems by harnessing their different perspectives, intellectual skills and knowledge bases. Other persons present provide additional sources of cognitive stimulation. A group, consequently, potentially can generate more ideas than an individual, and these are more varied in nature and hence increase the probability of generating creative ideas. GSS facilitate access to **diverse groups** of individuals thereby promoting divergent thinking (Huber, 1990). GSS prevents the loss of valuable input from all participants by supporting equality of participation and lowered inhibition (George, Easton, Nunamaker and Northcraft, 1990; Jessup and Tansik, 1991; McCleod, 1992; Nunamaker et al., 1991) and even distribution of influence (Zigurs, Poole, and DeSanctis, 1988).

Additional evidence is available that computer-mediated groups will generate **more unshared alternatives** than verbal groups (George, Easton, Nunamaker and Northcraft, 1990). Also, effective group sizes can be larger with GSS (Dennis, Valacich, and Nunamaker, 1990; Gallupe, Dennis, Cooper, and Bastianutti, 1992), potentially leading to more ideas, and more diversity.

Working with others also has its share of problems. A major impediment to creative idea generation in a group context is a phenomenon called **production blocking**: the condition where a group member is unable to think of ideas because of the need to listen to the ideas of others as well as remember and rehearse ideas that have already generated. Numerous studies (e.g., Dennis and Valacich, 1993; Easton, Vogel, Nunamaker, 1992) have found that the use of GSS reduces production blocking, thereby resulting in the production of a larger number of ideas.

The diversity of perspective so critical to creativity can be a double-edged sword. Group work introduces the danger of low productivity caused the tendency to of digress from the given task. This calls for way to enforce a process that will help the group advance steadily to its goal. GSS provide excellent **support for process structuring** (Dennis, Valacich, Connolly, and Wynne, 1996). The process structuring ability of GSS helps divide a task into distinct phases. Tools for both divergence and convergence are provided in some GSS. Consequently, GSS can be used to support the CPS methodology.

Summary. The research so far has focused primarily on process and to a lesser extent on product. The process, however, typically is presented as the complete, unanalyzed technology or technique as a whole, rather than in terms of its component structures and mechanisms. The product, in most cases, has been measured in terms of the quantity rather than in terms of more specific attributes that are descriptive of the nature of the output.

4 Looking into the future

Couger (1996) presented a three-dimensional framework for future creativity research in IS. We present some thoughts regarding future research in the more specific area of GSS and creativity in terms of the 4Ps. The 4Ps are organized into the model shown in Figure 3. A person (or group) with a certain set of relevant attributes (e.g. creativity style, idea fluency, etc.) moderated by a process supported using a GSS and incorporating a set of identified structures (e.g., anonymity, visual stimuli), generates creative products evaluated with a set of measures. The creative process occurs within the context of a given environment or press.

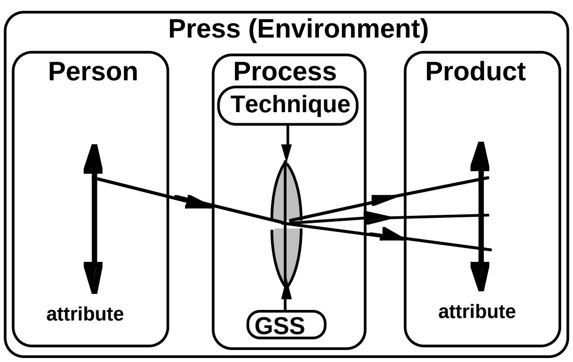

Figure 3. GSS-Creativity research model.

In most studies, the key dependent measures relate to the products generated. After all, of what use is creativity if nothing is created? In a given organizational context, neither the environment nor the individuals can be changed over the short term. The factor most amenable to manipulation is the creative process used. Process (which is a combination of techniques, technologies, and procedures employed) is usually the main independent variable. Person and press are often control variables, but in cross organizational or cross-departmental studies, could also be independent variables. For instance, one could compare the effects of two different cultures, say in the marketing department and the R&D department, or in two different divisions or corporations, on their creative output.

Organizational interventions, over time, can have the effect of changing individual behavior, and in some instances, entire cultures. For instance, the introduction of a GSS-supported creativity sessions in an organizations could be a independent variable whose effects on worker behavior and culture could be investigated. Instances of increased employee motivation and creativity consequent to the continued use of GSS have been observed by the authors.

The fit between two or more factors in the research model needs investigation. Do certain kinds of creative products demand the use of specific kinds of processes (product-process fit)? How different a process is needed for use with senior level executives as opposed to say, primary school teachers (person-process fit)? What kind of culture is appropriate for a corporation that develops and markets computer games as compared to another corporation that processes and sells gasoline (press-product fit)?

4.1 Product

While researchers have investigated the causes for differences in the quantity and quality of ideas generated while using GSS, they have not drawn significantly from the field of creativity research in order to inform and expand their research. Other dimensions for measuring product are needed.

Amabile (1983) argues for a subjective approach to measuring creativity whereby domain experts assess the creativity of products generated without necessarily making their criteria explicit. This approach was used by Lobert and Dologite (1994) and Massetti (1996), among others, for measuring the creativity of IS products.

Measures for creativity might depend on the nature of the task. Couger and Dengate (1992) developed a measure for IS products based on novelty and utility. Massetti operationalized creative performance in terms of idea fluency (i.e., quantity), novelty, and value. Nagasundaram and Bostrom (1995) introduced the creativity measure of paradigm-relatedness. The process they developed could be used to measure outputs of Business Process Reengineering where the need is typically for radical ideas. Besemer and O'Quinn (1986) have developed an instrument for measuring the creativity of products using multiple dimensions.

According to Adaptive Structuration Theory (DeSanctis and Poole, 1994) the success of a technology or process derives from the manner in which it is appropriated by its users. A technology that is ill-appropriated (i.e., rejected or misused), however well-conceived, is a failure. In the AST framework, user expectations are a key determinant of the successful or unsuccessful appropriation of a technology. It is important, therefore, for empirical studies to measure process measures such as user satisfaction, ease of use, and perceived usefulness of an investigated process. An instrument developed and validated by Davis (1989) has been used in several studies for measuring such process variables and is well suited for GSS-creativity research.

4.2 Process

A close attention to the specific structures of a creative process is essential to unraveling the mysteries and harnessing the powers of human creativity using GSS. Structures and mechanisms exist both in manual and computer-augmented processes.

DeSanctis and Poole (1994 is one of several articles they have written on the subject) introduced the concept of structures as a means of understanding how group processes are shaped by the techniques and technologies used to support them. Nagasundaram and Bostrom (1995) identified a set of structures available in GSS and related them to the paradigm-relatedness of the product generated (Table 3).

Structures that promote paradigm-modification are called PM structures, while those that tend to preserve paradigms, are called PP structures. Structures that might encourage creativity but are oriented neither towards paradigm-modification or -preservation are called paradigm-neutral (PN) structures. Cognitive structures act directly on the individual, shaping thought processes. Social and Procedural structures moderate the group experience and act indirectly on the individual. Relating the structures available in creative processes with outcomes could provide a better understanding of how creative processes happen.

Some of the structures in two creativity techniques, brainstorming and GSS electronic brainwriting, are listed in Table 3. In the case of brainstorming, **stimuli** are not supplied by the GSS, but are generated during the process itself by participants verbalizing their ideas. These serve to stimulate other participants. Hence, stimuli are available and forced on participants. This is a PM structure. Further, the **stimulation process** itself uses free association and there is no deliberate attempt to shift perspective. Since free association is unpredictable, it may or may not bring about a radical perspective shift. The **stimuli** generated generally are **related** (a PP structure), except of serendipitous excursions. Indeed, by definition, free association is not designed to link to unrelated ideas and is a PP structure. In the GSS process, participants are typically anonymous, and participate simultaneously. Stimuli, while available, may be ignored by participants.

Table 3. Structures in specific techniques

Structures	**GSS**	***PR***	**BS**	***PR***
Cognitive				
Stimulus availability	Optional	PN	Forced	PM
Stimulus relatedness	Related	PP	Related	PP
Stimulation method	Free assoc.	PP	Free assoc.	PP
Social				
Identifiability	Anon.	PN	Identified	PP
Procedural				
Simultaneity	Simult.	PN	Turn-taking	PM

Abbreviations: GSS = GSS Electronic Brainwriting; BS = Brainstorming.

Table 3 indicates that there are at least two PM structures in verbal brainstorming, while there are none in GSS electronic brainstorming. This might suggest that verbal brainstorming is more likely to lead to PM ideas than GSS brainstorming.

For a GSS to be able to support different techniques or processes, the appropriate structures need to be available for manipulation. The identification and elaboration of these structures is essential for the design of such structures into GSS. The Nagasundaram and Bostrom (1995) classification provides a initial framework which can be extended and modified . Once structures are identified they can be used to design and evaluate new GSS tools to support creativity.

There is a need to explore the effects of different kinds of tool designs on the different steps in the CPS process. In most current GSS, the principal means of stimulating creative thought is through the exchange of ideas among participants. There are, however, a variety of ways in which stimulation is effected in the different creativity techniques (visual, auditory, etc.). Whole new technologies have emerged and are becoming commonplace that might be relevant to GSS-Creativity research. The use of Virtual Reality technology, such as VR goggles could provide a variety of visual stimuli, especially surreal ones, that might promote creative thought. The use of these in conjunction with GSS merits investigation.

The World Wide Web has become ubiquitous and is now a means for both bringing together minds that are geographically displaced, as well as providing a variety of cognitive stimulation for the creative process. A whole new generation of GSS collaborative tools is emerging that can be used over the internet. These are less resource intensive than same-time-same-place GSS labs. Entirely new forms of group interaction are now possible. These technologies provide the potential to use research participants that are not co-located. Hiltz, Turoff and their associates (Ocker, Hiltz, Turoff, and Fjermestad, 1995, 1996) have led the way in this regard but the research in non-same-time-same-place environments has been very limited. Clearly much more research is needed here!

Many creativity techniques involve a fairly complex sequence of activities as compared to the very simple procedures, often a variant of brainstorming, adopted in GSS studies. For benefits to be gained from their use, these techniques need to be faithfully appropriated. Facilitation is one way to ensure faithful appropriation. Another avenue of research is to study and model successful facilitators and use these as the basis for designing GSS structures that perform some of the human facilitator's functions. Very little is now known both about the structures embedded in various techniques and technologies and how they influence both process and outcome variables. Among the most critical research tasks is to develop a more complete taxonomy of creativity structures and how they intervene in the creative process.

Training is another way to ensure faithful appropriation. Yet no GSS study so far has investigated how creativity training might impact results. Westberg (1996) compared the performance of an experimental group that had received eight lessons on the invention process with a control group that had received one introductory lesson and the opportunity to develop inventions. The experimental group produced significantly more inventions than the control group, but there was no difference in the quality of inventions. No technology, however, was used in the study. Marakas and Elam (in press), reviewed earlier, also report a significant effect on creative output, for training.

The GSS itself, could be used as a tool for training groups in the CPS process. For instance, MacCrimmon and Wagner (1994) report that the performance of subjects in their experiment were boosted when using just a word processor for generating ideas, if in two immediately preceding sessions they had used a creativity support tool for generating ideas. Many of the principles of creativity such as deferred judgment, divergence and convergence, and separation of the creative process into phases are easily administered with a GSS to the point where, with continued use, it becomes a natural discipline for participants.

GSS research tends to emphasize divergent processes while both divergent and convergent processes are equally important components of creativity. More research is required to develop structures that support convergence.

Another neglected area in GSS creativity research is the effect of emotions on the process. Positive affect is a important factor in promoting creative behavior (e.g., Ferris, 1976). While post-test process measures are often gathered in GSS studies, there is no research that has investigated affect as a key variable in GSS-creativity research. One of the key aspects of running a creativity session is to balance the socio-emotional and task dimensions (Kelly and Bostrom, 1997). The socio-emotional dimension is especially critical in times of radical change, a time when you want people to be creative. Kelly and Bostrom (1997) studied excellent GSS facilitators and developed a model of how they use a GSS to effectively manage emotions. Their work provides a foundation for exploring socio-emotional issues in a GSS supported creativity process. Issues such as designing GSS tools that support creating positive affect. We outlined in the product section how attitudes and emotions are key variables in system appropriation and use. They can also strongly influence the creative products produced.

In the same vein, most GSS research, particular that related to creativity, is designed as input-output studies. The process is treated as a black box. This is as useful as treating a software package or creativity technique as an unanalyzed whole rather than in terms of its component structures. There is a lot to be learned about how process issues such as emotional states shape the appropriation of technologies. Hence more studies should investigate process variables as key dependent and independent variables.

4.3 Person

Studies so far have shown little concern to how individual characteristics relate to the characteristics of creative products generated or to the appropriate processes that may be used. Researchers tend to draw conclusions about a general population rather than about specific kinds of populations. There is a need to make finer distinctions than these.

Since creativity is about change, Kirton's (1989) work on creativity style (which addresses the issue of the individual's preferred mode of change) and the Kirton Adaption-Innovation Inventory (KAI) instrument (which measures style), needs more attention in GSS-creativity research. Different creative processes might be appropriate for adaptors and innovators. For instance, Nagasundaram

(1995) found a performance difference for innovators using the Guided Fantasy technique over adaptors. This would influence the selection of techniques as well as the design of appropriate structures in GSS.

While the Kirton Adaption-Innovation Inventory (KAI), an instrument for measuring creativity style, has been used successfully with the general business population, Higgins and Couger (1995) found the Innovation Style Profile (ISP) more appropriate for the sub-population of systems professionals. Likewise, it may be that creativity techniques that work well with one homogeneous segment of a population are less effective with another segment.

Real groups in organizations are made up of individuals varying in their creative abilities. While some functional areas, such as Research and Development, might consist of high creatives, while others, such as shipping, generally might have fewer creatives, a cross functional team might be constituted of individuals of different creative ability. It would be interest to investigate the creative performance of such groups, by varying the creative mix in the group.

4.4 Press

The environment factor has been completely ignored in the GSS-creativity literature. This issue may be approached from at least two perspectives: First, How does the use of a GSS influence the creative climate of organizations, and second, How does the climate of an organization lead to or influence the creative use of GSS.

In one example, a product development project group from a high-technology corporation used a university GSS facility to assess different aspects of the project upon its completion. The group was so satisfied with its GSS experience, that the GSS facility has become a regular haunt for project groups from the corporation. The news spread around the corporation through word of mouth and using the GSS facility has become incorporated into the culture. This example illustrates how GSS might have a cultural impact.

Amabile (Amabile, Conti, Coon, Lazenby and Herron, 1996), have developed an instrument called KEYS to assess an organization’s climate for creativity. One possible study is to use creative climate as a dependent variable and assess it, with the help of KEYS, before and after the introduction of GSS into an organization.

The creativity research on the Press factor clearly demonstrates that individual creativity, and it’s manifestation in group or organizational settings, is strongly influenced by the climate of the setting and the behaviors of the leader(s) (Amabile, 1988, Amabile et al., 1996). GSS researchers would be interested to determine how the creative environment influences the use of a GSS. The KEYS instrument could be use as independent or covariate measure in such studies.

4.5 Channels for publication of research results

Journals such as the Journal of Creative Behavior, Creativity Research Journal, Creative and Innovative Management, are already accepting IS related creativity research. Journals in the social and behavioral sciences such as Small Group Research and the Journal of Applied Psychology have published GSS research relating idea generation, and one would expect a positive response to GSS/creativity research. There is growing interest in industry in creativity, and management journals such as the Academy of Management Review (e.g., Woodman and Sawyer, 1993), have published articles in both creativity and GSS. Creativity related articles have already found acceptance in MIS journals such as MIS Quarterly, JMIS, and ISR, and conferences such as AIS and HICSS. Other IT journals such as the CACM, IEEE journals and the Journal of Organizational Computing would be good targets for articles.

5 Conclusion

GSS research, despite its relative youth, has achieved a high degree of maturity. The technology and its impacts are sufficiently well-understood for GSS to be successfully deployed in industry.

GSS are quite evidently a useful tool to support creative group processes. The mantra of corporate creativity can be heard from every organizational and media pulpit today, and GSS are well up to the task of serving this very practical organizational need on a routine basis.

GSS research, however, has not drawn significantly on creativity research, despite their relevance to GSS design and use. In particular, the **person** dimension, so critical to creative output, has not merited any significant attention, and also the link between person and process. There are numerous avenues for applying concepts from the field of creativity to GSS research. Such research could help to expand the application of GSS in business and industry.

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