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Use of GDSS and training of group members to improve decision-making: An empirical study

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ABSTRACT

Using Group Decision Support Systems (GDSS) to enhance group work has been emphasized in several GDSS studies. Despite the volume of accumulated research, little attention has been paid to investigating the member training effects on group performance. Member training includes group task management techniques, such as constructive attitudes toward group task and decision-making by consensus. This empirical study evaluated the effects of using a GDSS and member training on group performance. The experiment found that groups with member training had better decision quality and GDSS groups demonstrated better decision quality.

INTRODUCTION

Groups outperform individuals working alone especially when tasks require multiple skills, judgments, and experiences. With the increasing complexity of tasks and demands on teamwork, many organizations are relying on information technology to support group work. The computer industry has gone through a transition from the personal computer to the interpersonal computer, i.e., from PC to networking. Training individuals with group coordination and communication skills to increase group performance is an exigency for organizations (Nelson, Whitener, & Philcox, 1995). The emerging information technology to augment group tasks is linked to pressing user needs to aid group decision-making. So far, there is no clear evidence that any research has
addressed the impact of a combination of both the member training and the group decision support technology.

Managerial problems have become increasingly complex in post-industrial society. As tasks become complicated, no single person may have the knowledge or capability to deal with them alone. Accordingly, most organizations utilize groups such as committees, tasks forces, teams, and other types of groups, rather than individuals, to make important decisions. March and Simon (1958) dubbed the limitations in an individual's inherent capabilities of comprehending and comparing more than a few alternatives at a time as "bounded rationality." As individuals are added to an organization, the bounds of rationality are expanded and enlarged, because each member adds to the understanding of the problems that are faced. When member abilities can be pooled in a proper manner, group of knowledgeable individuals with diverse managerial and technical expertise is therefore more likely to arrive at effective decisions than a lone individual. Besides the abilities of individual members, characteristics of the group, such as teamwork skills and experience, group structure, and interpersonal relations, also affect group performance (McGrath, 1984). How individuals interact with and perceive one another is important for task completion. The practical matter of having group members trained in interpersonal skills and teamwork skills has direct implications for improving group decision-making, and hence group performance.

Although training has been studied in traditional manual groups, little research has been done regarding member training in computer-supported environments. The issue of computer support arises because many meetings focus on solving complex tasks which require processing vast amounts of information through group collaboration. Traditional manual approaches are ill-suited for such information-intensive tasks. Computer support becomes one of the most promising means in conquering the problems of (1) handling a multitude of problem dimensions simultaneously and (2) not overburdening the cognitive limitations of individuals.

Group Decision Support Systems (GDSS) attempt to solve these problems by providing valuable aid to group members. GDSS should assist groups in making effective decisions more quickly and with a higher level of participation. Unfortunately, most GDSS studies have focused on the technical training using GDSS (Gallupe, DeSanctis, & Dickson, 1988; Waston, DeSanctis, & Poole, 1988; Connolly, Jessup, & Valacich, 1990), training the meeting facilitator (Dickson, Partridge, & Robinson, 1993; Anson, Bostrom, & Wynne, 1995), or providing a written instruction sheet of the group process (Niderman & DeSanctis, 1995), rather than training group members to fully utilize their own expertise, knowledge, and resources to address the task at hand. Furthermore, the computer support systems used in most GDSS investigations provided only electronic communication support—that is, Level-1 GDSS rather than an aid such as decision tree to decision-making, called Level-2 GDSS (see DeSanctis & Gallupe, 1987 for an explanation of the levels).

In this study, we attempt to address two important issues: the effect of training of participants in collaborative decision-making and the effect of utilizing a Level-2 type of GDSS in group performance. As far as we know, this is the first research of its kind. The remainder of the
The paper is organized by first reviewing previous work done on group member training and GDSS. The next section outlines the research questions we posed and the design methodology for addressing them. We then describe the experiment we conducted, followed by a discussion of the results of our study. We conclude with sections on the limitations of our research, as well as additional areas for further research.

GROUP MEMBER TRAINING

Group member training intervention is designed to train group members to make more effective use of their existing knowledge. Most research in small group decision-making has sought to identify process barriers of optimal resource use. Researchers have tried to overcome these limitations, either through training in group dynamics or by structural changes that eliminate face-to-face contact. Other researchers have examined the relationship between group performance and individual ability. Tuckman and Lorge (1962) find that the ability of group members, rather than the interaction between them, determines group superiority.

Some previous research has emphasized the role of group member resources in determining group performance (e.g., Einhorn, Hogarth, & Klempner, 1977; Yetton & Bottger, 1982, 1983). These studies suggest that manipulation of member expertise would have a substantial influence on subsequent group performance. Other studies found strong effects of member ability on group effectiveness (Laughlin et al., 1976; Einhorn, Hogarth, & Klempner, 1977; Kabanoff & O'Brien, 1979).

Pfeiffer and Jones (1973) propose guidelines consisting of five design skills to aid in developing a training program. The five design skills include the following: (1) identifying learning goals, (2) being sensitive to participant responses, (3) sequencing, (4) collaborating with other designers or the facilitator, and (5) modifying designs during the delivery. They also identify four basic design components—intensive small groups, structured experiences, lectures, and instrument—as vehicles for implementing an experiential learning cycle (Pfeiffer & Jones, 1973). Their training design considerations provide an explicit checklist of the mechanics involved in the design process. It is directly related to Kolb's (1984) experiential learning theory and can be used to develop an effective training program.

Based on Pfeiffer and Jones' (1973) training design guidelines, we devised a training outline to direct group members in utilizing their resources effectively and in avoiding low-quality decisions. A professional training agency developed the training program according to our outline. This program consisted of important coping mechanisms for general conflicts during the meeting process. General conflicts include not using divergent and convergent thinking skills, accepting or rejecting a solution without adequate search and evaluation, rejecting responsibility for the decision, avoiding corrective information, or panicking because of perceived lack of essential resources such as time and knowledge. In order to minimize such risks, the training program was designed to provide individual task training to promote more effective use of an individual's resources.
GROUP DECISION SUPPORT SYSTEMS

A new and evolving information technology to support group meeting processes such as idea generation, decision-making, and negotiation, is Group Decision Support systems, or GDSS. The term GDSS is used to represent the technology involved in the computer support of group decision-making. Kraemer and King (1988) indicate that this information technology can be applied to support a wider range of tasks than simply decision-making. For example, Computer-Supported Cooperative Work, Electronic Meeting Systems, Group Support Systems, and Groupware all try to broaden the scope of GDSS.

GDSS research has grown immensely in the past few years (George et al., 1990; Dickson, Partridge, & Robinson, 1993; Anson, Bostrom, & Wynne, 1995). Laboratory studies have dominated the literature, and they have been the primary method of investigating the effects of GDSS. Steeb and Johnston (1981) conducted an experiment to compare the effects of a chauffeured GDSS called Group Decision Aid. The system was tested using ten groups, each with three members, on an international terrorist simulation case. Five groups had computer support and the other five groups had manual support (they were given pencils, paper, and a blackboard to use). The paper lists several problems in group problem solving, including:

- the order of discussions may be manipulated to favor a certain choice;
- group members seldom collect or process information very well;
- proponents of different viewpoints look at high-visibility issues rather than substantive points of disagreement; and
- decision makers are typically unable to consider more than a few dimensions of value.

The authors suggest that the use of a decision tree and a multi-attribute utility theory can mediate these problems. Their GDSS aids users in five ways:

1. through structured building of decision trees;
2. by full participation through independent entry of data;
3. through sensitivity analysis to identify critical issues;
4. by identifying a value conflict and supplying a multi-attribute utility model to address the conflict; and
5. by providing a decision recommendation.

The experiment compared GDSS-supported against non-GDSS-supported groups. Differences were statistically significant for the following dependent variables: problem attributes considered, actions and events considered, decision content, decision breadth, and decision details. The GDSS used in our research has a built-in decision tree model to assist group members in making decisions. A group support system with a decision aid model is categorized as a Level-2 GDSS (DeSanctis & Galuppo, 1987).

Connolly, Jessup, and Valacichi (1990) performed a laboratory experiment using ninety-six undergraduate students, assigned to four-person groups, to evaluate the effects of anonymity and evaluation tone on idea generation and evaluation task using a GDSS called PLEXSYS. PLEXSYS was the forerunner of the now commercially available GroupSystems V. Anonymity was mani-
pulated by either attaching the participant's name to the idea as it was entered into the electronic brainstorming system (EBS) or by not having it attached to the idea. Overall, main effects showed that groups working under anonymous conditions generated more ideas than those that were working under identified conditions and critical groups generated more ideas than supportive groups. Members of supportive groups were more satisfied with the group interaction than those in critical groups. Interactions indicated that groups who worked under the anonymous and critical conditions produced the most original solutions and most overall comments. Those working in an identified, but supportive conditions were the most satisfied, yet had the fewest original solutions and fewest overall comments.

In our GDSS, anonymity is a default feature. Members' identifications are protected and are not shown with their ideas (Chen, 1993). The individual workstations were linked together through a local area network (LAN) to exchange information. Also included on the network were a public display screen, a file server used for storing data and application files, and a laser printer. Users can exchange ideas on the LAN and contemplate their decisions at the public screen. They can print ideas at any time to aid in their decision-making. A system terminal was provided for use by the facilitator. A facilitator in this research project is a person who assists the group with the GDSS but does not interfere with the group's decision-making process. This individual is generally responsible for instructing group members in using the software tools as well as running the system-level software and public screen operations. Thus, the facilitator here is a chauffeur of the GDSS (Dickson, Partridge, & Robinson, 1993). This GDSS setting is built upon the previous research to provide a congruous group decision-making environment. The results of this research should complement the literature and augment the use of GDSS.

RESEARCH QUESTIONS AND DESIGN METHODOLOGY

The main focus of this study included the following issues: Do the training of group members and the use of GDSS improve decision outcomes? This question concerns group task outcomes, i.e., characteristics of the decision made by the group. GDSS and small group decision-making researchers usually examine tasks by assessing the quality of group decisions rather than the implemented results of these decisions. GDSS laboratory research thus far has produced mixed findings concerning the effectiveness of GDSS support (Nunamaker et al., 1991). On the other hand, small group decision-making studies have found that group member training mechanisms are more consistently positive concerning their effects (Hare, 1976).

Pinsonneault and Kraemer (1990) developed a framework from a systematic review of the literature in organizational behavior and group psychology. They applied this framework to analyze empirical research in GDSS and group communication support systems (GCSS). A modified version of the Pinsonneault and Kraemer (1990) model was used in this study to represent a conceptual framework of training and GDSS, as shown in Figure 1. This framework reflects the research variables from which the hypotheses to be tested are developed. It is a model that
represents the effects of the major factors in this study, i.e., the group member training and the group task, as input variables that affect group performance. The combined forces of the training and task flow through the communication network and create interaction effects on group outcomes. According to previous research, training and task may have a direct impact on group performance (Hare, 1976; Gallupe, DeSanctis, & Dickson, 1988). The model addresses the direct effects from training and task as well as their combined effects through the communication network on decision outcomes.

The dependent variables of interest are decision outcomes. These variables can be mapped to the group process, task-related, and group-related outcomes in the Pinsonneault and Kraemer (1990) framework. Decision outcome events are associated with the quality of the decision and can be measured by decision quality, acceptance of the decision, and satisfaction with the decision.

The basic premise of this study was that group member training with GDSS support will subdue many of the dysfunctional factors inherent in group decision-making. This belief was based on the support capabilities provided by group member training and GDSS. Specific combinations of these variables are the basis for the hypotheses that follow. The following hypotheses, stated in an alternative form, were tested based on the effects of the two independent variables: group member training and GDSS support.
Main Effects for Group Member Training Support (A)

HA1: Groups with group member training support will have better decision quality than will groups without group member training support.

HA2: Groups with group member training support will have greater member acceptance of their decision than will groups without group member training support.

HA3: Groups with group member training support will be more satisfied with the group decision than will groups without group member training support.

Main Effects for GDSS Support (B)

HB1: Groups with GDSS support will have better decision quality than will groups without GDSS support.

HB2: Groups with GDSS support will have greater member acceptance of their decision than will groups without GDSS support.

HB3: Groups with GDSS support will be more satisfied with the group decision than will groups without GDSS support.

Interaction Effects for Group Member Training and GDSS (AB)

In a factorial design, it is possible to have an interaction effect between two factors. To simplify the hypothesis statement, we address it as follows:

HAB: The joint effect of group member training and GDSS impacts the decision outcomes.

The research design used in this study is a 2x2 factorial design. The dichotomous independent variables are group member training support (training vs. no training) and GDSS support (GDSS vs. no GDSS). Students enrolled in junior- and senior-level information systems and management sciences courses were selected to take part in the experiment. Each five-person group participated in a single session. Subjects were randomly assigned to ad hoc groups at the beginning of the experiment. The task used in this study was a widely used case dealing with car dealership problems (Hawkins & McCosh, 1984).

A power analysis was conducted prior to the current study to determine a sufficient sample size to produce an acceptable Type II error level. Baroudi and Orlikowski (1989) studied the problem of statistical power in MIS research and concluded that, clearly, adequate power is vital in order to draw meaningful conclusions from statistical tests of hypotheses with empirical research data. Cohen (1965) suggests that power should be 0.80 and have a significance level of 0.05. To achieve high statistical power, the necessary number of duplicate samples of each treatment group was carefully determined using the following methods: (a) the Operating Characteristic Curve (Montgomery, 1991); (b) the power approach (Neter, Wasserman, & Kutner, 1990); and (c) calculations based on previous GDSS experiments by Hwang (1989) and Holmes (1990). Furthermore, several other experiments were analyzed to gauge sample size. The appropriate
number of groups fell in a range of four to twelve groups. This experiment assigned seven groups to each treatment in order to achieve a significant degree of statistical power.

RESULTS

Three dependent variables were measured in this study. Decision quality was specified by a seven-member expert panel based on five different strategies provided by the authors of the case used for the task. Five raters evaluated each group's final decision to determine the decision quality score according to guidelines established by the expert panel. The rest of the group performance variables—acceptance of the decision and satisfaction with group decision—were measured by post-experiment questionnaires.

The seven expert judges evaluated the list of five strategies. Each expert judge assessed the strategies based on four criteria: 1) growth, 2) emphasis on new car sales, 3) good customer relations, and 4) profit, all of which were also suggested by the case authors. A seven-point Likert scale was employed for each criterion. A semantic differential scale with seven as "extremely good" and one as "extremely bad" was utilized for the expert judges to get an overall score for each strategy. Then, the expert judges ranked these five strategies according to their personal judgments.

Each judge ranked the strategies independently and without feedback from any other person. Finally, these ranks were totaled and averaged to form a final solution base. The inter-rater reliability (i.e., Cronbach's Alpha) among the rankings of all seven judges was 0.9460. This alpha (α) level is considered to be very reasonable for the type of decisions that were evaluated. Therefore, it can be said that the solution base determined by the panel of expert judges is a valid instrument and can be used confidently to grade group decision quality.

The five raters then rated the final decisions against the solution base determined by the expert judges. Ratings given by these five raters were averaged as group decision quality scores. A Cronbach's alpha of 0.9620 indicated that the raters' ratings were highly reliable.

The semantic differential technique was applied to develop the post-experiment questionnaire. Subjects answered the questionnaire by circling a number on a seven-point Likert scale. Factor analysis was used to ensure that the questionnaire did measure the other two dependent variables (acceptance of the decision and satisfaction with group decision).

MANOVA protects experimental Type I errors better than using a series of ANOVAs. Also, MANOVA may identify some potential differences that ANOVAs cannot. MANOVA was applied here to corroborate the subsequent univariate ANOVAs. Because this study was a two-factor experiment, an interaction effect of these two factors should be considered. The MANOVA result indicated that the interaction between the two factors was insignificant (p-value = 0.76). Hence, the MANOVA procedure was further performed to test this two-factor non-interaction model.
MANOVA test criteria and F-statistics for the hypothesis of no overall factor effects were calculated. When decision outcome responses were modeled without an interaction term, the combined dependent variables (DV$s$) were significantly impacted by the training factor with a 0.0466 p-value shown by a Wilks' Lambda indicator, while the p-value for the GDSS factor showed a nearly significant value of 0.0787. Thus, the non-interaction model indicated that the training factor had significant overall influence on the combination of DV$s$. The GDSS factor did not show a strong impact on the combination of DV$s$ at the 0.05 level, but did show a nearly significant one. However, sufficient evidence of a GDSS effect existed to require further investigation. Therefore, we proceeded with the follow-up univariate analysis to detect the impact on individual dependent variables of GDSS and training factors with the caveat of a possibly inflated Type I error. The results are listed in Table 1 and Table 2.

<table>
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<tr>
<th>Table 1. Group Member Training Main Effect</th>
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<td>Hypothesis</td>
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<tr>
<td>Decision Quality</td>
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<tr>
<td>Acceptance of Decision</td>
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<td>Satisfaction with Decision</td>
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**Significant at \( \alpha = 0.05 \)

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<th>Table 2. GDSS Main Effect</th>
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<tr>
<td>Hypothesis</td>
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<td>Satisfaction with Decision</td>
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**Significant at \( \alpha = 0.10 \)
Hypotheses HA1 and HB1 are related to the quality of decisions made by groups having training and GDSS support. The form of training support showed a significant effect on the groups' decision quality. Groups receiving group member training learned to approach the task with an open mind and good judgment. Training groups were trained to focus on the task using divergent and convergent thinking techniques. Hence, they looked for acceptable solutions rather than tried to prove individual superiority.

Decision quality was nearly affected by GDSS. Hypothesis HB1 was not supported at $\alpha = 0.05$, but was at $\alpha = 0.10$. This result shows that the average quality of decisions made by GDSS groups was nearly significantly higher than the average quality of decisions made by non-GDSS groups. Other GDSS research provides empirical evidence that the utilization of GDSS increases the quality of decisions made by groups (Steeb & Johnston, 1981; Gallupe et al., 1988). One possible explanation for the insignificance of decision quality made by GDSS and non-GDSS groups is the novelty of the GDSS technology. The GDSS used in the study was a Level-2 decision aid, which had more features than a Level-1 GDSS.

Some subjects were observed to have anxiety in using the new technology. Consequently, an unfamiliar decision-making tool may decrease the decision quality. Therefore, although GDSS participants had hands-on experience with the computer workstation, the anxiety could have been caused by unfamiliarity with the GDSS system. Another possible reason is that the strict adherence to the allotted times could have affected the results. GDSS groups need more time in the earlier stages to get familiar with the system. The lack of sufficient time to comprehend the system could explain the insignificance in the decision quality between GDSS and non-GDSS groups. From a statistical viewpoint, an increase in sample size may change the effects of GDSS to significant.

IMPLICATIONS, LIMITATIONS, AND CONCLUSIONS

This study differs from previous GDSS research. It is the first study to make use of an icon-driven Level-2 GDSS, which is a highly user-friendly system. User-friendliness is an important issue in MIS research, especially in user-interface and user satisfaction areas. This system, according to users' post-hoc feedback, met their information requirements. Hence, it provided a necessary condition for allowing relevant behavioral measures to be operationalized (Ives & Olson, 1984).

Furthermore, the choice of the decision-making task, also called preference task, differentiates the task from other tasks used in GDSS research. Many tasks used in the other GDSS studies are creative tasks and intellective tasks that can be done by a single decision maker (McGrath, 1984). Further, the decision-making task consists of conflicts and conceptual differences that require group members to work collaboratively. Group member training becomes vital in removing the conflicts among members and in utilizing their different resources. A group management technique adopted in this study, decision-making by consensus, renders a significant aid to groups facing a decision-making task.
The use of group member training as a factor in the experiment was an exploratory attempt. Training the group members is an intervention to improve decision outcomes. The applications of these strong relationships in a less controlled environment are relatively unknown at present. Hence, practical implications of this study must be arrived at with caution.

Organizations must maintain a proper balance between their emphasis on the team and its individuals. If the training emphasizes team building too much, it may inadvertently encourage people to relinquish their creativity in favor of the management process. Divergent/convergent thinking techniques can help to avoid this pitfall. Using the decision-making by consensus technique furnishes groups with a harmonious meeting atmosphere. Human motivation and learning patterns should be known before a training program is developed. Meyer-Briggs Type Indicator is one of the psychological tests that can be used to assess these characteristics. Training is an effective means for top management to help employees do a better job and certainly to improve meeting productivity. Top management should also see training as a reward, a chance to grow in competence, rather than as a punishment.

A laboratory experiment was conducted in this study. Laboratory experiments have a number of limitations, which have been well-documented (Campbell & Stanley, 1969). These include low external validity, experimenter bias, and subject representativeness. Low external validity may be the greatest impediment to the issue of generalization. Much caution should be taken in generalizing the findings of this study to different settings. For example, using student subjects is not the same as using professionals. The task case in our study dealt with an actual car dealership to preserve as much external validity as possible.

To drastically reduce experimenter bias, strict experimental procedures were followed to ensure that all experimental groups followed the same approach. Written scripts and instructions were provided for each facilitator, written training scripts and guidelines were distributed to each trainee, and all groups followed the same decision sequence and meeting procedure. The meeting time allotted for GDSS and non-GDSS groups was the same. Obtaining subjects with business as their major, finding ones willing to participate in the experiment, and utilizing a training program which was developed by a professional training agency were also part of the effort to maintain a high level of validity.

This research study is the first to implement a group member training session and use Level-2 GDSS to measure face-to-face group decision-making processes and outcomes. The results are very encouraging. Group member training does significantly improve one of the most important meeting outcomes—that of decision quality. Thus, meeting effectiveness can be improved with group member training.

REFERENCES


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