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dures to overcome some of the problems associated with cooperative, team efforts and thereby improve performance.

Researchers have identified a variety of intervention techniques that can be effectively applied to group processes. These have included intervention techniques without computer support such as extending idea generation, discussing task procedures, emphasizing consensus acceptance, applying active listening techniques, and delaying solutions (Ball and Jones 1977, Hackman and Kaplan 1974, Hall and Watson 1974, Bostrom 1989, Hoffman 1979). Recently, computerized Group Support Systems (henceforth, GSS) have been developed and used as intervention techniques to improve group outcomes. The results of comparing the performance of GSS and non-GSS supported interventions has however, been inconclusive. Lim and Benbasat (1991) conducted a meta analysis of 29 studies comparing GSS and non-GSS groups and found GSS had some desirable effects (greater participation, better quality decisions) and some undesirable effects (reduced consensus, confidence, and satisfaction). These results suggest that there may be significant benefits to combining GSS and non-GSS intervention techniques to structure group processes. Few efforts, however, have evaluated the effectiveness of such hybrid systems on group performance. This study assesses the effectiveness of an integrated GSS (combining GSS and non-GSS interventions) on team outcomes. A related issue involved assessing the impact of task complexity on performance of the integrated GSS. These issues are explored by focusing on three main questions:

1. Do teams perceive that GSS add value to the decision making process?
2. Does task complexity moderate the effect of GSS?
3. Does integrating non-GSS intervention techniques such as knowledge and active facilitation with GSS improve team outcomes in complex task domains?

The rest of the paper is organized as follows. In section I the integrated GSS is described. Section II provides a description of the research design and methodology. The results are presented in section III. The paper concludes with a discussion in section IV.

I. INTEGRATED GROUP SUPPORT SYSTEMS (IGSS)

1.1 Description of the Integrated Group Support System

In recent times, researchers have built and tested a variety of computer based systems to support group decision-making. These systems have become known by a variety of terms such as Group Support Systems, Computer Supported Cooperative Work, Groupware and Electronic Meeting Systems. The use of such electronic medium and "distributed meetings" (that is, people do

not have to be in the same place to 'meet') are becoming popular in group decision making exercises because they can help overcome some of the familiar problems of face to face meetings— lack of focus, overbearing individual participants, fear of reprisal, and individualized recall of meeting content (Gallupe and Cooper, 1993). Further, electronic meetings have the ability to improve the quality of decisions and enhance efficiency by enabling: generation of a wider collection of ideas through anonymous comments by participants (if participants can accept the notion of working anonymously, see Gallupe and Cooper, 1993); the processing of comments simultaneously and the recording of all comments automatically.

Thus, these types of electronic meeting systems (henceforth GSS) were developed as intervention techniques to improve the group interaction process. The GSS were expected to provide effective intervention in group processes by providing structured communication and decision making procedures thereby allowing groups to achieve higher quality outcomes. However, a meta analysis of studies comparing GSS supported versus non-GSS groups revealed mixed results in that both positive and negative effects of GSS were observed (Lim and Benbasat 1991). The results suggest that some of the negative effects of GSS can be overcome by developing integrated systems which combine the benefits of GSS non-GSS based interventions.

This study examines the effectiveness of integrating two non-GSS based interventions (knowledge and active facilitation) with GSS in addressing complex group tasks. In complex problem domains, integrating knowledge with the GSS is likely to add value. The basic premise behind the power of teams is that combining the knowledge and skills of members is likely to produce outcomes which would not have been possible with individual knowledge. In "constructivist" thinking, learning occurs more effectively as learners construct, or discover, their own knowledge based upon experience, new ideas, and information (Leidner and Jarvenpaa, 1995). It assumes that learning occurs as individuals meet, interact and share information (Slavin, 1990). Thus, individual members bring knowledge to the table and the group process adds synergistic value. In real situations, group members often have familiarity with the task before meeting to identify solutions (Anson et al., 1995). However, most experimental studies have not required participants to acquire prior knowledge and skills relevant to the task before the meeting.

Group interaction processes can lead to higher quality outcomes only when knowledge is brought to the table. Previous experimental studies used unrealistic tasks such as building airplanes which may not benefit from knowledge acquisition. Few studies have required teams to conduct exercises starting from problem definition and ending with problem resolution and requiring higher order critical thinking. Such tasks generally benefit from

Assessing the Impact of Integrated Group Support Systems on the Performance of Teams

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INTRODUCTION

The effective utilization of teams, technology, and knowledge has the potential to lead to dramatic improvements in performance. Thus, it comes as no surprise that organizations and researchers are showing an increased willingness to study their combined impact on effectiveness of group processes. Teams have the potential to create synergies not available when individuals work alone. Katzenbach and Smith (1996) suggest that teams outperform individuals working alone or in larger organizational groupings, especially when dealing with situations that require multiple skills, judgements, and experiences. However, teams cannot be effective without the individual skills and knowledge of its members. Raizen (1989) concludes that individuals working in groups construct knowledge which increases productivity. As a result, knowledge has become a major source of competitive advantage and a popular management goal is the creation of a "learning organization" (Nonaka, 1991; Senge, 1991). Such organizations strive to generate, organize, manage, and apply knowledge (Mankin et al. 1995). Technology is yet another element which has the potential to improve organizational performance. Researchers have provided strong evidence to suggest that technology can improve the performance of teams. For instance, Rathnam, et al., (1995) identify several characteristics of information technology that assist in the management of coordination gaps among customer support teams. The authors suggest that both the nature of the tools used and the methods of integrating them with each other helps people work together in resolving problems. Since teams,

technology, and knowledge, individually have the potential to impact performance, it is only natural to explore their combined effectiveness in resolving organizational problems.

While there appears to be strong consensus regarding the value of using teams to address organization problems, less agreement exists on intervention methods that have the potential to positively impact the quality of group effort. A number of problems arise when a group of diverse individuals attempts to work on a set of interdependent tasks. Working in groups or teams involves meetings, discussions, exchange of ideas, collective (or collaborative) decision making, and presumably results in some worthwhile, measurable product. The conventional model of teams involves face-to-face meetings, which numerous studies have shown can consume time and decrease productivity (Monge et al, 1981; Mosvik and Nelson, 1987; Tobią and Becker, 1990). A major challenge involves getting all participants to focus on the same issue at the same time. Many opinions may surface with the resulting 'fragments' of time available to each individual being very limited. Important points may be lost and frustration heightened at the necessarily sequential nature of the discussion. Several group researchers have observed that the typical behavior patterns in groups are counterproductive to achieving task and interpersonal outcomes (Poole, 1991, Hirokawa and Gouran 1989). Thus, a central task for researchers and the main object of this study, is to identify and integrate intervention techniques that promote structured communication and decision making proce-

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the efforts of individual members studying and analyzing the problem prior to conducting the exercise. This study examines the effectiveness of integrating knowledge with the GSS in addressing complex decision tasks.

Another non-GSS type intervention that we include in the integrated system is active facilitation. Several studies have stressed the importance of including facilitation in GSS settings. However, few studies have examined the impact of active facilitation in multi-user GSS settings, (Anson, et al., 1995). There are two basic types of facilitation in group processes. The first type of facilitation is generally referred to as the "fixed scripted approach" which is generally applied before or during the group process. In this approach, the facilitator provides technical assistance, provides the agenda and generally assists in process facilitation. The facilitator does not modify the agenda or respond to evolving group needs. The planning for this type of facilitation can be anticipated and performed prior to the meeting. Most studies that have examined the role of the facilitator have considered this fixed scripted version. While this scripted facilitation may work in some group situations, especially those addressing simple tasks, in other situations they may produce poor outcomes. Clawson, et al., (1993) identified three important dimensions of effective facilitation; (1) Planning and designing the meeting, (2) providing clarifications and integrating information, and (3) demonstrating a flexible approach. These critical dimensions are generally missing in a fixed scripted approach. Dickson et al. (1993) found evidence to suggest that scripted facilitation produces weak outcomes. The authors noted that groups often resisted the structure imposed by the facilitator leading to poor decision quality. The scripted facilitation can be considered an integral part of a GSS since it can be embedded into the GSS tools. Thus, integrating the scripted facilitation with the GSS is unlikely to provide any additional benefits.

We consider another type of facilitation which we call active facilitation. This type of facilitation is generally observed in face-to-face meetings. The facilitator applies process oriented techniques to guide the group process. The facilitator leads the discussion, identifies the key issues, provides guidance on tools to be used and then unleashes the group. As the process flows, the facilitator actively listens to the discussion and integrates information. Based on his/her judgement of the direction the discussion is headed, the facilitator may modify the agenda, provide additional information, or ask group members to consider additional issues. Thus, the facilitator undertakes all the critical facilitation functions identified by Clawson et al. (1993). Overall, in active facilitation, the facilitator becomes part of the group process and the team benefits from his/her knowledge. Active facilitation is interactive and cannot be preplanned or embedded within the GSS. Thus, active facilitation is a non-GSS type of intervention. Such non-GSS type facilitation when integrated with a traditional GSS may

lead to better outcomes. Anson, et al., (1995) attempted to measure the effectiveness of a GSS combined with active facilitation on group outcomes. The results of their study provided weak evidence of benefits. However, they tested the combined effectiveness on simple tasks such as constructing a model airplane. Active facilitation is unlikely to add value to tasks that do not require higher order thinking. We predict that active facilitation integrated with GSS are likely to produce superior outcomes in complex decision tasks.

The integrated group support system (henceforth IGSS) used in this study has three components. It includes the GSS, and two non-GSS based interventions; knowledge, and active facilitation. The effectiveness of the IGSS is evaluated based on several outcome measures. Further the effectiveness of the GSS and IGSS are compared in complex problem domains.

II. RESEARCH DESIGN AND METHODOLOGY

2.1. Description of GSS

The study used the University of Arizona GroupSystems™ software to support a number of functions that occur in team meetings: brainstorming, organizing information, list building, information gathering, prioritizing, consensus building, and decision making. Several GroupSystems™ software tools were used. Electronic brainstorming is an idea-generating tool that allows participants to share ideas anonymously on a specific question posed to the group. Unlike traditional brainstorming sessions, participants are able to contribute ideas simultaneously without loss of information. The Categorizer feature assists groups in creating lists of ideas, generating comments which elaborate on or support the ideas, and developing categories to organize the ideas. The Topic Commentator helps the group generate lists of topics and then add comments and information which elaborate upon the topics in a more structured manner than with electronic brainstorming. The Voting tool is used to prioritize and measure the degree of consensus among group members. Results can be viewed in text reports, graphs, and voting matrices.

2.2. Design of Study Teams

Participants were divided into three teams. Members of all three teams sat at computer workstations in the same laboratory and collectively worked on the problem. Participants communicated by using a client workstation with a split display screen so that they are able to view others' comments in one window, while at the same time type their ideas in the other. All comments were anonymous. The results of the exercises were saved to diskettes and some were transcribed. Each team received different instructions/cases, but all teams worked from terminals in computer labs.

The teams received different facilitator treatments. Teams A and B received the fixed, scripted, GSS type facilitation. Team C, on the other hand, received the active,

non-GSS type facilitation. A brief description of the teams and the treatments received by them is provided below:

Team A. Team members were asked to analyze a case on a topic they were relatively familiar with. Instructions and brief directions were provided. The decision task was straightforward. The participants were asked to read the case prior to coming to class for the group decision making exercise. The facilitator followed a fixed scripted approach providing technical assistance, answering questions and ensuring the meeting proceeded smoothly. This team received a GSS intervention. GSS tools used included electronic brainstorming and voting.

Team B. Team B members were asked to analyze a significantly more complex case -- one with multiple issues and dimensions requiring higher order thinking skills of analysis, synthesis and evaluation-- than team A's case. Participants were asked to read the case prior to coming to class for the group decision making exercise. Thus, the basic difference between the two teams was task complexity. Team B also received a fixed scripted type facilitation. Thus, this team received a GSS intervention. The GSS tools used by team B included brainstorming, categorizing, and voting.

Team C. Team C members also received a complex case, one requiring a step by step analysis of a problem situation. The steps included problem definition, idea generation, evaluation of alternatives, and recommendations. The participants were explicitly required to analyze the case before coming to class to conduct the group decision making exercise. Each participant was asked to work individually on the problem, to write up their analysis and informed that their individual report would be evaluated. The aim was to ensure that all participants were fully prepared for discussion and had acquired sufficient knowledge of the problem and issues at hand. Team C received active facilitation. Team C received the IGSS treatment. GSS tools used included brainstorming, categorizer, topic commentator, and voting. The difference between teams B and C are the type of facilitation and knowledge requirements of team members. Thus, team C received the IGSS treatment while team B received the GSS treatment. The differences between teams A and C are problem complexity, type of facilitation and knowledge.

Table 1 provides a comparison of the differences between the three teams.

TABLE 1
Comparison of Teams

Teams	Differences
Team C versus Team B	Knowledge, Facilitation (IGSS versus GSS)
Team C versus Team A	Knowledge, Complexity, and Facilitation
Team B versus Team A	Problem Complexity

III. RESULTS AND IMPLICATIONS

Performance of teams was evaluated based on levels of several outcome variables. The outcome variables were used to assess the following: (1) effectiveness of GSS, (2) whether problem complexity moderated the effects of GSS and (3) assessing the effectiveness of the IGSS versus GSS in dealing with complex decision tasks.

3.1. Performance of GSS

The levels of user satisfaction on several dimensions affecting team performance is likely to provide some insights to the extent of value added by the GSS. After completing the electronic case assignments, participants receiving the GSS treatment were asked to rate several factors driving user satisfaction on a 1-5 scale with 5 representing the highest level. The level of user satisfaction was measured on factors such as learning outcomes, ease of use, solution quality, additional insights over face-to-face (Non-GSS) discussions, quality of facilitation, etc. The variable LEARN measures the learning outcomes achieved by team members as a result of participating in the group exercise. It is important that participants feel comfortable with the technology so as to focus on the decision problem at hand rather than get distracted with technical issues. EOU measures the ease of use and user friendliness of the GSS. UNST measures team members' satisfaction with the group process in defining the problem. SOLQU measures the users' satisfaction with the decision process. INSIGHT represents the user perception of additional insights gained by the team members over a conventional face-to-face case discussion. IDEA represents the extent to which users felt comfortable in generating ideas for the team members to evaluate. Another problem with conventional face-to-face meetings is that important points may be lost due to the sequential nature of the discussion and airtime fragmentation. KEY measures the user perception of the ability of the team to focus on key ideas during the group exercise. The participants also evaluated the quality of facilitation on several dimensions. The variable FAC represents the extent to which the facilitator imposed his/her viewpoint on the team. ROLE represents the user perception of the quality of the facilitation in terms of value added to the decision process. Finally, the variable BENEFIT captures the overall satisfaction with the team meeting process. The above variables are described in Table 2. The means and standard deviations of responses for each factor are also reported.

The results provide strong evidence of the extent of value provided by GSS interventions in terms of team outcomes. The team members strongly indicate that they perceive the GSS add considerable value to the learning, idea generation, and problem definition processes. Further, users perceive that the performance of the team is enhanced by the GSS since it improved the satisfaction with the solution. Team members show a strong preference for the GSS over conventional face-to-face meetings.

TABLE 2
Results of GSS Performance

User Satisfaction Factors	Mean	Std Dev
Assessment of Learning		
Outcomes (LEARN)	4.00	0.69
Ease of Use (EOU)	4.38	0.84
Problem Definition (UNDST)	4.10	0.92
Solution Quality (SOLQU)	4.21	0.73
Overall Benefit of Meeting (BENEFIT)	4.38	0.65
Extent Facilitator Imposed Views (FAC)	2.24	1.44
Additional Insights over face-to-face (INSIGHT)	4.48	0.59
Idea Generation (IDEA)	4.69	0.59
Ability to focus on key ideas (KEY)	4.57	0.58
Quality of facilitation (ROLE)	4.14	0.77

The technology is also perceived to be user friendly and does not distract from addressing the decision problem at hand. The quality of facilitation is also highly rated. Further, members do not perceive that scripted facilitation results in the facilitator imposing his/her opinion on the group. Overall, the team members show strong approval for the GSS which can also be seen by the high score assigned to the variable BENEFIT.

3.2. Task Complexity and GSS Effectiveness

The above results suggest strong benefits to using GSS intervention. However, the effectiveness of GSS may decline in complex problem domains. A comparison of outcomes between teams A and B provides an opportunity to assess the effectiveness of GSS in simple versus complex problem domains. As noted earlier, team A addressed a problem area which represented familiar territory, while team B addressed a considerably more complex and unfamiliar problem requiring higher order critical thinking skills.

Table 3 provides a comparison between teams A and B on three critical group outcomes. These include learning outcomes (LEARN), additional insights obtained over a typical non-GSS (face-to-face) discussion (INSIGHT), and overall satisfaction with the GSS in addressing the decision problem (BENEFIT).

TABLE 3
Comparison of the Mean Values of User Satisfaction

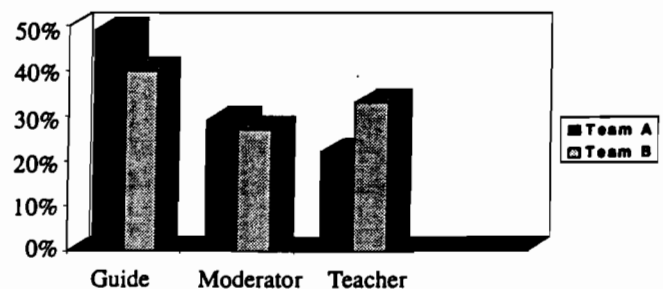
Dimension	Team A	Team B
LEARN	4.23	3.48 ^a
INSIGHT	4.19	3.90 ^b
BENEFIT	4.50	3.93 ^c

^{a,b,c} imply that the mean of team B is significantly different than that of A at the 0.01, 0.05, and 0.10 level

The results in table 3 suggest that the perceived effectiveness of the GSS declines when addressing complex tasks. Team B experiences significantly lower levels of satisfaction with the GSS in terms of learning outcomes achieved in comparison to team A. The mean value of LEARN is 4.23 for team A versus a significantly lower 3.48 for team B. Further, the results in table 3 indicate that users perceive that the additional insights gained over a typical non-GSS (face-to-face) discussion are significantly higher for simple versus complex problem domains. The users also perceive that the overall benefits of using GSS decline significantly for complex tasks. Thus, overall there is strong evidence to suggest that the effectiveness of GSS declines when addressing complex group decision tasks.

An interesting question which arises is identifying the source of lower levels of satisfaction with GSS in complex problem domains? A related question is whether non-GSS type interventions such as active facilitation and knowledge when integrated with the GSS can overcome this problem and lead to superior outcomes when dealing with complex problems. An indication of whether including non-GSS type interventions can improve performance can be seen from figure 1. Participants of teams A and B were asked to provide their perceptions of the role of the facilitator in helping address the decision problem. Three roles were evaluated. These include the facilitator as a guide providing technical assistance, as a moderator keeping things on track and encouraging participation, and as a teacher listening to and integrating information, refocusing discussion, suggesting avenues to explore and generally responding to the evolving needs of the group. The first two represent the scripted facilitation while the teacher role is indicative of a non-GSS type facilitation. The results suggest that there are some important differences in perceptions between the two teams on the primary role of a facilitator. For instance, forty nine percent of team A felt that the primary role of a facilitator is that of a guide versus forty percent for team B. On the other hand, thirty three percent of team B see the facilitator as a teacher versus twenty two percent for team A. Thus, it appears, that for complex problem domains, users perceive that non-GSS type active facilitation can add value.

FIGURE 1
User Perception of Role of Facilitator



3.3. Performance of the IGSS

To address whether the IGSS provides superior outcomes compared to the GSS in complex problem domains, we compare the performance of team C with A and B. As discussed earlier, team C received the IGSS treatment (GSS along with non-GSS interventions such as active facilitation and knowledge). If the IGSS is more effective than GSS in complex problem domains, we would expect to achieve better outcomes with team C versus team B. Table 4 provides a comparison of teams B and C on critical group outcomes.

TABLE 4
Effectiveness of IGSS in Complex Task Domains

Dimension	Team B	Team C
LEARN	3.48 ^a	4.00 ^d
INSIGHT	3.90 ^b	4.38 ^c
BENEFIT	3.93 ^c	4.38 ^c

^{a,b,c} imply that the mean of team C is significantly different from that of B at the 0.01, 0.05, and 0.10 levels respectively.

The results in Table 4 suggest that performance outcomes are significantly higher for team C compared to team B. For instance, the mean level of LEARN is 4.00 for team C versus 3.38 for team B and the difference is statistically significant. Further, team C has significantly better outcomes in terms of INSIGHT and BENEFIT compared to team B. Integrating non-GSS activities such as knowledge and facilitation have added value to the GSS. Thus, the results provide strong evidence to suggest that the IGSS is significantly more effective than the GSS in dealing with complex tasks.

To identify the sources of benefits of integrating Non-GSS activities such as facilitation and knowledge with GSS in complex problem domains, a comparison between teams B and C on several outcomes is provided in Table 5. Higher levels of user satisfaction among team C compared to team B would suggest specific areas where the IGSS adds value to the complex decision task. From table 5, It can be seen the mean values of UNST and SOLQU are significantly higher for team C versus team B. This suggests that integration adds value through enhanced ability to define the problem and higher satisfaction with the solution identified. There is no significant difference between the two teams on perceived ease of use (EOU) of the system. This is as expected, since both problem knowledge and active facilitation are unrelated to understanding the technology behind GSS and thus not expected to impact the relationship. One potential drawback of the IGSS is that as a result of active facilitation, team members may perceive that the facilitator imposed his/her viewpoint on the group. The results suggest no evidence of this hypothesis. In fact, team C perceived lower levels of facilitator

imposing his/her viewpoint compared to team B. Thus, the active facilitation adds value to the group decision process. Overall, the results provide strong evidence to suggest that the IGSS provides substantial additional benefits which helps improve team outcomes in complex problem domains.

TABLE 5
Sources of Value Added by the IGSS

User Satisfaction Factors	Team B	Team C
Ease of Use (EOU)	4.76	4.48
Increased Understanding of the Problem (UNDST)	3.67	4.10 ^a
Solution Quality (SOLQU)	3.72	4.21 ^b
Facilitator Imposing Viewpoint (FACPT)	2.76	2.24 ^c

^{a,b,c} represent significance at the 0.01, 0.05, and 0.10 levels respectively.

IV. DISCUSSION AND CONCLUSION

Previous studies comparing the performance of GSS versus non-GSS intervention in group processes report mixed results. GSS were found to have some positive and some negative effects in structuring group activities. This study attempts to examine whether GSS performance can be enhanced by integrating non-GSS interventions. A related issue is whether task complexity moderates the effectiveness of GSS.

The study finds that users perceive GSS to add significant value to the group decision process. However, the beneficial effects of GSS decline when addressing complex problem domains. In such situations, the integrated GSS (GSS integrated with non-GSS type interventions such as flexible facilitation and knowledge) are significantly more effective than the GSS. The sources of benefits include greater degree of satisfaction with the problem definition process and satisfaction with the solution arrived at. Both these outcomes are likely to be heavily influenced by the knowledge intervention. Another source of IGSS effectiveness is the quality of the facilitation. Active facilitation adds value in complex problem domains where team members see more utility in facilitators taking on the additional role of a teacher/coach.

Our study has some important implications for GSS design. Several researchers have suggested the possibility of automating functions such as facilitation by embedding them as GSS tools. Our results suggest that the benefits of this form of automation may exist for simple problem domains. In complex problem domains, however, such automated GSS are likely to produce lower group outcomes. Complex problems require integration of non-GSS type interventions with the GSS. The specific type of non-GSS interventions which can be integrated are likely to depend on the type of problem, size of groups, and

similar considerations. Identifying effective non-GSS interventions as candidates for integration with GSS is likely to be a fruitful area of future research.

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