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The effect of group size and computer support on group idea generation for creativity tasks: An experimental evaluation using a repeated measures design

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THE EFFECT OF GROUP SIZE AND COMPUTER SUPPORT ON GROUP IDEA GENERATION FOR CREATIVITY TASKS: AN EXPERIMENTAL EVALUATION USING A REPEATED MEASURES DESIGN

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ACCEPTANCE

Accepted by the Graduate Faculty, Indiana University, in partial fulfillment of the requirements of the Degree of Doctor of Philosophy.

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July 10, 1989

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DEDICATION

To my parents, who shared with me their gifts
of love, knowledge, and learning,
as well as the importance of
sharing these gifts with others

ACKNOWLEDGMENTS

A doctoral dissertation is supposed to be the final indication of the doctoral candidate's ability to do "independent" research. However, the dissertation may be the "least independent" piece of research that anyone ever does -- and this study was no exception. There are many people who have contributed to the successful completion of this study, from long before the time I entered graduate school, through each and every step along the way.

My dissertation cochairmen, Bob Bostrom and Bye Wynne, have been with me every wonderful, agonizing step of the process. Their knowledge, abilities, and positive attitudes have complemented one another throughout this process. More importantly, their friendship and support have made the process an enjoyable one. Bob has, over the last five years, helped guide my growth, both professionally and personally. His ideas, perceptiveness, and determination have facilitated this process. For the last two years I have greatly enjoyed working with Bye. His practical insight, humor, and resolution have helped this project to succeed. Both have contributed greatly to this study. Both have spent many long hours reading and providing valuable, immediate feedback. I would be remiss without also acknowledging the contributions of Nancy Bostrom and Carol Pierce, for their support of Bob and Bye, and me as well.

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ABSTRACT

Most decision making, problem solving, and planning processes begin with the generation of ideas. While the use of groups for these processes is quite prevalent, a number of dysfunctional characteristics often negatively impact a group's performance -- this is especially true as group size increases. The main research question addressed in this study was whether idea generation techniques with computer support, as provided by a Group Decision Support System (GDSS), could improve group performance for idea generation, while also maintaining this level of performance as group size increased. A laboratory experiment using a 2 X 2 X 2 full factorial design with repeated measures was conducted. Two hundred forty undergraduate student subjects were randomly assigned to 32 groups, with each group participating in two ideas generation sessions, one with GDSS support and one without GDSS support. Two other independent variables manipulated were:

1) **Structure** to support the group idea generation process was provided to half the groups (Osborn's brainstorming instructions), and

2) **Group size** was either five or ten persons.

The four dependent variables measured were:

1) **Quantity** of ideas,
2) **Quality** of the ideas,
3) Group member **satisfaction** with the group idea generation process, and
4) **Perceived usefulness** of the idea generation technique.

All other variables were controlled.

Results showed that groups generated significantly more total ideas, different ideas, ideas of higher total quality, more good ideas (as rated by expert judges), and were more satisfied with the group idea generation process when provided with GDSS support. GDSS support also allowed groups of ten to perform at the same per person level as groups of five for performance variables (quantity and quality of ideas) as well as maintaining the same level of satisfaction and perceived usefulness. No significant differences were found between groups provided with structure and those without structure, for supporting the idea generation process.

CHAPTER 1

INTRODUCTION

1.0 Introduction

Most problem solving, decision making, and planning processes used by organizations start with the generation of ideas or alternatives. Therefore, it is important that both the quantity and the quality of the ideas generated be as high as possible. While the use of groups for such processes is an approach that has been around for some time, today's knowledge workers are spending more and more of their time working in groups. Research has shown that professionals and managers spend from 25% to 85% of their time in meetings (Mosvick and Nelson, 1987).

There are a number of reasons why organizational problem solving, decision making, and planning processes are depending more and more on the actions and participation of groups rather than just individuals. Hanson (1981) states that: "... as society becomes more complex and organizations become multi-faceted, decisions that affect many lives are rarely made by individuals alone. More and more decision making is done within the context of a group." DeSanctis and Gallupe (1987) echo this point and add that the decision making process will require more knowledge, quicker responses, and greater participation by groups. Weisberg (1986) points out why groups are required for these processes: 1) Many problems require several different types of expertise and 2) in order to maximize the chance the solution will be accepted by the group members (p. 64).

The factors that impact the increasing need for groups also influence the size of the group. While a group size of five is often cited as optimal in terms of maximizing interacting group performance (Steiner, 1972), many groups will undoubtedly involve more than five participants. Mosvick (1988), based on over thirty years of experience in observing, studying, and working with groups, described different types of work groups that ranged in size from five to twenty members, depending on the type of group composition and the reason for the group's formation. A recent study of 26 executive-level teams by Lefton and Buzzotta (1987) showed that the range in group size for these groups was from six to twenty members, with an average just over ten. Overall, group size has been shown to have both positive and negative influences on group processes and performance (Shaw, 1981).

While the need for using groups in organizations is increasing, this situation is complicated by the fact that, for idea generation, groups have traditionally performed very poorly when compared to individuals. A large body of research that has been accumulating for over 30 years shows the dominance of individual performance over group performance for idea generation (Lamm and Trommsdorff, 1973; Diehl and Stroebe, 1987). These results point to many dysfunctional behaviors inherent in group idea generation.

These behaviors include such factors as: dominance of the group by individual members, fear of personal evaluation, fear of speaking in public, pressure for conformity, bringing evaluation into the idea generation process too soon, and the restriction of having only one person speak at a time. These results are reinforced by additional research which indicates that over 50% of the billions of hours spent in meetings each year are wasted (Mosvick and Nelson, 1987).

To improve the performance of groups for idea generation, the dysfunctional behaviors that inhibit group performance need to be overcome. At the same time the factors which favor individual performance and necessitate group interaction need to be enhanced. Many techniques and strategies have been developed in an effort to overcome these problems. Group idea generation techniques such as brainstorming (Osborn, 1957), brainwriting (Geschka, et al., 1973), the nominal group technique (Van de Ven and Delbecq, 1971) and the Delphi technique (Dalkey, 1972) have been developed and used. While the results from these techniques have been mixed, recent advances in computer technologies (e.g., local area networks, microcomputers, user interfaces, data bases) have brought about a new type of information technology which advocates hope will improve group's utilization of these techniques for such processes as idea generation. This new information technology is called Group Decision Support Systems (GDSS).

DeSanctis and Gallupe (1985) define a GDSS as "...an interactive, computer-based system which facilitates solution of unstructured problems by a set of decision makers working together as a group" (p. 3). The goal of a GDSS is to improve the information processing capabilities of the group and therefore improve the group decision making process. Nunamaker, et al. (1987) cite research that shows computer-mediated communication to influence group productivity, roles, structure, and decision making activities. They indicate that GDSS impacts groups by decreasing inhibition in the idea generation process so that the status, authority, and roles of group members are divorced from their comments -- which allows each comment to be evaluated on its own merit, rather than based on the role and status of the person who suggested it. Additionally, all group members are provided an equal opportunity to participate, thus preventing one or two members from dominating the discussion. Nunamaker, et al. (1987) conclude that this new type of technology "does significantly influence the idea generation process" (p. 18).

Initial research indicates that GDSS support may have been able to overcome some of the dysfunctional behaviors traditionally inherent in groups. This research provides empirical support that groups with GDSS support generate more ideas than groups without GDSS support (Steeb and Johnston, 1981; Lewis, 1982; and Gallupe, 1985; Gallupe, et al., 1988; Chidambaram, 1989). While this initial support exists, there is a need for further research to provide additional evidence of the capabilities of these systems (Poole and DeSanctis, 1987; Jessup, 1987; Dennis, et al., 1988a; DeSanctis, 1988). The main question of interest in this study was whether idea generation techniques with GDSS support could enhance the positive characteristics of groups, while overcoming the negative factors, thus bringing about an improvement in the performance of groups for generating ideas.

The term GDSS is commonly recognized as defining computer support for groups engaged in decision making; however, it is important to address three very important distinctions. First, while the term "DS" in "GDSS" stands for "Decision Support", groups often engage in a number of activities that are not necessarily confined to just "decision making". McGrath (1984) indicates that groups may undertake a variety of different tasks, including planning, problem solving, and negotiation. Additionally, each of these tasks represents a composite of activities, such as problem/task definition, idea/alternative generation, categorization of ideas/alternatives, evaluation, selection, and implementation of a decision/plan.

Second, the term "GDSS" is often used to imply any form of computer support provided to groups. For purposes of this study, GDSS implies that each individual group member has access to the GDSS via a personal computer or computer terminal, which is linked with the machines used by all other group members via a computer network. This allows group members to share information with, and access information from, the other group members, as well as enabling a public display of group information.

Finally, a GDSS often provides a number of components or tools, which may be used independently or in conjunction with one another, to support a variety of group processes. Often the term "GDSS" is used to refer to a number of these components. For the purposes of this study, however, GDSS will refer to one component used to provide support for one phase (idea generation) in the decision making, problem solving, or planning processes in which groups participate.

1.1 Research Questions

The main research question to be investigated is:

Do idea generation techniques with GDSS support improve the performance of group idea production?

Idea generation techniques are commonly used to generate ideas for creativity tasks. Creativity tasks require the generation of as many novel ideas as possible (McGrath, 1984). To investigate the above research question, groups generated ideas for two creativity tasks: one with GDSS support and one without GDSS support. While all groups had GDSS support for one task, half of the groups were also given instructions pertaining to idea production. These instructions were used to provide structure to support their idea generation. It is often argued that just providing structure will improve group idea generation, and previous idea generation literature provides support for this claim (e.g., Bouchard, 1969; Gryskiewicz, 1980). For idea generation, structure traditionally involves techniques that promote: the sharing of ideas among group members, means for building on the ideas of others, and delaying evaluation of ideas until later. The impact of providing structure for groups engaged in idea generation is addressed by the second research question:

> **What is the impact of providing structure to groups to support the idea generation process?**

While GDSS support and/or structure may lead to the improvement in the idea generation process for groups, one question still remains: Can this improvement be maintained as group size increases? For idea generation tasks, research has shown that increasing group size decreases group performance in terms of the number of ideas generated, both overall and per person (Bouchard and Hare, 1970; Bouchard, et al., 1974). Therefore, the evaluation of the impact of idea generation techniques with GDSS support on groups of increasing sizes becomes an important issue. This issue is evaluated in this study based on the following question:

> **What is the impact of GDSS support on the idea generation process as group size increases?**

In this study groups had either five or ten members. While it is possible that the larger groups would be more productive overall (in terms of the total number of ideas generated by the group) given their size advantage, the key issue is whether or not the GDSS support would allow for individual productivity to be maintained as group size increased.

1.2 Research Framework

To investigate these three research questions, a laboratory experiment was performed to evaluate the impact of GDSS support and structure on groups of two different sizes. McGrath's (1984) Conceptual Framework for the Study of Groups provided the foundation for this study. Bostrom, et al. (1987), building on McGrath's framework, developed a Model of an Electronic Meeting as an Information Processing System. A modified version of this model is shown in Figure 1. The figure shows inputs to, and outputs from, the group idea generation process.

Five factors, which are inputs into the group interaction, are displayed in Figure 1. Two of these factors were manipulated in the study: group size and environment. Groups consisted of either five or ten members. Environment consisted of two factors: GDSS support and idea generation technique support (structure). Each group generated ideas for two tasks: one with GDSS support and one without GDSS support. In addition to the GDSS support, half of the groups were provided with structure to support the idea generation process. Structure was operationalized by providing these groups with Osborn's

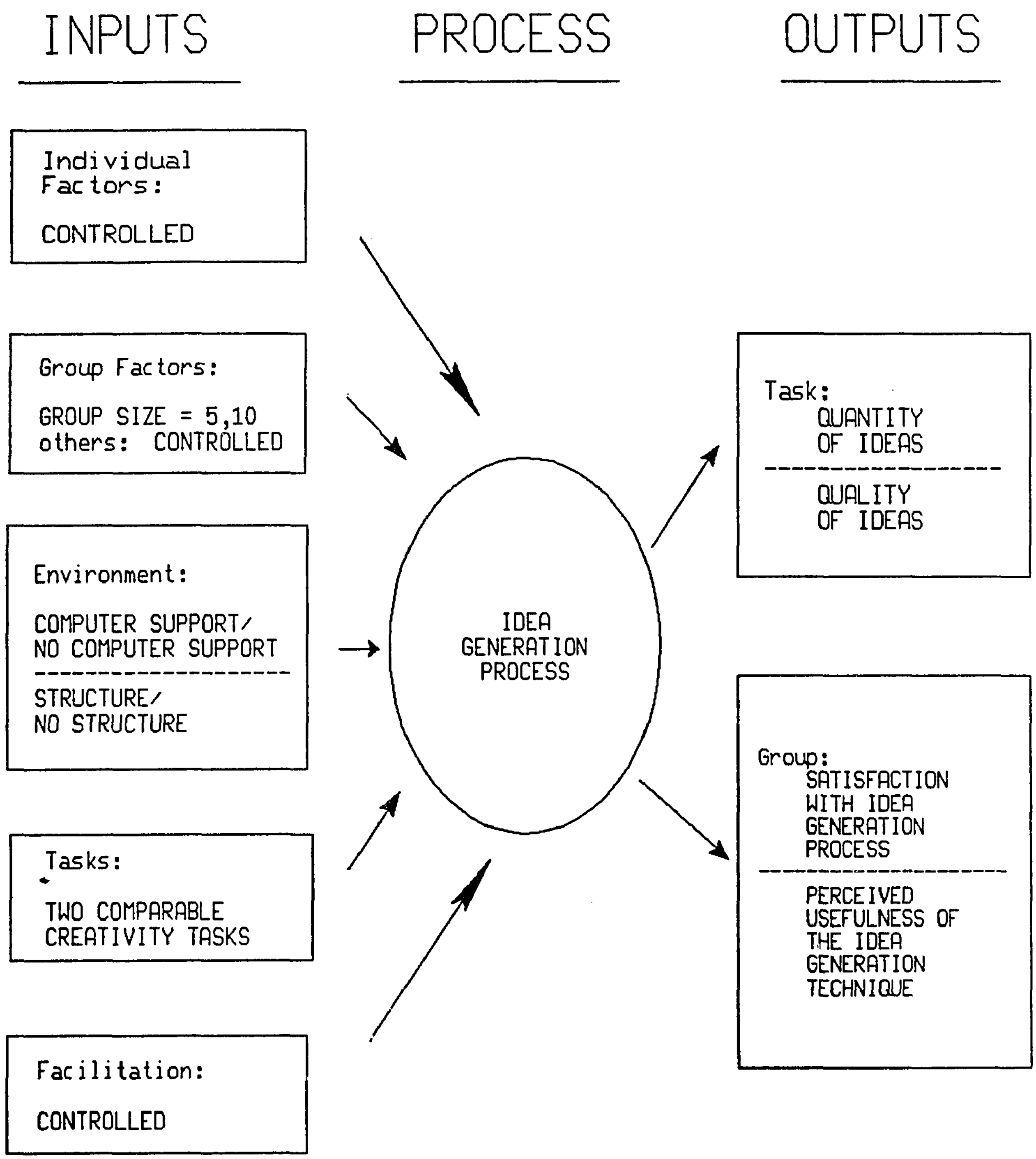


Figure 1

Model of Electronic Meeting as an Information Processing System
(modified from Bostrom, et al. (1987))

(1957) brainstorming instructions pertaining to group idea production. The other input factors -- individual differences, other group factors, and facilitation -- were all controlled. One final input factor, the two creativity tasks used, were determined to be comparable through pilot testing.

The resulting outcomes or outputs of the group interaction are also shown in Figure 1. Task outcomes evaluated in this study were the number of ideas generated and the quality of the ideas. Group outcomes consisted of the group's satisfaction with the idea generation process and their perceived usefulness of the idea generation technique.

The basic premise of this study was that there would be a significant advantage for groups using GDSS support as opposed to their not using GDSS support regardless of the group size. It was believed that as group size increased, GDSS support would allow each individual in a group to be just as productive as those in the smaller groups -- which was not anticipated for the groups without GDSS support. It was also believed that providing groups with structure to support the idea generation process would allow them to outperform groups who were not provided with such support, for both groups with GDSS support and groups without GDSS support.

1.3 Research Approach

To investigate the research questions of interest a controlled laboratory experiment using a repeated measures research design was conducted. Two hundred forty undergraduate students were recruited from 11 sections of an introductory Computers in Business course to participate in the study. These students were randomly assigned to the 32 groups used in the study, and treatments were randomly assigned to the groups. Each group participated in two idea generation sessions: one with GDSS support and one without GDSS support.

A completely counterbalanced experimental design allowed half of the groups to participate in the session with GDSS support first, then the session without GDSS support; this was reversed for the other groups. Groups generated ideas for two comparable tasks, one pertaining to the problems associated with parking on-campus, the other with having materials damaged or stolen from campus libraries. A pilot study was conducted to refine the tasks, procedures, and instruments used in this study. GDSS support was provided by the topic commenter component of the University of Arizona PLEXSYS system.

1.4 Importance of the Research and its Contribution to Knowledge

Maier (1970) points out that "If the potential for group problem solving can be exploited and if its deficiencies can be avoided, it follows that group problem solving can attain a level of proficiency not ordinarily achieved." Efforts to improve the effectiveness of groups are very critical given the amount of time professionals spend working in groups and the dysfunctional behaviors and resulting loss of productivity that occur. This is especially true for idea generation due to its strategic position at or near the beginning of most problem solving, decision making, and planning processes. Given this situation, it is important to improve the performance of groups for idea generation. The development of new information technologies, like GDSS, are an attempt to address the need to improve group performance. GDSS support should assist groups in making more effective decisions, more quickly, and with greater participation (Poole and DeSanctis, 1987). While it is believed that GDSS can help enhance group processes, there is still a need for additional research to provide the evidence to support these claims (Poole and DeSanctis, 1987; Jessup, 1987; Dennis, et al., 1988a; DeSanctis, 1988).

Currently, the most comprehensive GDSS are found only in major universities (Bostrom and Anson, 1988c). However, numerous organizations have expressed interest in utilizing this new technology, or have undertaken development projects in this area (Richman, 1987; Straub and Beauclair, 1988; Freilberger, 1988). Given this interest, and the potential impact of GDSS on organizations, it is very important to determine precisely what the capabilities and potential benefits are for these systems. Therefore, research to provide guidance for systems design, implementation, and use in organizations is essential.

The current lack of GDSS research is confounded by the inconsistent results that have been presented (Dennis, et al., 1988a). Some GDSS research has compared groups using GDSS support with groups without any support, some with groups using an equivalent technique without GDSS support, while yet other studies have just reported on GDSS use and provide no comparisons at all. Most GDSS studies have considered the effectiveness of a GDSS using a number of components, rather than focusing on just one component used to support a single process (e.g., idea generation). Poole and DeSanctis (1987) stress the need for these two types of control groups to be compared with GDSS use: those with no support and those with an equivalent paper-and-pencil support system. They state that "By using two types of control groups, the relative advantage or disadvantage of GDSS for simply offering structure or adding an electronic medium can be precisely determined" (p. 35). No previous study has yet evaluated just idea generation techniques by providing groups with GDSS support, groups with an equivalent technique but without GDSS support, and groups with no support provided whatsoever. That is precisely what this study has done.

There are a number of additional ways in which this study contributes to knowledge in the field, while endeavoring to overcome the problems encountered by many previous GDSS studies. This was one of the first GDSS studies in which there were both groups with GDSS support and groups without GDSS support, thus providing for comparisons based upon actual use of both techniques. This GDSS study is the among the first to evaluate the quality of the ideas generated.

This GDSS study is among the first to evaluate the impact of group size. While two previous studies compared three- and four-person groups, both with GDSS support and without GDSS support (Zigurs, 1987; Watson, 1987), this study provided comparisons of five- and ten-person groups. Another recent study compared three- and nine-person groups (Valacich, et al., 1989); however, all the groups used GDSS and no comparisons were made with groups not having GDSS support. Based on the GDSS field study research reported with real, ongoing groups, many of the benefits of the GDSS support start to become apparent with groups larger than six to eight members (Nunamaker, et al., 1987). Prior to the present study, there had been no research that provided a controlled evaluation of the impact of GDSS support and group size on the idea generation process with groups of realistic sizes. Dennis, et al. (1988a) stress the need for experimental research using larger groups, since business groups tend to be larger than groups traditionally used in GDSS experiments. By using groups of five and ten persons -- both with and without GDSS support in a controlled setting -- the impact of the GDSS support on both the group performance and processes has been more accurately assessed.

1.5 Summary

Awareness of the strategic importance of idea generation in organizational planning, decision making, and problem solving processes continues to grow along with the increasing use of groups for such processes. While many techniques have been developed to support idea generation, the potential additional benefits provided by GDSS offer great opportunities for improving group performance. However, several studies evaluating GDSS have been completed, the inconsistencies in experimental procedures, tasks, subjects, GDSS used, and results point to the need for additional empirical evaluations to take place (George, et al., 1989).

While idea generation has been studied for a number of years in such disciplines as Psychology, Organizational Behavior, and Speech Communications, in none of these disciplines has the impact of information technology on the idea generation process been studied (DeSanctis, 1988). The results of this study should further understanding of how information technology can be used to assist decision makers and support the group processes that are increasingly becoming an integral part of today's organizational climate.

1.6 Overview of the Dissertation

Chapter Two presents a review of the literature relevant to this study. Previous literature from the following areas is discussed: group idea generation techniques, problems associated with group idea generation, group size, Group Decision Support Systems (GDSS), and GDSS support capabilities that facilitate group idea generation. The results of prior research in these areas is presented and summarized. There are three main purposes for this overview: 1) to identify significant themes in the research, 2) to determine where research is lacking and where problems and inconsistencies have been encountered in this research, and 3) to develop the theoretical justification for the hypotheses that are to be tested in this study.

Chapter Three includes the detailed statement of the problem, the research framework to be used for this study, the variables pertinent to the study, and the specific hypotheses to be tested. McGrath's (1984) Conceptual Framework for the Study of Groups is the basis for the research framework used in this study.

Chapter Four describes the research methodology used in this study. The main sections in this chapter pertain to the experimental design and experimental procedures used in the study. The setting, tasks, subjects, procedures, and a summary of the pilot study results are presented.

Chapter Five presents the results of the study. A detailed description of statistical techniques, the data analysis, and the hypothesis testing are presented.

Chapter Six includes a discussion and summary of the results as well as their implications for both practitioners and researchers. Key limitations and assumptions associated with the study are presented. Future research directions are also outlined.

All materials connected with the study -- the experimental procedures, instructions for the subjects, task descriptions, instruments completed by the subjects, and other relevant information -- are included in appendices.

CHAPTER 2

SIGNIFICANT PRIOR RESEARCH

2.0 Introduction

This chapter provides a review of previous research pertinent to the study conducted. The first area covered is that of traditional group idea generation techniques and the problems encountered with their use. The next section provides background information pertaining to group size and its impact on group productivity. In the following section previous research in the Group Decision Support Systems (GDSS) area will be presented and summarized. The chapter concludes with a summary of the problems and inconsistencies with previous GDSS research and a discussion of steps taken in this study to alleviate many of these problems.

2.1 Group Idea Generation Techniques

By drawing upon the work of many theorists and researchers in the group task classification area, McGrath (1984) developed a framework for defining group tasks (see Figure 2, the Task Circumplex). There are eight different types of tasks defined in the Circumplex, but Type 2, creativity tasks, are the task type of interest for this study. Creativity tasks are tasks that require the production of as many novel ideas as possible. When addressing creativity tasks (tasks for which there is usually not one best, known answer), the most widely known and commonly used technique is "brainstorming".

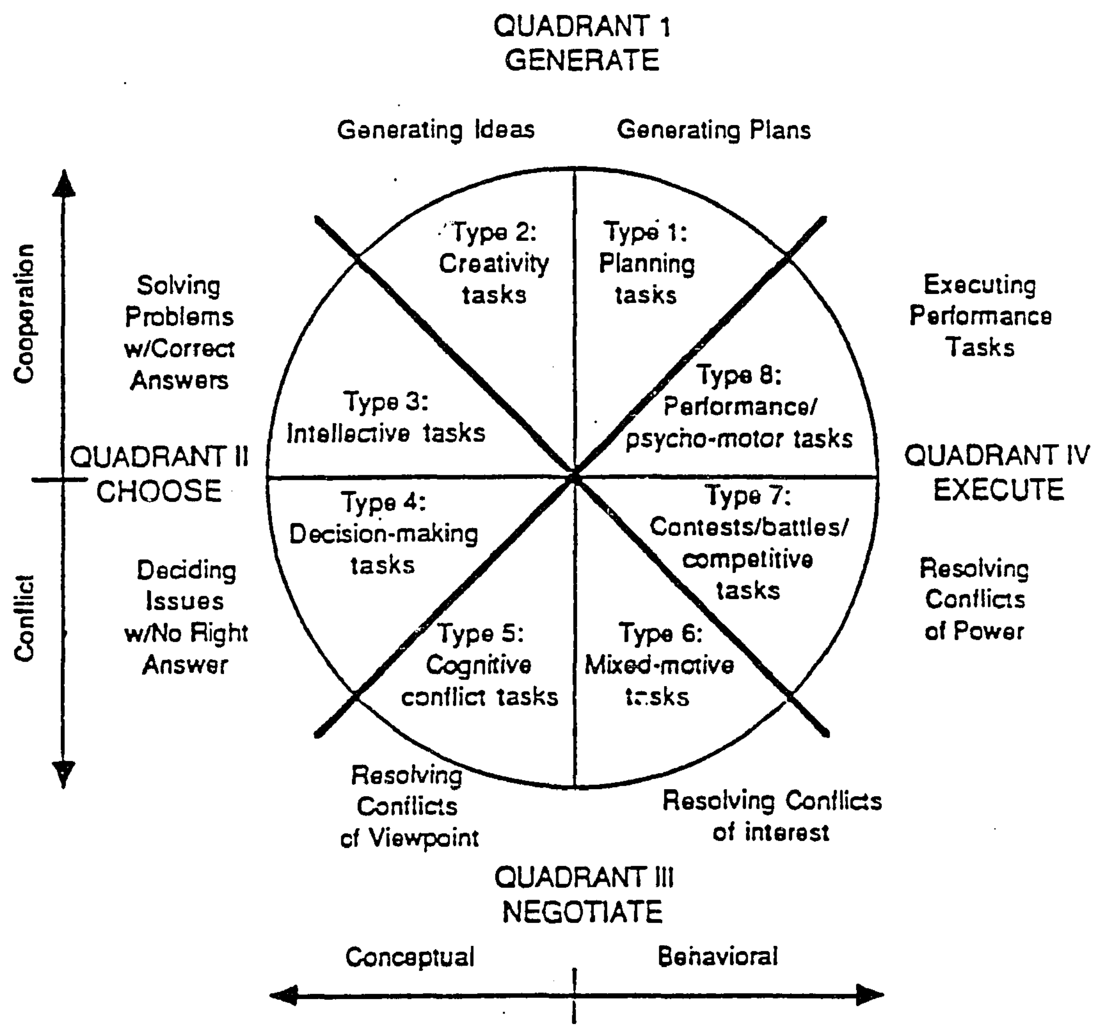


Figure 2

The Group Task Circumplex

(from McGrath, 1984; p. 61)

Brainstorming was used in this study to provide structure to support group idea generation.

2.1.1 Brainstorming

Osborn (1957) is credited with the development of the brainstorming technique. McGrath (1984) indicates the idea behind brainstorming is for group members to generate as many ideas on a given question as they can within a certain time limit. There is no evaluation or criticism of ideas (that is to be done later) and building upon the ideas of others is strongly encouraged (called "piggybacking"). There are four main rules for brainstorming (Weisberg, 1986; p. 60):

1) Criticism is ruled out. Adverse judgment of ideas is withheld until later. No judgment is made of any idea until all ideas have been produced.

2) Freewheeling is welcomed. Because it is easier to tame down than to think up, the wilder the idea the better. An idea that is too wild may be modified in a way that solves the problem, but if never produced in the first place, nothing will be accomplished.

3) Quantity is wanted. The more ideas, the greater the likelihood of winners.

4) Combination and improvement are sought. In addition to contributing ideas of their own, participants suggest how the ideas of others can be made better, or how two or more ideas can be joined into still another idea. Different individuals may have different sets of ideas, and one may see implications in the ideas of others that were not apparent to those who produced them. Therefore, a group may carry a given idea further than an individual might. Furthermore, since a creative solution to a problem often involves old ideas in a new form, active encouragement of such combinations is sought.

Osborn (1957) claimed that such a technique could increase creativity in a group setting (the old adage that "two heads are better than one") and Forsyth (1983) indicates that the early studies supported Osborn's claims. But Forsyth also points out that in many of these studies the investigators "stacked the deck" in favor of groups: Groups were given the four brainstorming instructions, while the individuals were given no rules concerning productivity. In many of the studies that followed, in which the individuals were given the same information about the purpose of the study and the need for creative responses, the individuals tended to generate more ideas than groups. In their now classic review of the brainstorming research literature, Lamm and Trommsdorff (1973) provide empirical evidence that strongly supports the fact that pooled individual subjects (referred to as "nominal groups") generate more ideas than subjects working together in groups ("real groups"). They do indicate that distinctions are less clear concerning quality, uniqueness, and variety of ideas. Diehl and Stroebe (1987), also in a more recent review of the literature, strongly support the contention of nominal group superiority over real groups (many studies are cited in both articles). Since this study is focusing on real, or interacting groups, literature pertaining to comparisons of nominal groups and real groups will only be covered in summary form, unless issues pertinent to this study are addressed.

Although the evidence against the use of brainstorming is substantial, Graham and Dillon (1974) point out that "While brainstorming ... appears to be an ineffective way of generating ideas, it is unlikely that organizations will suddenly stop using groups for tasks that require productive thinking" (p. 101). The important issue then becomes determining why (brainstorming) groups are so ineffective and what can be done to overcome these problems and improve their productivity.

2.1.2 Why Brainstorming Doesn't Work

Lamm and Trommsdorff (1973) interpret the research findings in an effort to determine why brainstorming, although intuitively appealing, does not seem to work. They cite three main reasons that they believe cause the discrepancy of results between real and nominal groups: production blocking, social inhibition, and the role of cognitive uniformity versus interstimulation. Diehl and Stroebe (1987) also theorize why the differences occur, providing three explanations: production blocking, evaluation apprehension, and free riding. Diehl and Stroebe's evaluation apprehension and Lamm and Trommsdorff's social inhibition have several similarities and will be grouped together for subsequent discussion. In order to assess the impact of factors previously mentioned, Diehl and Stroebe performed four experiments using brainstorming groups. The results of these experiments and other research are presented in the evaluation of factors that impede the performance of real group brainstorming.

2.1.2.1 Cognitive Uniformity Versus Interstimulation

Lamm and Trommsdorff (1973) indicate that one of the factors believed to contribute to the inferiority of real groups is cognitive uniformity, where a group tends to develop "one-track thinking," or "get stuck in a rut," when generating ideas. The other side of this issue is the argument that the potential for cognitive interstimulation in groups may lead to a wider variety of ideas. What this implies is that if one group member offers an idea, and another member offers another idea of the same kind (in the same category), then the group may neglect other categories of potential ideas. The result may be more ideas within one category, but this may come at the expense of ideas in other categories which, depending on the problem, may be of greater importance.

2.1.2.2 Free Riding

Free riding, sometimes referred to as "social loafing," results when group members, expecting their ideas to be pooled with the ideas of others, become tempted to "free ride" on the efforts of others. On the other hand, subjects working individually expect their productivity to be individually measured and do not see any way of eluding the control of the experimenter. Another interpretation indicates that the propensity to free ride may increase as the group size increases and each group member perceives his/her contribution to be less important. Diehl and Stroebe (1987) indicate that there is evidence that free riding does occur in groups for brainstorming tasks and that this interpretation can even account for some of the inconsistent findings that have occurred. However, the results of two experiments performed by Diehl and Stroebe (1987; experiments 1 and 3) provided little evidence to support free riding in brainstorming groups.

2.1.2.3 Social Inhibition/Evaluation Apprehension

It has been argued that the failure of real brainstorming groups to perform as well as, or better than, nominal groups is due to the socially inhibiting characteristics of groups. Lamm and Trommsdorff (1973) indicate that group members tend to hold back ideas due to a fear of negative evaluation by other group members (even though the brainstorming rules require no evaluation) who may be judging the ideas on some criterion (e.g., unfeasible, improbable, useless, bizarre, far-fetched). They state that various group members are inhibited differently, some more than others, so that the less inhibited, but possibly the less capable, group members may have the floor. Van de Ven (1974), drawing on the previous research in this area, provides a number of reasons why group processes, such as idea generation, may be inhibited: the group pressures for conformity, the influence of dominant personalities, the inevitable presence of status incongruities in most groups, covert judgments made but not expressed, the amount of time required for group maintenance, and the tendency to reach "speedy" decisions before all problem dimensions have been considered.

While these factors are important for group interactions, Lamm and Trommsdorff (1973) indicate that "It may be assumed that there is little social inhibition operating in brainstorming groups..." They take this statement one step further by adding: "It can be tentatively concluded that the inferiority of brainstorming groups relative to individuals is less attributable to social inhibition than has been assumed by many authors." However, while they believe that social inhibition is not the main problem with brainstorming groups, they do add that it "does play a role in idea production in group contexts" (pp. 382-383). Diehl and Stroebe (1987) echo this point. Based on their experiments, they conclude that: "Because brainstorming instructions are designed specifically to free group members from the inhibiting effects of criticism by other group members, it is plausible that members of brainstorming groups do not constitute powerful sources of social inhibition for each other" (p. 507).

2.1.2.4 Production Blocking

Production blocking refers to the fact that only one member of a group may speak at a time. Therefore, if there are four members in a group, then theoretically each member could only speak one fourth (or 25%) of the time (this obviously becomes less as the group size increases). Lamm and Trommsdorff (1973) believe this to be the most important factor in the inferiority of real groups as to compared nominal groups. However, they point out that often the group "runs out of ideas" long before the time is up, so it is unlikely that the lack of speaking time is the main problem. Evidence of production blocking occurs in Gurman's (1968) study of nominal and real brainstorming groups. Gurman believed that the time limitation imposed on real groups caused the major difference in performance. Gurman stated that: "This limitation was evidenced by instances when a real-group subject would show signs of having an idea to present to the group and then having to wait patiently for another member of the group to finish the explanation of his idea to the group" (p. 476). While these two notions, groups "running out of ideas" and group members having to wait for others to finish, seem contradictory, most researchers indicate that brainstorming activity comes in spurts: Groups may be very active, generating many ideas in a relatively short period of time, then go for some time without generating additional ideas.

Diehl and Stroebe (1987), who also advocate the predominant role of production blocking in the inferiority of real groups, suggest that group members who cannot express their ideas while others are speaking may either forget or suppress them, especially if the idea seems less relevant or original later on. Another possibility is that real group members, while listening to others express their ideas, may be distracted and have their own thoughts interrupted. Both reviews indicate that there was not any substantial evidence for production blocking, nor had it ever been directly tested. Therefore, Diehl and Stroebe (1987; experiment 4) performed an experiment to evaluate the effect of production blocking on real group brainstorming. The results of their experiment provide strong support for the impact of production blocking. They theorize that while production blocking may not cause subjects to forget ideas, it may prohibit them from developing new thoughts while waiting their turn. They hypothesize that this may be due to the limited amount of short term memory and to the fact that group members may be able to store only a small number of ideas at one time.

2.1.3 Overcoming the Limitations of Brainstorming

The factors previously cited for the failure of real groups in brainstorming tasks combine several different notions: production blocking, free riding, cognitive uniformity, evaluation apprehension, and social inhibition. For real group idea generation to be more effective, techniques must be utilized that can overcome these negative factors. One such technique which has shown some initial success is brainwriting, a non-verbal adaptation of brainstorming which was developed at the Battelle Institute in Frankfurt, Germany (Geschka, et al., 1973). Gryskiewicz

(1980) describes brainwriting as "A non-oral creative problem solving technology which follows the rules of brainstorming but all idea generation and the communication of these ideas to others is written" (p. 56). The results of Gryskiewicz's (1980) field experiments show that real brainwriting groups produce a greater quantity of ideas than nominal brainwriting groups, thus providing the first significant evidence of real group superiority over nominal groups for an idea generation technique. He also found that real groups using brainwriting produce more ideas than real groups using brainstorming. Gryskiewicz felt that it was "the ability to overcome uniformity pressure with a non-oral technology" that led to this success. Given the evidence cited in the previous section pertaining to socially inhibiting characteristics, it could be argued that removing these factors was not as important as overcoming production blocking by letting all real group members generate ideas simultaneously (when using brainwriting all group members could write ideas at the same time, whereas in brainstorming, only one member usually speaks at a time).

Another approach developed to overcome the problems encountered by interacting (real) groups is the nominal group technique (NGT) (Van de Ven and Delbecq, 1971). NGT overcomes the problem of production blocking by allowing all group members to generate ideas simultaneously before sharing the ideas with the other group members in a roundrobin manner. Conflict and influence are held at a minimum during the sharing of ideas and subsequent voting that takes place. Reitz (1987) reports on NGT research which found that where both productivity and satisfaction were concerned, nominal groups of ten members were found to be optimal. It is possible that the ability of the NGT to overcome production blocking affords the NGT a much larger optimal group size than normally cited optimal group size for real groups (five) (Steiner, 1972). While NGT has some advantages, Van Gundy (1984) points out that the lack of external stimulation and sharing of ideas could result in the quality of ideas being rather low. Therefore, while NGT is very efficient it is not likely to produce the novel ideas that are possible with other methods. Reitz (1987) also indicates that the restrictions on interpersonal interaction imposed by the NGT apparently detract from the feelings of participation for group members.

Another technique developed to improve group performance is the Delphi technique (Dalkey, 1972). The Delphi technique overcomes production blocking and many of the socially inhibiting characteristics of real groups since all participants generate ideas individually and anonymously from their homes/offices. The iterative process of receiving a list of all previous suggestions, and then generating additional ideas, does provide access to ideas of others; yet it is a very inefficient process that may require considerable effort and a long period of time until a consensus or solution is reached.

While there has been progress in identifying and overcoming many of the problems that groups encounter for processes such as idea generation, many problems still exist. Some of these problems can be overcome by the techniques previously presented, yet no single technique appears to be able to overcome all the problems. Some of these problems may be greatly impacted by the size of the group. The next section presents information about group size and its impact on group productivity.

2.2 Group Size

Many researchers indicate that the relationship between group size and performance depends on the type of task being performed (e.g., Frank and Anderson, 1971; Steiner, 1972). Shaw (1981) outlines three different types of tasks. The first is additive, in which the outcome is based on the combination of individual products; thus, as group size increases, so should group performance. The second is disjunctive, in which at least one person in the group needs to be able to perform the task. Therefore, as group size increases, more people become available to perform the task and, thus, group performance should increase. The final type is conjunctive, which requires that all group members accomplish the task. In this type of task, as group size increases, the group performance is expected to decrease given that at least one member will probably not be able to complete the task. Potentially, the advantage goes to larger groups in performing additive and disjunctive tasks, while smaller groups have an advantage with conjunctive tasks.

Steiner (1972) was the first to investigate the relationship between a group's potential productivity and its actual productivity. He states the relationship as follows:

Actual productivity = potential productivity
- losses due to faulty processes

Steiner indicates that losses due to faulty processes are the result of structural inefficiencies in group processes. In Steiner's equation the size of the group is expected to influence both potential productivity and decision making processes of the group. Figure 3 provides an illustration of Steiner's equation. Based on these graphs it appears that the optimal group size, in terms of maximizing productivity, is between four and five. An optimal group size of five has been reinforced by results from several studies (e.g., Hare, 1952; Slater, 1958; Hackman and Vidmar, 1970).

Idea generation is an additive task combining the ideas of a number of individuals; therefore, the logical assumption is that the larger the group, the more ideas will be generated. Several researchers indicate that larger groups provide a wider range of ideas and judgments than smaller groups, thus resulting in more suggestions or

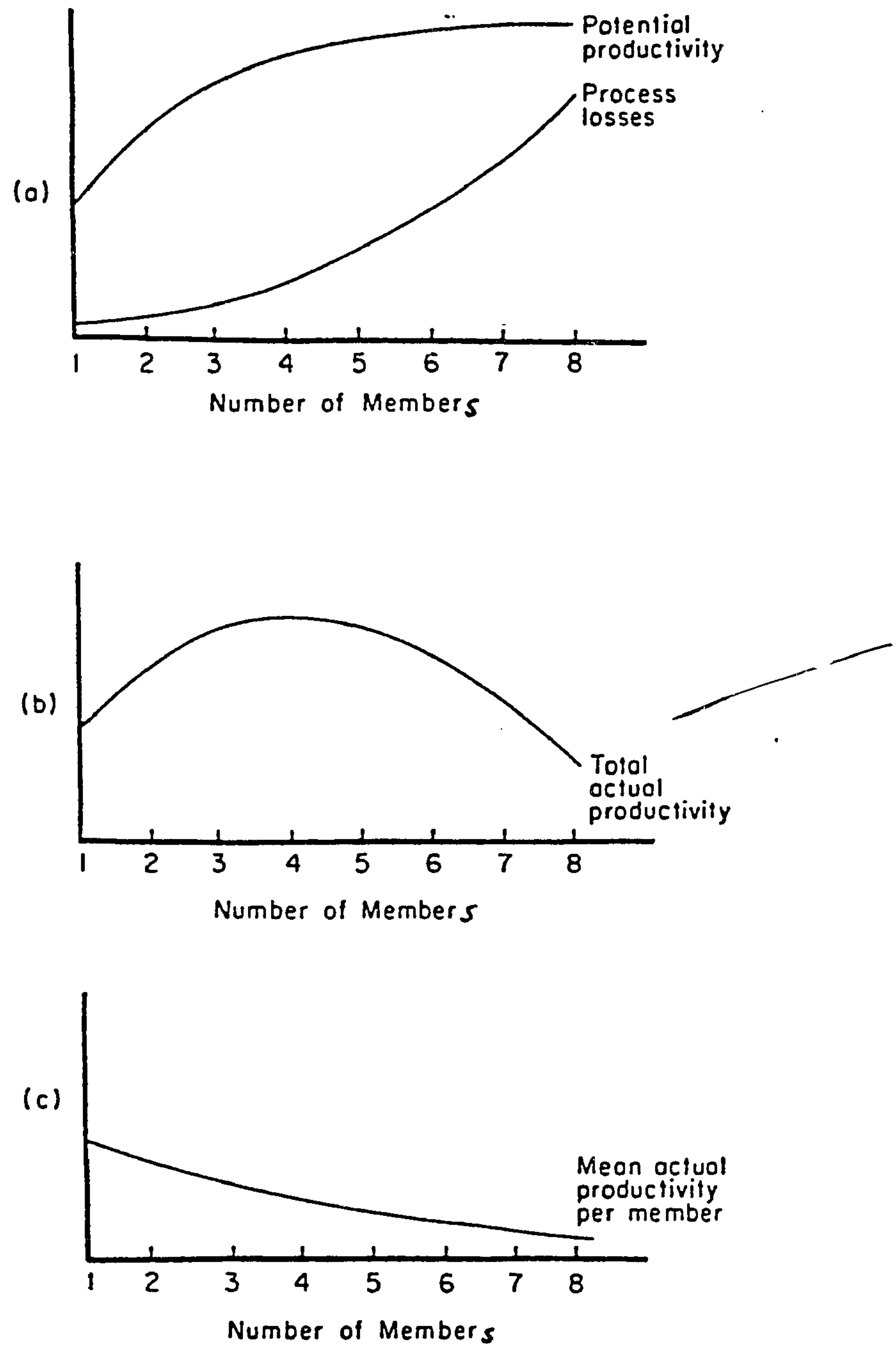


Figure 3 - The Relationship Between Group Size and Group Productivity

solutions to the problem (Steiner, 1966; Hare, 1976). However, Steiner (1972) points out that "As groups become larger, process losses will ordinarily increase at an accelerating rate" (p. 103). Idea generation research which investigated group size supports this notion and indicates that as group size increases, nominal groups perform significantly better than real groups and that real group idea production, on a per person basis, drops off significantly (Bouchard and Hare, 1970; Bouchard, et al., 1974). The dysfunctional behaviors previously cited that impact the performance of brainstorming groups appear to get worse as group size increases, further detracting from the group performance. Additional research pertaining to group size has found that satisfaction with group processes tends to be negatively correlated with group size: As groups get larger, satisfaction becomes lower (Schellenberg, 1959; Hackman and Vidmar, 1970; Lundgren and Bogart, 1974; Valacich, et al., 1989).

While five is often cited as the optimal size for an interacting group (Steiner, 1972), many groups will undoubtedly involve more than five participants. Mosvick (1988), based on over thirty years of experience in working with groups, described three different types of groups: first, groups of subordinates working with the boss tend to have five to seven persons; second, business meetings, or task forces, which are made up of mainly "equals", often consist of from seven to twelve persons; and third, senior executive committees which range upwards to 20 persons. A recent study of 26 executive-level teams by Lefton and Buzzotta (1987) showed that the range in group size is from six to twenty members, with an average just over ten.

Research pertaining to GDSS will be fully addressed in Section 2.3; however, some pertinent issues pertaining to group size will be presented in this section. While group size is often discussed as an important variable for GDSS research, it has been minimally addressed thus far. GDSS experimental research has focused mainly on groups of three or four undergraduate students (Dennis, et al., 1988a). Few experimental studies have varied group size at all. Two such studies (Watson, 1987; Zigurs, 1987) did vary group size, but then only with groups of three and four students. Their results show no significant differences between the groups. It is debatable whether differences in groups of these sizes could be significant, or even worth studying. However, one recent study (Valacich, et al. 1989) provided the first realistic comparison of groups of two different sizes, three and nine, although they did not provide comparisons with groups without GDSS support. They also did not provide groups with instructions, such as brainstorming instructions, for delaying evaluation of ideas until later. They did find that smaller groups generated more unique ideas of higher quality and were more satisfied with the group idea generation process than larger groups.

Field study research reported in the GDSS area tends to report on larger groups (with from 10 to 30 participants) which are composed mainly of managers and professionals (Dennis, et al., 1988a). Vogel, et al. (1987), based on over two years experience in running more than 75 real groups at the University of Arizona Planning and Decision Lab, indicate that the groups ranged in size from three to sixteen members, with the typical number being around nine or ten. They believe that the efficiency provided by a GDSS comes into play with larger groups (eight or more members), due mainly to the ability to support simultaneous generation of ideas by all participants. They also believe that effectiveness in handling a number of complex issues can be greatly enhanced by a GDSS for groups of six to eight (or larger). Finally, they state that when groups are larger, there is better group member satisfaction with the process. Larger groups appreciate the structure provided by the GDSS, as well as its capability to reduce dominance by a group member's personality.

2.3 Group Decision Support Systems

A new and different type of approach to support group processes, such as idea generation, is Group Decision Support Systems (GDSS). A number of laboratory experiments and field studies have been performed in the GDSS area. Those pertinent to this study are discussed below.

2.3.1 Laboratory Experiments

Steeb and Johnston (1981) performed an experiment to compare the performance of five three-person groups assigned to a GDSS (Group Decision Aid), with five three-person groups that were given no support (they were given paper, pencils, and a blackboard to use). These ten groups, composed mainly of graduate students, were given a task requiring a rapid response to a terrorist situation. The groups using the GDSS generated more alternatives, had final decisions judged to be of higher quality, were more confident in their responses, and were more satisfied with the process.

Lewis (1982) performed an experiment using a GDSS he developed called FACILITATOR. Thirty three-person groups of undergraduate students generated ideas for a creativity task involving a university facing a financial crisis. Groups were assigned to one of three treatments: the GDSS, the equivalent support in a booklet form, and control groups that received no help at all (ten groups per treatment). The results showed that groups using the GDSS produced more feasible solutions, considered more alternatives, and had a reduction in the domination by a single group member, when compared to either of the other two treatment groups. There were no significant differences in satisfaction with the method used. However, those who used the GDSS rated the creativity of their process higher.

Gallupe (1985) performed an experiment in which groups were provided with either GDSS support or no support, while performing a task of either low or high difficulty. Twenty-four three-person groups of undergraduate students were given a problem finding task to determine why a firm's profits were declining. Gallupe found that the groups using the GDSS (DECAID) had higher decision quality for both easy and difficult tasks, generated and considered more alternatives in greater detail, but tended to have decreased satisfaction with the process. The decreased satisfaction was especially true for the low difficulty tasks.

Beauclair (1987) conducted an experiment using a GDSS (Decision Lab) in which 16 five-person groups of undergraduate students were asked to provide a recommendation for dealing with a case of student misconduct in a residence hall. Groups were to generate alternatives, rank and evaluate the alternatives, and make a final recommendation. Four different types of support were provided: computer-supported brainstorming and voting, computer-supported brainstorming only (voting was "manual"), computer-supported voting (brainstorming was "manual"), and no computer support (control group). No differences were found between any of these groups in terms of group decision quality and individual group member contributions. The number of alternatives generated was not reported. Beauclair identifies two factors that may have led to the lack of significant results: the level of difficulty of the task and the subjects used in the study. Another factor that may have led to the lack of significant results was the task used in the study. There were a limited number of alternatives that the groups could have generated, which raises questions concerning the appropriateness of the match of task to technology.

Gallupe, et al. (1988) performed an experiment using 24 three-person groups of undergraduate students to address a problem finding task in which a firm's profits had been declining (same task as used by Gallupe, 1985). Groups were either provided computer support through a GDSS (DECAID), or a set of problem solving steps; there were also two levels of task difficulty (high and low). Results showed that for difficult tasks GDSS support enabled the groups to generate more alternatives and improved the overall decision quality. However, these groups also tended to have less satisfaction than groups without GDSS support.

Connolly, et al. (1988) performed an experiment using 96 undergraduate students, assigned to four-person groups, to evaluate the effects of anonymity and evaluative tone on idea generation and evaluation using a technique with GDSS support. A creativity task pertaining to the parking problem on campus was used. A confederate was used to manipulate evaluative tone by entering either "supportive" or "critical" comments. Anonymity was manipulated by either attaching the participant's name to the idea as it was entered into the electronic brainstorming system component of the GDSS (PLEXSYS) or by not having it attached to the idea. Overall, main effects showed that groups working under the anonymous condition generated more ideas than those working under the identified condition; and critical groups generated more ideas than supportive groups. Group 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/critical condition produced the most original solutions and most overall comments. Those working in an identified, but supportive condition were the most satisfied, but had the fewest original solutions and lowest overall comments.

Jessup, et al. (1988) performed an experiment using 80 undergraduate students, assigned to four-person groups, to evaluate the effects of anonymity and proximity on idea generation with GDSS support. Groups used the electronic brainstorming component of the GDSS (PLEXSYS) to generate ideas in different settings: either in the same room or in separate locations, and either anonymous or identified. A creativity task pertaining to a parking problem on campus was used (same as Connolly, et al. (1988) above). The researchers found that groups who worked anonymously, but apart, generated more comments. The level of satisfaction was increased by having group members work in the same room. Group members reported the highest level of perceived effectiveness when working under anonymity.

Valacich, et al. (1989) performed an experiment to evaluate the effects of anonymity and group size for idea generation. One-hundred and twenty-six undergraduate students were assigned to groups with either three or nine members. The groups were either identified or anonymous. The groups were to identify and discuss all "people, groups, and organizations" that would be affected by requiring all business students to have access to a personal computer. The electronic brainstorming component of a GDSS (PLEXSYS) was used to support the groups. The authors referred to this as a "generate" task, based on McGrath's (1984) Task Circumplex. The results indicated that there was no difference in the output (comments) per person between small and large groups, but that the smaller groups generated more unique solutions per person than larger groups.

The authors reported that larger groups had a "higher solution quality" (p. 14) than smaller groups. Although not reported, it can easily be calculated from the data provided in the paper that quality, on a per person basis, is higher for smaller groups (data reported in Table 2, page 30, shows that for small groups the average quality per person is 9.8, while for large groups it is 5.3). These figures do not substantiate the authors' claim that the GDSS "allowed larger groups to outperform smaller groups" (p. 24).

Smaller groups also tended to be more satisfied with the group interaction than larger groups. A potential problem with this study may be the task used (identifying people) since, overall, only 30 people were identified (of which six were eliminated by the judges). The use of this task as a "generate" task may not have provided ample opportunity for the generation of solutions given the time provided to subjects to generate (30 minutes), and the low average number of unique solutions per group: 2.8 for three-person groups and 1.7 for nine-person groups.

Chidambaram (1989) performed an experiment to assess the impact of a GDSS (PLEXSYS) on group development and decision making. One-hundred and forty undergraduate students were assigned to five-person groups; half received GDSS support, the other half were provided with equivalent manual support. The groups met once a week for four weeks and in each session addressed a different decision making task (four different strategic international business cases). In the first phase of each session the groups generated ideas for potential solutions or courses of action for these problems. Results showed that the groups using the electronic brainstorming component of the GDSS (PLEXSYS) generated significantly <u>more alternatives</u>, over the four sessions, than the groups without GDSS support. No overall difference was found in <u>solution quality</u> between the two sets of groups over the four sessions.

Generally, groups provided GDSS support have generated more ideas or alternatives than groups without GDSS support (equivalent techniques) or with no support. While overall decision quality between groups with GDSS support and groups without GDSS support has been mixed, assessment of the quality of the individual ideas generated has been basically ignored or not reported (with the exception of Valacich, et al., 1989). The results pertaining to satisfaction with the idea generation process have been inconsistent. Some possible reasons for these inconsistencies are presented in the summary of this chapter. A summary of GDSS laboratory experiments comparing groups with GDSS support to groups without GDSS support is provided in Table 1A. Table 1B provides a summary of GDSS laboratory experiments where comparisons are made between differently-configured GDSS-supported groups (e.g., anonymity, proximity, evaluative tone).

2.3.2 Field Studies

While there have been inconsistencies in the results of laboratory experiments, the results of field studies are more consistent. Vogel, et al. (1987) provide a summary of determinants of GDSS success based on over two years of observing groups using a GDSS (PLEXSYS) at the University of Arizona Planning and Decision Laboratory. Essentially, their findings indicate that the degree of support provided by the GDSS becomes more evident as the size of the group increases. As group size increases, so does the group's effectiveness and its satisfaction with the group process.

Author(s) & Date	GDSS Used	Task		Group			Results	
		Type	Content	Type	Size	Total N	# of Ideas	Satisfaction
Steeb & Johnson, 1981	Group Decision Aid	Planning	Responding to a Terrorist Threat	Grad. Stdnts	Three-person	30	GS > NGS	GS > NGS
Lewis, 1982	FACILITATOR	Creativity	University w/ Financial Probs	Und. Stdnts	Three-person	90	GS > NGS > NS	No Differences
Gallupe, 1985	DECAID	Problem Finding	Firm w/ Declining Profits	Und. Stdnts	Three-person	72	GS > NGS	NGS > GS
Beauclair, 1987	Decision Lab	Policy Formulation	Student Misconduct Case	Und. Stdnts.	Five-person	80	NR	NR
Gallupe, et al., 1987	DECAID	Problem Finding	Firm w/ Declining Profits	Und. Stdnts.	Three-person	72	GS > NGS	NGS > GS
Chidambaram, 1989	PLEXSYS	Decision-Making	Strategic International Business Cases	Und. Stdnts.	Five-person	140	GS > NGS	NR

GS - Techniques with GDSS Support
NGS - Techniques without GDSS Support (Manual Support/Structure Provided)
NS - No Supported Provided
NR - Not Reported

Table 1A

Summary of GDSS Lab Experiments Comparing Groups with GDSS Support and Groups without GDSS Support

Authors & Date	GDSS Used	Task Type and Content	Independent Variables	Group			Results	
				Type	Size	N	# of Ideas	Satisfaction
Connolly, et al., 1988	PLEXSYS	Creativity - University Parking Problem	**Anonymity:** Yes or No; **Evaluative Tone:** Cricital or Supportive	Und. Stdnts	Four-person	96	More ideas for groups with Anonymity; Anon/ Critical groups had the most uniques solutions & overall comments	Groups in the Supportive/ Identified condition were the most satisfied
Jessup, et al., 1988	PLEXSYS	Creativity - University Parking Problem	**Anonymity:** Yes or No; **Proximity:** Same / Different Room	Und. Stdnts	Four-person	80	More comments from groups who were Anonymous, but in Different Rooms	Was increased by having group members work in the same room
Valacich, et al., 1989	PLEXSYS	Creativity - Student Access to a PC	**Anonymity:** Yes or No; **Group Size:** Three- and Nine-person	Und. Stdnts	Three- and Nine-person	126	Three-person groups generated more unique solutions per person; Nine-person groups more total ideas	Three-person, Identified groups were more satisfied

Table 1B

Summary of GDSS Lab Experiments Comparing Differently-Configured GDSS-Supported Groups

They also indicate that the anonymity provided by the GDSS tends to create a sense of equality among the group participants. There is a downside to this sense of equality in that group members tend to be more blunt and assertive, and thus the amount of conflict tends to heighten.

Nunamaker, et al. (1987) describe their experience working with planners using the electronic brainstorming system component of a GDSS (PLEXSYS). They report that electronic brainstorming (the automated version of brainwriting) does appear to overcome many of the dysfunctional characteristics inherent to group idea generation: anonymity is maintained, authority is neutralized, and the domination of the communication/discussion by one person is overcome by the ability of all group members to simultaneously enter ideas. They did indicate that during times of verbal discussion among the group members, one or two persons tended to dominate the discussion. They also present a discussion of some factors that can actually inhibit the idea generation process for some group members when using the GDSS: the size of the computer screen, the computer keyboard, and possible network inefficiencies in handling the transfer of data (ideas) among group members. However, they found that the group members were highly satisfied with using electronic brainstorming as a tool for generating ideas.

Anson and Harvey (1988) report on the use of a GDSS

(PLEXSYS) to support a case conference of 13 human service professionals who participated in a two hour planning session. The participants indicated that using the GDSS resulted in less influence being exerted by one or two people than in previous meetings, and that they were more comfortable and found it easier to express ideas.

Dennis, et al. (1988b) reported using a GDSS (PLEXSYS) to provide support for 31 executives (senior managers) participating in a three day strategic planning session. A large majority of the participants (22 of the 26 who responded to surveys at the end of the session) believed that the automated process was better than a manual process (the other four had no preference). Survey responses and comments supported the importance of anonymity which allowed people to ask questions or raise issues that would not have otherwise been expressed. Comments also indicated that the simultaneous entering of comments and ideas allowed for much greater participation than could have occurred without the GDSS support. Overall, the participants were satisfied with the GDSS-supported process.

Fellers, et al. (1988) used the electronic brainstorming component of a GDSS (PLEXSYS) to provide support for 13 expert systems professionals who generated factors as a basis for a critical success factors study on knowledge acquisition and expert systems development. In just over one hour the 13 participants, working at eight stations, generated nearly 150 factors. It is unlikely that nearly so many factors could have been generated in such a short time without the GDSS support. Observations and participant comments indicated that the use of the system led to a much higher and quicker cohesion of the group members, most of whom did not know one another. Additional comments from the participants indicated a high degree of satisfaction with using the GDSS and with participation in the session.

Lewis and Keleman (1988) describe their experience using a GDSS (FACILITATOR) with two different groups to support the groups' planning process. The groups had 13 and 15 participants, respectively. For both sessions, the group members felt that the GDSS support provided better equity of opportunity to voice opinions and provided a high level of satisfaction with using the GDSS to achieve their goals.

Bostrom and Anson (1989) discuss the results of using a GDSS (PLEXSYS) to support a three day planning and budget review meeting of 14 officers and staff members of a professional association. When compared to previous meetings without GDSS support, this meeting was rated as more positive in terms of both meeting processes and outcomes. Specifically, anonymity provided by the GDSS enabled participants to more easily contribute ideas, simultaneous generation of ideas made generating ideas more efficient, and the electronic recording and display kept ideas from getting lost.

The field studies of groups using GDSS support provide strong evidence of the potential benefits of GDSS use in meetings. GDSS support for idea generation universally allowed groups to generate more ideas, provided anonymity, and reduced dominance of meetings by a minority of members. Group members also appear to be highly satisfied with the group interaction. Table 2 provides a summary of the GDSS field studies covered in this section.

2.4 How GDSS Can Facilitate the Group Idea Generation Process

Bostrom and Anson (1988a) describe a number of GDSS support capabilities and their intended benefits for meeting environments based on previous GDSS research. In their analysis, they draw especially on their experience in running GDSS sessions and other GDSS field studies (see Table 3). These capabilities and benefits provide potential reasons to explain how GDSS can improve group performance. GDSS support provides group members with: anonymity; simultaneous input of ideas, comments, votes, etc.; a means for structuring the process; electronic recording and display of information; and extended information processing capabilities. Many of these benefits are provided by other idea generation techniques as well; however, it is believed that GDSS is the only one which provides all of these capabilities. Additionally, it provides them in a much more efficient and effective manner (see Table 4 for a comparison

Author(s) & Date	Group Size	Task Type	Group Satisfaction	Key GDSS Factors
Vogel, et al., 1987	3 - 16	Planning (mainly)	High Level of Satisfaction	Anonymity; Increased Equity of Participation
Nunamaker, et al., 1987	22	Planning	High Level of Satisfaction	Anonymity; Simultaneity
Anson & Harvey, 1988	13	Planning	More Comfortable	Increased Equity of Participation
Dennis, et al., 1988	31	Planning	Very Satisfied	Anonymity; Simultaneity
Fellers, et al., 1988	13	Idea Genera-tion	Enjoyed Participating in the Meeting	Anonymity; Simultaneity
Lewis & Kel-man, 1988	13 - 15	Planning	High Level of Satisfaction	Increased Equity of Participation
Bostrom & Anson, 1988	14	Planning, Budgeting	More Positive than Previous Meetings	Anonymity; Simultaneity

Table 2

Previous GDSS Field Studies

GDSS Support Provides	Benefits in Meeting Environment
1) Anonymity	a) reduced individual inhibitions due to - fear of social disapproval - speaking anxiety - presence of authority or "expert figures" b) focus on ideas rather than on the individuals who contributed ideas c) enhanced "group ownership" of meeting outputs
2) Simultaneous Input (or ideas, comments, votes, etc.)	a) broader, more active participation (more people inputing) b) more efficient information generation (more input in less time) c) reduces minority domination of communication
3) Means for Process Structuring	a) improved application of group process structuring techniques (e.g., brainstorming, brainwriting) b) separated idea generation from evaluation c) improved topic focus (less topic wandering) d) facilitates agenda control of meeting activities
4) Electronic Recording and Display	a) immediate display of individual and group information b) easier to modify information during process c) easier to prepare information inputs prior to meeting d) easier to distribute information following meeting e) reduced information loss f) retained original wording and meaning of inputs g) electronic integration of meeting information with other computer tools h) enhanced group memory of previous meetings or events in current meetings
5) Extended Information Processing Capacity	a) automates complex analysis tasks such as vote aggregation b) easy access to external infomration c) easy access to other computer tools d) quick and efficient access to others ideas and opinions

Table 3

GDSS Support Capabilities and Their Benefits in Meeting Environment

of idea generation techniques and their ability to overcome the problems frequently encountered in interacting groups).

While it is believed that all the capabilities listed in Table 3 will contribute to improved performance of groups by overcoming many of the previously discussed factors detrimental to group performance, two factors -- simultaneity and anonymity -- should have the greatest impact on idea generation. Each proposed capability will be discussed in terms of its relationship to the previously described factors that inhibit real group idea generation.

2.4.1 Anonymity

Anonymity is essential for ensuring that an idea is evaluated based upon its own merit, not that of the group member who suggested it. Generating ideas non-orally provides an escape from the fear of social disapproval, from speaking anxiety, and from the pressure of authority, "expert", or dominant figures in the group. By not assigning ownership of ideas to individuals, "group ownership" of ideas can be enhanced, which is an important element for group commitment and acceptance. While techniques such as brainwriting propose to provide anonymity, there is still the potential for group members to see who wrote down an idea or recognize someone's handwriting. Idea generation techniques with GDSS support provides the capability for supporting complete anonymity of idea generation by group participants. Under condition of complete anonymity, group members have no way of knowing who

Problem	Techniques					
	NGT	Delphi	BW	BS	NI	GDSS
Dominance by one or two individuals in the group	Y	Y	Y	N	N	Y
Fear of personal evaluation	P	Y	P	N	N	Y
Fear of public speaking	P	Y	Y	N	N	Y
Pressure for conformity	P	Y	Y	N	N	Y
Bringing evaluation into the process too soon	Y	Y	Y	Y	N	Y
Production blocking: only one idea can be generated at a time	Y	Y	Y	N	N	Y
Cognitive uniformity: the ideas tend to "fall into a rut"	P	Y	P	N	N	Y
Inability to get simultaneous access to the ideas of others	N	N	P	Y	Y	Y
Inefficient access to ideas of others	P	N	P	P	P	Y
Ability to "free ride" on work of others	P	P	P	Y	Y	P

NGT - Nominal Group Technique
BW - Brainwriting
NI - No instructions
Delphi - Delphi Technique
BS - Brainstorming
GDSS - Group Decision Support System

Y - Yes; Does Overcome the Problem
P - Partially; Does Partially Overcome the Problem
N - No; Does Not Overcome the Problem

Table 4

Capabilities of Idea Generation Techniques to Overcome Problems Commonly Encountered in Groups entered the idea (at least not from the system; however, depending on the group history, individual quirks such as phrasing and spelling may identify the contributor of the idea). Both GDSS laboratory and field studies find support for the importance of anonymity in improving the performance and satisfaction of groups for idea generation (e.g., Connolly, et al., 1988; Jessup, et al., 1988; Vogel, et al., 1987; Nunamaker, et al., 1987; Dennis, et al., 1988b; Bostrom and Anson, 1989).

2.4.2 Simultaneous Input of Ideas and Comments

Based on the opinions of Lamm and Trommsdorff (1973), and on the research of Diehl and Stroebe (1987), the ability to support the simultaneous generation of ideas appears to be the key factor in overcoming production blocking. Production blocking is felt to be the main detriment to the effectiveness of real group idea generation. Simultaneous input of ideas allows all group members to participate by entering ideas at the same time. This allows for greater individual participation, more efficient information generation, and less domination of communication. Simultaneous generation of ideas by all group members was cited in several field studies as leading to better group productivity and satisfaction, while also reducing dominance of communication by one or two members (e.g., Nunamaker, et al., 1987; Dennis, et al., 1988b; Bostrom and Anson, 1989). It is also the probable reason for the success Gryskiewicz (1980) had with brainwriting, since all group members were allowed to generate ideas simultaneously. Moving beyond techniques like brainwriting, the automation provided by GDSS support yields capabilities for a much more efficient idea generation process.

2.4.3 Additional Contributing Capabilities

While traditional brainstorming sessions have utilized handwritten or tape-recorded responses, techniques with GDSS support provide for electronic recording and display of ideas. This frees group members from having to write down ideas or wait for someone else to write down the ideas. The electronic display of ideas also provides access to previously generated ideas in an efficient and easy-to-read manner. This allows group members immediate access to the ideas of others: They can read the ideas more quickly, thus providing them with greater stimulation for the generation of new ideas. Additionally, the capability to store and print results of the idea generation session can help facilitate any additional sessions or subsequent steps in a decision making, problem solving, or planning process.

The use of techniques with GDSS support provides a greater means for process structuring. This improves the application of techniques such as brainstorming, and also helps to keep the group focused on idea generation and not evaluation. While this is an extremely significant factor for most group interactions, it was not as important for this study, since group members were involved in only one phase or step (idea generation) of a problem solving process.

The use of <u>extended information processing capabilities</u>, afforded by GDSS support, provides group members access to other external information, including: ideas generated by the same group at a previous session, ideas generated by another group, or to other tools and modules in the same computer system. Again, the participation in just one idea generation session with GDSS support reduced the importance of later access to ideas for the participants in this study.

2.5 Summary

For nearly thirty years idea generation studies have shown the superiority of nominal groups over real groups for idea generation. This research has identified a number of factors which potentially impact the performance of real groups. Initial research with a new type of information technology, GDSS, has provided an indication that GDSS support can overcome many of these detrimental factors.

While several studies have been conducted in the GDSS area, many of the findings are inconsistent. Dennis and Nunamaker (1988) point out several problems with research in the GDSS area. One problem is simply the lack of research: It is a relatively new area and as yet there has not been a significant body of research. Some of the problems with the research that has been performed include the use of groups with different characteristics, different types of tasks, differing contexts, different GDSS (not all systems are uniform), and different experimental designs. Finally, there have been few replications of GDSS studies.

While much of the previous GDSS research has produced mixed results, this study has overcome many of the problems that have contributed to these inconsistencies. This study evaluated just one component of a GDSS, not the entire system. As Bostrom and Anson (1988b) indicate, the use of the entire system "may confound the effects of different system components" (p. 30). Jarvenpaa, et al. (1988) also support the isolated study of individual GDSS components, indicating the need to "assess their individual usefulness", adding that further studies could be "conducted later to examine the interaction effects of components" (p. 646).

Unlike studies that have used just three- or four-person groups, this study used five- and ten-person groups. By comparing the two group sizes -- five-person groups, where group productivity is found to be maximized (Steiner, 1972), and ten-person groups of a more realistic size -- this study has provided a clearer picture of the interaction of the GDSS support and group size. This permitted the determination as to whether or not GDSS support can maintain the same level of productivity, on a per person basis, as group size increases. The tasks used in this study were of the same type, and had been pretested to ensure that they were of comparable difficulty and that the match of technology to task was appropriate. The use of the repeated measures design provided for evaluation of results based on groups that participated in sessions both with GDSS support and without GDSS support. Finally, the roles of leadership or facilitation, often overlooked in previous studies, were controlled in this study, and therefore, were not a confounding factor.

CHAPTER 3

RESEARCH FRAMEWORK

3.0 Introduction

This chapter presents the conceptual foundations used for the study. This is followed by the problem statement, description of the independent, control, and dependent variables, and the hypotheses to be tested in this study.

3.1 Research Framework

A commonly accepted framework for GDSS research is the Conceptual Framework for the Study of Groups developed by McGrath (1984) (used by Zigurs, 1987; Murthy, 1987). McGrath's conceptual framework has four major classes of variables that set the conditions under which the group interaction will take place. These variables are the properties of:

- Group members
- The standing group
- The task/situation
- The surrounding environment

McGrath states that "the effects of these four sets of properties, singly and in combination, are forces that shape the group interaction process" (p. 14). A modified conceptualization of McGrath's model, shown in Figure 4, utilizes the input - process - output model of a group meeting developed by Bostrom, et al. (1987) to provide a framework for the variables and factors of interest in this study. Inputs (independent variables: IV's), processes (factors that inhibit group idea generation and GDSS

Inputs (IV's)	Processes	Outputs (DV's)
Properties of the INDIVIDUALS - controlled Properties of the STANDING GROUP - group sizes of five and ten - other factors: controlled Properties of the TASK - two comparable creativity tasks Properties of the ENVIRONMENT - GDSS Support, No GDSS Support - Brainstorming, Instructions, No Instructions - Other factors: controlled FACILITATION FACTORS - controlled	That INHIBIT Group IDEA GENERATION: 1) Cognitive Uniformity 2) Free Riding 3) Social Inhibition/ Personal Evaluation 4) Production Blocking - - - - - - - - - - - - - TIME to Complete Each Task: - controlled - - - - - - - - - - - - - GDSS Features that FACILITATE Group IDEA GENERATION: 1) Anonymity 2) Simultaneity 3) Improved Information Recording and Display 4) Means for Process Structuring 5) Extended Information Processing Capability	TASK OUTCOMES: 1) QUANTITY of IDEAS GENERATED 2) QUALITY of IDEAS GENERATED GROUP OUTCOMES: 1) SATISFACTION w/ the IDEA GENERATION PROCESS 2) PERCEIVED USEFULNESS of the IDEA GENERATION TECHNIQUE

Figure 4 - Framework for Idea Generation Tasks

features that facilitate group idea generation), and outputs (dependent variables: DV's) for the idea generation process are shown in Figure 4. These four classes of variables are discussed as they pertain to this study.

3.1.1 Properties of Individuals

These represent the biological, social, and psychological properties of individuals. While individual differences of participants are often cited as a major source of variation in group studies, they were not the focal point of this study. In this study individuals were randomly assigned to groups, and groups to treatments; therefore, no measures of individual differences were manipulated. A typing test was given and tested as a potential covariate to ensure that individual typing ability, given the use of the computer keyboard to enter ideas, did not impact performance.

3.1.2 Properties of the Standing Group

Properties of the standing group pertain to a number of factors inherent in group interactions: shared norms of group members, group objectives, group size, member status, and group history. Zero-history groups composed of undergraduate students were used in the study. All factors except group size were controlled through randomization: Groups of five and ten persons were used in the study.

3.1.3 Properties of the Task

McGrath's Task Circumplex (Figure 2) illustrates the different types of tasks performed by groups. Creativity tasks, which required the groups to generate as many novel ideas as they could in a fixed amount of time, were used in the study. The two main tasks used had been tested in the pilot study to ensure that task comparability did exist. Two additional creativity tasks were used for "warm-up" tasks, as is often done in idea generation studies (they had also been pretested for comparability).

3.1.4 Properties of the Environment

All characteristics of the task environment were held constant, except for GDSS support and structure to support the idea generation process. All groups had GDSS support for one task: half of the groups for the first task, the other half for the second task. Half of the groups had structure (brainstorming instructions) provided, the other half did not.

3.2 Problem Statement and Variables

The goal of this study was to examine the impact of idea generation techniques with GDSS support, with and without structure (provided by Osborn's brainstorming instructions), for idea generation on groups of two different sizes (five and ten persons). The importance of using groups for problem solving, decision making, and planning, as well as the need for overcoming their dysfunctional behaviors and improving their productivity for idea generation, is well documented. Given the lack of empirical GDSS research pertaining to group size, it is also important to evaluate in a controlled manner the impact of groups of realistic sizes on the idea generation process. Given these objectives, measures of group performance, satisfaction with the idea generation process, and perceived usefulness of each technique were assessed. The independent, control, and dependent variables used in this study are defined in this section. Figure 5 provides a summary of how these variables were operationalized.

3.2.1 Independent/Input Variables

There were three independent variables manipulated in this study: technique support (which is composed of two of these variables GDSS support and structure) and group size.

3.2.1.1 Technique Support

Technique support consists of two factors, with two levels each, that were manipulated in this study. The first was GDSS support: groups had GDSS support for one task, and no GDSS support for the other task. The second factor was the structure provided to support the idea generation process: half of the groups were provided with Osborn's (1957) brainstorming instructions, the other groups were given no instructions pertaining to idea production. The combination of these two factors provides four experimental treatments for technique support: electronic brainstorming (EBS), brainstorming (BS), electronic no instructions (ENI), and no instructions (NI). Each was administered as follows:

> **Electronic Brainstorming** was an automated version of the brainstorming procedure in which all generation and exchange of ideas took place through a GDSS. No oral

VARIABLES	OPERATIONALIZATION
Independent Variables:	
Group size	Five- and ten-person groups
Technique Support:	
GDSS	GDSS / No GDSS
Structure	Brainstorming instructions / No brainstorming instructions
Control Variables:	
Task type and complexity	Two comparable creativity tasks
Time taken	Same for all sessions
Properties of individuals	Controlled thru random assignment
Other group factors	Controlled thru random assignment
Physical environment	Same for all sessions
Facilitation	Same facilitator/procedures for all sessions
Dependent Variables:	
Number of ideas	Computer logs, flipchart lists, and audio tape recordings
Quality of ideas	Ratings provided by expert judges (three different judges per task)
Satisfaction with the idea generation process	Post-session questionnaire
Perceived usefulness of each technique	Post-session questionnaire

Figure 5 - Summary of Variables and Their Operationalization

communication between group members was allowed. Groups followed Osborn's (1957) brainstorming instructions which allowed them to focus on creative generation and combination of ideas, while delaying evaluation until later. Group members could see each idea as it was generated on a main viewing screen, as well as having access to all ideas that the group had generated on their own personal computer screen. GDSS support for this technique was provided by the topic commenter component of the University of Arizona PLEXSYS system. (It should be noted that "Electronic Brainstorming", as used in this study, is not the same as the "Electronic Brainstorming System" as used on PLEXSYS; Electronic Brainstorming is actually an automated version of the brainwriting procedure.)

Brainstorming was used as originally prescribed by Osborn (1957). Groups used the brainstorming instructions which allowed them to focus on creative generation and combination of ideas, while delaying evaluation until later. All generation of ideas was oral. Ideas were recorded by tape recorder and written on a flipchart pad by the facilitator. Each sheet was then posted on the wall to allow group members access to all ideas the group had generated.

Electronic No Instructions simply followed the same procedures as electronic brainstorming, without the introduction of Osborn's four instructions that govern idea production.

No Instructions were provided to the subjects. In other words, the four brainstorming rules were not provided to the subjects. All generation of ideas was oral. Ideas were recorded by tape recorder and written on a flipchart pad by the facilitator. Each sheet was posted on the wall to allow group members access to all ideas the group had generated.

3.2.1.2 Group Size

An equal number of five- and ten-person groups were used to generate ideas for both tasks. Rationale for the selection of these group sizes is as follows:

Five: Much of the group literature cites a group size of five as the optimal for group productivity (Steiner, 1972). Gallupe (1985) has also suggested that a group size of five is optimal and should be used in GDSS studies.

Ten: It is believed that the advantages of GDSS support will become more apparent as group size increases and the potential for dysfunctional group behavior increases (and group productivity has traditionally decreased). Research with nominal and real brainstorming groups found significant advantages for nominal groups as group size increased (group sizes were four, five, seven, and nine; Bouchard and Hare, 1970; Bouchard, et al., 1974). Research with the NGT found ten to be the optimal group size (Reitz, 1987). Lefton and Buzzotta (1987) and Vogel, et al. (1987) both indicate that the typical size for real groups they worked with in their research was approximately ten members. Previous GDSS field study research has indicated that the advantages of the technology will not become evident until the group size is at least six or eight (Nunamaker, et al., 1987). A group size of ten provides an opportunity to evaluate the impact of the GDSS on groups larger than six to eight. A practical reason for the selection of ten, as opposed to a larger group size, was the physical constraints of the research facility, in which only ten machines were available which provided a uniform interface (keyboard and monitor) for all group members.

3.2.2 Control Variables

To allow provision for accurate manipulation and measurement of the variables of interest, a number of other variables must be controlled. The control variables in this study were task type, task complexity, time allowed to perform the task, individual differences, additional group factors (other than group size), and physical environment.

3.2.2.1 Task Type

The characteristics of the task determine the type of support needed for the group. It is therefore important to match the type of technique support to be provided with the task at hand. Creativity tasks require support for generating as many novel ideas as possible. Such support was provided by the different structured techniques (electronic brainstorming and brainstorming) evaluated in this study. Groups with no support were added to provide for baseline measures.

3.2.2.2 Task Complexity

Task complexity has been shown to affect group performance (Gallupe, 1985). Pilot testing indicated that the tasks used in this study, for both the warm-up and main task, were of equal difficulty for idea generation. A completely counterbalanced design was employed to allow for the evaluation of task, order and/or learning effects: half of the groups did task "1" first, then task "2"; while the other half of the groups did the task "2" first, then task "1". The warm-up tasks were also assigned so that half of the groups that did one main task first used warm-up task "A" and the other half of the groups used warm-up task "B".

3.2.2.3 Time

Time was held constant at twenty (20) minutes for each main task, following a five (5) minute warm-up task. Twenty minutes was selected as the time for the main task after substantial pilot testing. It is also a time that has been used in numerous previous idea generation studies (e.g., Bouchard, 1972a; Bouchard, 1972b; Graham and Dillon, 1974; Harari and Graham, 1975; Sappington and Farrar, 1982; Ruback, et al., 1984; Price, 1985). Many previous idea generation studies have also used five minute warm-up tasks (e.g., Bouchard, 1972a; Bouchard, 1972b; Jablin, et al., 1977; Jablin, 1981); Jablin (1981) presents the rationale for the use of a warm-up task, indicating that the warm-up exercise was used "because of its ability to foster creative thinking, while at the same time allowing subjects to get used to the brainstorming procedures" (p. 249). Warm-up tasks have also been used in previous GDSS research (e.g., Zigurs, et al., 1989).

3.2.2.4 Individual Differences

Individual differences may impact group behavior and performance. To help alleviate the possible impact of individual differences on group performance, subjects were randomly assigned to groups, and groups to treatments. Subjects were solicited from 11 different sections of the same course, had previous experience with computers (subsequently, computer keyboards, which the subjects will be required to use for idea entry), and had equal opportunity for assignment to all groups. Subjects were randomly assigned to groups; however, the gender mix of the groups was controlled as much as possible. Previous research has shown that if groups are predominately male, the female minority members will be inhibited from participation in group discussions (Craig and Sherif, 1986). In order to prevent this from being a problem, groups were controlled so that there were no more than 60% of one gender (i.e., five-person groups were always either three male and two female, or two male and three female; while ten-person groups were six male and four female, five of each gender, or four male and six female). This assignment of group members ensured that groups did not have predominant majority/minority gender membership.

3.2.2.5 Group Factors

While group size was manipulated in this study, all other factors pertaining to the properties of the standing group were controlled by random assignment of subjects to groups.

3.2.2.6 Physical Environment

The characteristics of the physical environment were the same for all groups for all tasks. The only difference was the personal computers, which were present for all sessions, but were not used for the sessions without GDSS support. All sessions were held in the Collaborative Work Support (CWS) Lab located at the Institute for the Study of Developmental Disabilities (ISDD). All sessions were run by the same experimenter/facilitator.

3.2.3 Dependent/Output Variables

The unit of analysis for this study was the group level. Group variables measured included the quantity and quality of ideas generated, the satisfaction level of the group with the idea generation process, and the group's perceived usefulness of the idea generation technique.

3.2.3.1 Quantity of Ideas Generated

Three different measures of the quantity of ideas generated were evaluated for each group (see Appendix D.1 for procedures used in rating ideas):

Total Number of Ideas: Total number of ideas generated by the group.

Number of Different Ideas: Total number of ideas minus the redundant, or duplicate, ideas generated by the group. If the same idea is suggested more than once, then it is counted as only one "different" idea.

Number of Unique Ideas: An idea is unique if it is only found once in the entire set of ideas generated by all groups. This measure reflects the number of ideas generated by one group only.

3.2.3.2 Quality of Ideas Generated

This measurement evaluation is based on ratings by three (different) expert judges for each task. The determination of quality was based upon two criteria: effectiveness and feasibility (the same criteria that have traditionally been used for this type of task in previous idea generation studies (Lamm and Trommsdorff, 1973). Each criterion was assessed on a scale of one to ten: one being very ineffective/infeasible and ten being very effective/feasible. The scores from the three judges were summed to provide a quality rating for each idea (therefore, the range of quality scores was from six to 60). Quality was measured on three levels (see Appendix D.2 for the instructions given to the judges):

Total Quality: Sum of all ratings for all different ideas generated by each group.

Average Quality: Divides total quality by the number of different ideas generated by a group.

Number of Good Ideas: A cut-off, or criterion, point is established on a scale so that any idea receiving a score above this point is classified as a "good" idea. This cut-off point is based on the quality score assigned to each idea. In previous idea generation studies this point has been set at four on an eight point scale (4 out of 8, or 50.0%; e.g., Bouchard, 1969). The resulting cut-off for this study was, using the same percentage (50.0%), 30.0 points (out of a potential 60). Therefore, any idea with a quality rating of 31 or higher was classified as a "good" idea. The resulting measure is the number of "good" ideas produced by the group.

3.2.3.3 User Acceptance of Technique

Davis (1985) developed the technology acceptance model (TAM) (see Figure 6), predicated on the notion that system usage is based on an individual's intention to use the system (BI), this is jointly determined by a person's attitude toward using the system (A) and the perceived usefulness (U) of the system. Perceived usefulness (U) is defined as: "The prospective user's subjective probability that using the particular system will increase his or her performance within an organizational context" (Bagozzi, et al., 1987; p. 6). Davis theorizes that perceived usefulness (U) has both a direct effect on intention to use (BI) and an indirect effect via attitude towards using (A).

Since this model was developed for user evaluation of computer-based systems it can be applied appropriately to the GDSS, a computer-based system, used in this study. Further, an argument can be made that the perceived usefulness measure is also appropriate for evaluating the idea generation techniques without GDSS support used in this study. This measure evaluates the set of beliefs and attitudes pertaining to the utility of a given (computer-based) system that leads to expectations about the potential

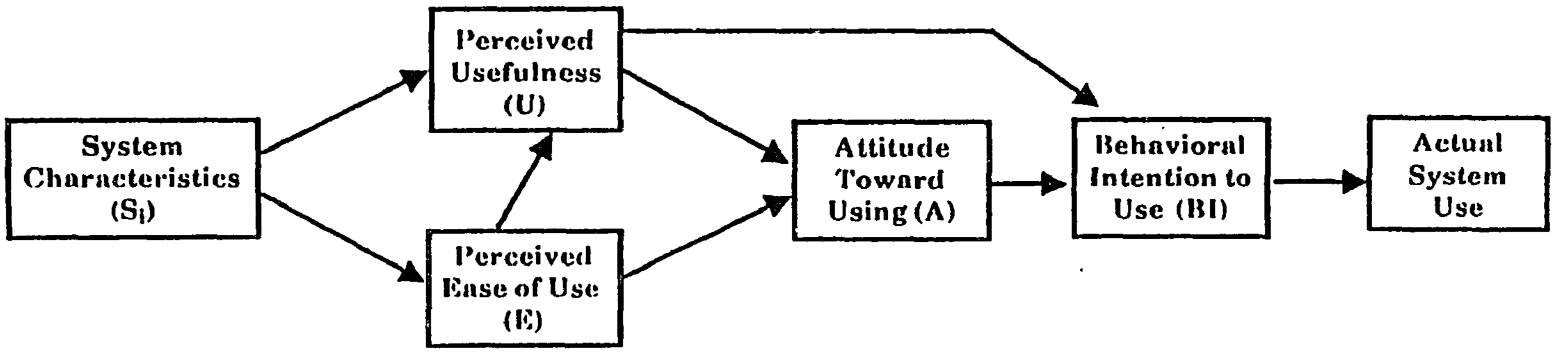


Figure 6 - Technology Acceptance Model

use and benefits of that given (computer-based) system. These same beliefs and attitudes pertaining to the potential usefulness of a given (computer-based) system also exist for techniques which do not have computer support, given that the goal of using any of these systems/techniques is to improve the performance of a person or group in a task-oriented situation in a group context. Perceived usefulness, therefore, is defined as the group member's assessment of how useful the technique would be to use in future work group situations. Davis' perceived usefulness measure captures these beliefs and attitudes in a general, technology independent manner, which allows the application of the perceived usefulness measure to both techniques with GDSS support and techniques without GDSS support. (See Appendix C.3 for copies of the instrument for each of the four idea generation techniques used in the study.)

3.2.3.4 Satisfaction with the Group Idea Generation Process

Participants were asked to rate their satisfaction with the group idea generation process for each of the two sessions, as well as being asked to indicate with which of the two sessions they were more satisfied (see Appendices C.4 and C.5 for the instruments used). An aggregated group satisfaction score was calculated by summing the individual satisfaction scores and dividing by the number of group members.

3.3 Hypotheses

The basic premise of this study was that idea generation techniques with GDSS support will overcome many of the dysfunctional characteristics inherent in group idea generation (as previously described in Chapter 2 and shown in Figure 4). This belief is based on the support capabilities provided by idea generation techniques with GDSS support (as defined in Chapter 2 and shown in Table 3 and Figure 4). Therefore, the following hypotheses, stated in alternative form, were tested based on the effects of the three independent variables: GDSS support (A), structure support (B), and group size (C). Diagrams are provided to help explain the hypothesized relationships between variables. For two of the dependent variables, quantity and quality of ideas, only one hypothesis is indicated; however, since each variable was measured along three dimensions, results for all three are reported. For idea quantity, the dimensions are: total quantity of ideas, number of different ideas, and number of unique ideas. For idea quality, the dimensions are: total quality of ideas, average quality of ideas, and number of good ideas.

3.3.1 Main Effects for GDSS Support (A)

The following hypotheses pertain to the main effect of the independent variable GDSS support (A):

HA1: Groups will generate more ideas when provided with GDSS support, as opposed to when they are not provided with GDSS support (see Figure 7a).

HA2: Groups will generate higher quality ideas when provided with GDSS support, as opposed to when they are not provided with GDSS support (see Figure 7b).

HA3: Groups will have a higher level of satisfaction with the idea generation process when provided with GDSS support, as opposed to when they are not provided GDSS support (see Figure 8a).

HA4: Groups will perceive the idea generation technique with GDSS support to be more useful than the idea generation technique without GDSS support (see Figure 8b).

Rationale for these hypotheses was based on the potential benefits provided by GDSS support, primarily: anonymity, simultaneous generation of ideas, and easy access to the ideas of others. Previous GDSS research has demonstrated that groups using GDSS support generated as many, or more, ideas than groups not using GDSS support (Steeb and Johnston, 1981; Lewis, 1982; Gallupe, 1985; Gallupe, et al., 1988; Chidambaram, 1989). Therefore, it is believed that groups with GDSS support will generate more ideas than groups without GDSS support.

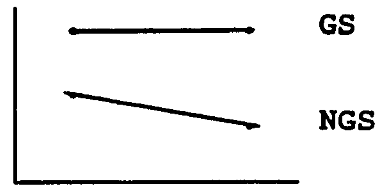
The same factors listed above should also enable groups with GDSS support to generate ideas of higher quality than groups without GDSS support. Previous GDSS literature has concentrated on final decisions and has not assessed the quality of individual ideas. However, GDSS-supported techniques generally have provided for improved quality of meeting outcomes (e.g., Steeb and Johnston, 1981; Lewis, 1982; Vogel, et al., 1987; Gallupe, et al., 1988; George, et al., 1987; Zigurs, 1987; Bui, et al., 1987).

a) Pertaining to the number of ideas generated:

HA1: GS > NGS

HAC1 A: GS (5=10);
B: NGS (5>10)

Number of Ideas (per group member)

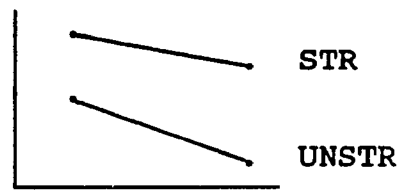


Group Size: 5 10

HB1: STR > UNSTR

HBC1 A: STR (5>10);
B: UNSTR (5>>10)

Number of Ideas (per group member)



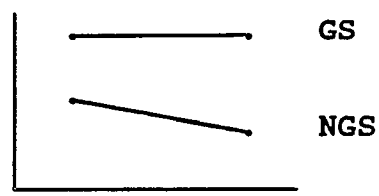
Group Size: 5 10

b) Pertaining to the quality of ideas generated:

HA2: GS > NGS

HAC2 A: GS (5=10);
B: NGS (5>10)

Number of Good Ideas (per group member)

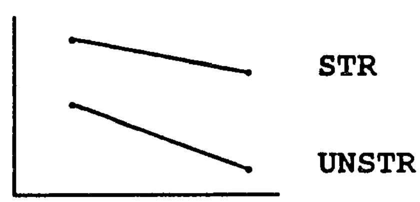


Group Size: 5 10

HB2: STR > UNSTR

HBC2 A: STR (5>10);
B: UNSTR (5>>10)

Number of Good Ideas (per group member)



Group Size: 5 10

KEY
GS - With GDSS Support
NGS - No GDSS Support
STR - Structured Techniques
UNSTR - Unstructured Techniques

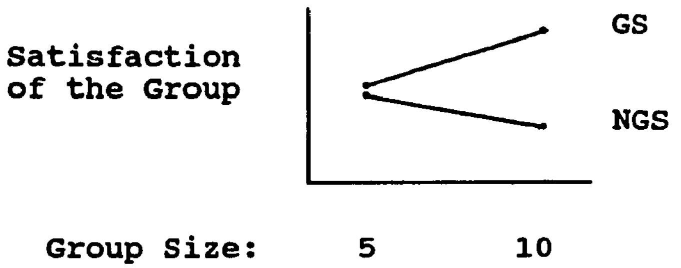
Figure 7

Hypotheses for Quantity and Quality of Ideas

a) Group member satisfaction with the idea generation process:

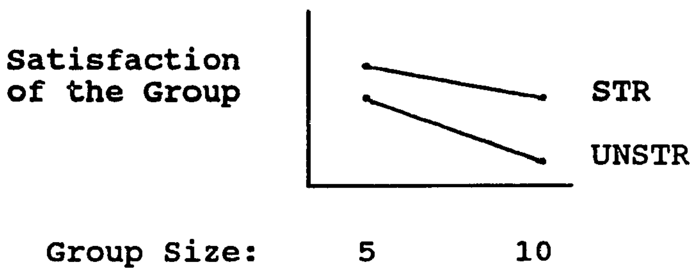
HA3: GS > NGS

HAC3 A: GS (5<10);
B: NGS (5>10)



HB3: STR > UNSTR

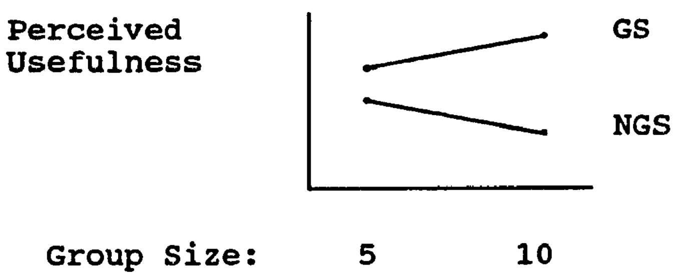
HBC3 A: STR (5>10);
B: UNSTR (5>>10)



b) Perceived usefulness of the idea generation technique:

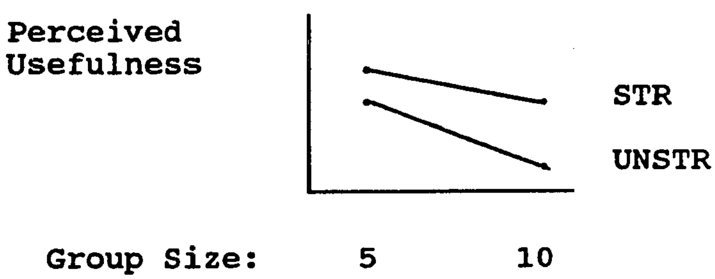
HA4: GS > NGS

HAC4 A: GS (5<10);
B: NGS (5>10)



HB3: STR > UNSTR

HBC3 A: STR (5>10);
B: UNSTR (5>>10)



KEY

GS - With GDSS Support
NGS - No GDSS Support
STR - Structured Techniques
UNSTR - Unstructured Techniques

Figure 8

Hypotheses for Satisfaction and Perceived Usefulness

Previous GDSS research has provided mixed results for group member satisfaction with GDSS-supported processes. While several studies have shown high satisfaction with GDSS use (Steeb and Johnston, 1981, Applegate, et al., 1986; Vogel, et al., 1987; Nunamaker, et al., 1987), others have shown GDSS to decrease satisfaction (Gallupe, et al., 1988; Watson, et al., 1987) and still others have found no significant difference in satisfaction between GDSS and no GDSS use (Lewis, 1982; George, et al., 1987). The difference in these results can be partially attributed to the factors that were previously cited as contributing to the inconsistencies in GDSS research. Given the type of task (creativity), and the need to generate as many novel ideas as possible, it is believed that the GDSS support will enhance the group's ability to generate ideas. Anonymity will enable group members to not feel inhibited to suggest ideas that they might otherwise be apprehensive to suggest in a group setting. Simultaneous idea generation will allow group members to suggest ideas without having to wait while other are suggesting ideas. All of these factors should increase group member satisfaction with the group idea generation process. Finally, many of the satisfaction assessments provided in previous GDSS research are for the use of several components of a GDSS. Group members may have been very satisfied with one component of the system (e.g., idea generation), but very dissatisfied with another (e.g., idea categorization, voting); the recency of the last component used, or possibly the dissatisfaction with another component, may have contributed to inconsistent findings. Given that this study evaluates only one component of a GDSS, this type of problem should not affect the findings.

3.3.2 Main Effects for Structure Support (B)

The following hypotheses pertain to the main effects of the independent variable structure support (B):

HB1: Groups with structure support will generate more ideas than groups without structure support (see Figure 7a).

HB2: Groups with structure support will generate higher quality ideas than groups without structure support (see Figure 7b).

HB3: Groups with structure support will have a higher level of satisfaction with the idea generation process than groups without structure support (see Figure 8a).

HB4: Idea generation techniques with structure support will be perceived to be more useful than idea generation techniques without structure support (see Figure 8b).

Several previous idea generation studies have compared the performance of groups using structure support (e.g., brainstorming instructions) with groups without any support (no instructions). It is often postulated that structure will improve performance in group processes, and the results of numerous studies indicate that the use of a structured technique, such as brainstorming, to support idea generation will result in the generation of significantly more ideas (e.g., Parnes and Meadow, 1959; Parloff and Hanlon, 1964; Brillhart and Jochem, 1964; Bouchard, 1969; Gryskiewicz, 1980). In the present study structure is operationalized by providing Osborn's (1957) four brainstorming instructions for half of the groups and no brainstorming instructions for the other groups. Therefore, it is believed that the groups provided structure, through the use of brainstorming instructions, will generate more ideas than the groups which are not provided with structure.

Previous idea generation research provides support for the superiority of the quality of ideas generated by groups utilizing structured techniques over those not utilizing any techniques (e.g., Meadow, et al., 1959; Parnes and Meadow, 1959; Turner and Rains, 1965; Bouchard, 1969; Gryskiewicz, 1980). Therefore, it is believed that the groups provided structure through the use of brainstorming instructions will generate more good ideas than the groups which are not provided with structure.

Most idea generation studies do not evaluate user satisfaction with the techniques. However, Gryskiewicz (1980) found user enjoyment to be higher for techniques with rules/instructions than for those without rules/ instructions. Reitz (1987) also found higher satisfaction levels for groups that used the NGT over interacting groups. Therefore, it is believed that the idea generation techniques that provide structure (brainstorming instructions) allow groups to achieve greater satisfaction with the idea generation process than groups without structure (no brainstorming instructions).

Based upon the potential benefits of adding structure (e.g., Osborn's brainstorming rules), it is believed that the group members will perceive the techniques with structure to be more useful for any future work group interactions in which they may be involved, as opposed to the techniques without structure.

3.3.3 Main Effects for Group Size (C)

Given the additive nature of idea generation, it might be reasonable to assume that groups of larger sizes would generate more ideas. In contrast, previous idea generation research has shown that as groups become larger the dysfunctional behaviors inherent in group interactions take effect. However, these overall group comparisons are not of particular interest in addressing the research questions put forth in this study, and therefore no specific hypotheses will be identified.

3.3.4 Interaction Effects for GDSS Support and Structure Support (AB)

Given the nature of the anticipated main effects for GDSS support and structure support, it is believed that the interaction of these two independent variables will not be significant. It is believed that GDSS support will provide a consistently higher level of performance than for groups without GDSS support; additionally, the structure support should lead to a consistently higher level of performance for groups without structure support.

3.3.5 Interaction Effects for GDSS Support and Group Size (AC)

The following hypotheses pertain to the interaction effects for GDSS support and group size.

HAC1: Quantity of Ideas (see Figure 7a):

A: Groups with GDSS support will generate an <u>equal</u> number of ideas, per group member, regardless of group size (whether in groups of five or ten persons).

B: Groups without GDSS support will generate <u>more</u> ideas, per group member, in smaller groups (groups of five persons) as opposed to larger groups (groups of ten persons).

HAC2: Quality of ideas (see Figure 7b):

A: Groups with GDSS support will generate ideas of <u>equal</u> quality, per group member, regardless of group size (groups of five or ten persons).

B: Groups without GDSS support will generate ideas of <u>higher</u> quality, per group member, in smaller groups (groups of five) as opposed to larger groups (groups of ten).

HAC3: Satisfaction with the idea generation process (see Figure 8a)

A: Groups using GDSS support will have a <u>higher</u> level of satisfaction with the idea generation process, per group member, in larger groups (groups of ten) than in smaller groups (groups of five).

B: Groups not using GDSS support will have a <u>higher</u> level of satisfaction with the idea generation process, per group member, in smaller groups (groups of five) than in larger groups (groups of ten).

HAC4: Perceived Usefulness of the idea generation technique (see Figure 8b):

A: Groups with GDSS support will perceive the idea generation technique to be <u>more</u> useful, per group member, in larger group (groups of ten) than in smaller groups (groups of five).

B: Groups without GDSS support will perceive the idea generation technique to be <u>more</u> useful, per group member, in smaller groups (groups of five) than in larger groups (groups of ten).

As group size increases, the potential for the dysfunctional behaviors inherent in group interactions also increases. The capabilities provided by GDSS support (e.g., anonymity, simultaneous generation of ideas, and easy access to the ideas of others) should allow groups with GDSS support to maintain the same level of individual idea generation (average number of ideas per group member) as group size increases from five to ten. It is believed therefore that the benefits provided by GDSS support are maintained as group size increases from five to ten. Research with brainstorming groups found that the average number of ideas generated per group member decreased as group size increased (Bouchard and Hare, 1970; Bouchard, et al., 1974). Therefore, it is believed that as group size increases from five to ten, the average number of ideas generated by each person within the group without GDSS support members will decrease. The same relationship for the quality of ideas should also exist: groups with GDSS support should be able to maintain the same level of quality, while groups without GDSS support will not.

Based on the results of previous GDSS research (see Chapter 2), the satisfaction level of groups with GDSS support and groups without GDSS support is anticipated to be very close for smaller groups (groups size of five).

However, with the larger groups (group size of ten), the GDSS support should overcome the dysfunctional behaviors that often occurs in groups of larger sizes, providing those group members who receive GDSS support with a higher level of satisfaction with the idea generation process. Conversely, the groups without GDSS support should run into the type of problems (e.g., dominance by one or two group members, ability of only one person to generate ideas at a time) which can greatly impact the satisfaction of the group members with the idea generation process. Therefore, it is believed that as group size increases from five to ten, the satisfaction with the idea generation process of the members of the groups without GDSS support will decrease.

Based on the potential benefits provided by GDSS support (e.g., anonymity, simultaneous generation of ideas, and easy access to the ideas of others), it is believed that the group members will perceive the usefulness of the techniques with GDSS support even higher, as the group size increases from five to ten. At the same time, the group members will perceive idea generation technique without GDSS support to be less useful, given its inability to deal with the problems caused by the increased group size.

3.3.6 Interaction Effects for Structure Support and Group Size (BC)

The following hypotheses pertain to the interaction effects for structure support and group size.

HBC1: Quality of ideas (see Figure 7a):

A: Groups with structure provided will generate <u>fewer</u> ideas per group member, in larger groups (groups of ten), than in smaller groups (groups of five).

B: Groups without structure provided will generate <u>significantly</u> <u>fewer</u> ideas, per group member, in larger groups (group of ten) than in smaller groups (groups of five).

HBC2: Quantity of ideas (see Figure 7b):

A: Group with structure provided will generate ideas of <u>lower</u> quality, per group member, in larger groups (groups of ten) than in smaller groups (groups of five).

B: Groups without structure provided will generate ideas of <u>significantly</u> <u>lower</u> quality, per group member, in larger groups (of ten) than in smaller groups (groups of five).

HBC3: Satisfaction with the idea generation process (see Figure 8a):

A: Groups with structure provided will have a <u>higher</u> level of satisfaction with the idea generation process, per group member, for smaller groups (groups of five) than for larger groups (groups of ten).

B: Groups without structure provided will have a <u>significantly</u> <u>lower</u> level of satisfaction with the idea generation process, per group member, for larger groups (groups of ten) than for smaller groups (groups of five).

HBC4: Perceived Usefulness for the idea generation technique (see Figure 8b):

A: Groups with structure provided will have a <u>higher</u> perceived usefulness, per group member, for smaller groups (groups of five) than for larger groups (groups of ten).

B: Groups without structure provided will have a <u>significantly</u> <u>lower</u> level of perceived usefulness, per group member, for smaller groups (groups of five) than for larger groups (groups of ten).

Previous idea generation research has shown that even with the use of idea generation techniques with structure the performance of groups, in terms of quantity and quality of ideas per group member, decreased as group size increased (Bouchard and Hare, 1970; Bouchard, et al., 1974). While groups with structure will have decreased performance as group size increases, groups with no such support will have significantly larger decreases in performance as group size increases (for both quantity and quality of ideas). A similar pattern exists for group members' satisfaction and perceived usefulness of the idea generation technique. Even with the structure provided to help support the idea generation process, the inability to overcome many of the dysfunctional characteristics of groups will lead group members to assess participation in the idea generation process as less satisfying as group size increases. Likewise, the techniques with structure are perceived to be less useful as the group size increases. While this may be true for structured techniques, it is even more true for unstructured techniques that provide no structure for the idea generation process.

3.3.7 Three-Way Interaction (ABC)

A three-way interaction is not likely to occur in this situation, but it was tested as a part of the statistical analysis undertaken for this study.

3.4 Summary

The purpose of this chapter was to introduce the conceptual framework used in this study, define the variables being studied, and to present the hypotheses being tested in this study. McGrath's (1984) Conceptual Framework for Groups provided the foundation for this study. This foundation, transformed into an input - process - output model, provided a framework to identify the variables of interest in this study. Three independent variables are manipulated: GDSS support, structure support, and group size. All groups had GDSS support for one of two tasks for which they generated ideas. Half of the groups had structure, operationalized by Osborn's (1957) brainstorming instructions. Groups of two different sizes, five- and ten-persons, were used.

Four variables of interest were measured in this study, including two task outcomes -- the number of ideas generated and the quality of the ideas -- and two group outcomes -- the group's satisfaction with the idea generation process and the perceived usefulness of the idea generation technique. Other variables that impact group performance, such as task type and difficulty, the amount of time allocated for the task, individual differences, other group factors (besides size), physical environment and facilitation, were all held constant in order to provide for more accurate manipulation and measurement of the variables under investigation.

Finally, the hypotheses to be tested in this study were presented. Main effects and interaction effects for the independent variables are presented, along with rationale for the anticipated results.

CHAPTER 4

EXPERIMENTAL DESIGN AND PROCEDURES

4.0 Introduction

This chapter describes the research methodology used in the study. The experimental design and experimental procedures used in the study are described. The experimental setting, subjects, tasks, procedures, and a summary of the pilot study are also presented.

4.1 Research Methodology

The use of controlled laboratory experiments for GDSS research is becoming quite common; nevertheless, there are still many unanswered questions and more research is needed to address these issues (DeSanctis, 1988). GDSS field study research has provided strong indications that group size plays an important role in determining the impact of the technology. Yet, the lack of controlled comparisons with groups of different sizes using different idea generation techniques emphasizes the need for further laboratory experimentation in this area. Given these factors and the availability of both a large population of student subjects and a research facility, the best way to address the research questions put forth in this study was through a controlled laboratory experiment utilizing undergraduate students as subjects.

4.1.1 Experimental Design

The experimental design used in this study was a 2 X 2 X 2 completely randomized factorial with repeated measures. There were three independent variables with two levels each. Group size was either five or ten persons; groups either had structure, provided by Osborn's (1957) brainstorming instructions, or no instructions; and all groups had GDSS support for one task and no GDSS support for the other task. The experimental design is labeled a "multigroup posttest-only design" by Huck, et al. (1974), or an extension of what Campbell and Stanley (1969) refer to as the "posttest-only control group design". The design is shown below in Figure 9 ("R" refers to random assignment of subjects to groups, "X1, X2, X3 and X4" are the treatments and "01 and 02" indicates the collection of survey data. The treatments (X's) are shown in Figure 10 in a different representation).

R	X1	01	X3	02
R	X2	01	X4	02
R	X3	01	X1	02
R	X4	01	X2	02

Figure 9 - Multigroup Posttest-Only Design (with Repeated Measures)

A completely counterbalanced design was used in which each group performed two tasks. Half of the groups generated ideas for the one task first, then the second task; the other groups reversed that order. Groups not utilizing GDSS support for the first task used GDSS support for the second task, and vice-versa. Subjects were randomly assigned to groups and groups to treatments (see Figure 11 for a diagram of the specific treatments and measurements taken).

	IDEA GENERATION TECHNIQUE			
	BRAINSTORMING		NO INSTRUCTIONS	
GROUP SIZE	FIVE	TEN	FIVE	TEN
With GDSS SUPPORT	Electronic Brainstorming (X2)		Electronic No Instructions (X4)	
Without GDSS SUPPORT	Brainstorming (X1)		No Instructions (X3)	

Figure 10 - Experimental Design

4.2 Experimental Setting

All sessions were conducted at the Collaborative Work Support (CWS) Lab which is located at the Institute for the Study of Developmental Disabilities (ISDD) on the Indiana University campus (see Appendix E for the CWS Lab configuration for each of the four treatments). The facility utilizes the University of Arizona PLEXSYS system, a state-of-the-art GDSS which provides automated support to groups for many of the activities in which they participate (e.g., idea generation, voting, policy formulation). The component of PLEXSYS used in this study was topic commenter, which is an automated version of the brainstorming procedure. Topic commenter allowed each group member to

		FIRST TASK				SECOND TASK				
R	01	EBS - T1	02	03		BS - T2	02	03	04	05
R	01	EBS - T2	02	03	B	BS - T1	02	03	04	05
R	01	BS - T1	02	03	R	EBS - T2	02	03	04	05
R	01	BS - T2	02	03	E	EBS - T1	02	03	04	05
R	01	ENI - T1	02	03	A	NI - T2	02	03	04	05
R	01	ENI - T2	02	03	K	NI - T1	02	03	04	05
R	01	NI - T1	02	03		ENI - T2	02	03	04	05
R	01	NI - T2	02	03		ENI - T1	02	03	04	05

R - Random Assignment of Subjects to Groups

EBS - ELECTRONIC BRAINSTORMING
BS - BRAINSTORMING
ENI - ELECTRONIC NO INSTRUCTIONS
NI - NO INSTRUCTIONS

01 - PRE-SESSION SURVEY
02 - PERCEIVED USEFULNESS (for each specific technique)
03 - POST SESSION SURVEY (for each session)
04 - TASK BACKGROUND QUESTIONNAIRE
05 - FINAL SURVEY

T1 - TASK NUMBER ONE
T2 - TASK NUMBER TWO

Figure 11

Detailed Experimental Design/Procedures

individually input ideas, which were subsequently displayed on a main viewing screen, as well as providing each group member individual access to all ideas generated by the group at any time at their own personal computer screen.

4.3 Experimental Methods

This section will discuss the experimental procedures that were used in this study, including subjects, tasks, experimental procedures, and data preparation for analysis.

4.3.1 Subjects

Gallupe (1986), based on previous GDSS research, recommends using students for subjects in GDSS research since they have been shown to be adequate surrogates for actual managers. DeSanctis (1988) presents a discussion of the pros and cons of using student subjects for GDSS experiments. Although students are often considered a poor choice as subjects, DeSanctis believes that there are actually a number of advantages to using student subjects since they: "have the advantages of a common organizational experience, experience in working in teams, and open attitudes toward experimenting with information technology" (p. 40).

There has been a long history of using student subjects in idea generation studies (Jablin, et al., 1977). Very few studies have used non-student samples (e.g., Dunnette, et al., 1963; Campbell, 1968; and Gryskiewicz, 1980, who used advertising personnel, research scientists, and business managers, instead of students). The results of the aforementioned studies were consistent with the studies using students: Nominal (brainstorming) groups consistently outperformed real (brainstorming) groups in terms of both the quantity and quality of ideas generated. Additionally, while there are justifiable calls for the use of ongoing, real groups in GDSS research, as opposed to ad hoc groups (e.g., Dennis, et al., 1988a), Jablin, et al. (1977) interpret the research on ad hoc versus established groups to indicate that for low conflict conditions, such as under brainstorming conditions, the two groups should perform about the same for the generation of ideas. To substantiate this interpretation, they performed an experiment which confirmed their proposition of little difference between ad hoc and established groups for idea generation.

Given the consistency of results of idea generation research involving student and professional subjects, and the lack of differences in previous research between ad hoc and established groups, ad hoc groups of undergraduate students participated in this study. Additionally, there were large numbers of students available, which is a necessity given the large numbers of subjects needed for group experiments in order to attain sufficient statistical power. Power calculations yield a total of 32 groups required to achieve a power level of 0.80 (based on an alpha level of 0.05 and a medium effect size) (Cohen, 1977). In an analysis of statistical power in Management Information

Systems (MIS) research, Boroudi and Orlikowski (1989) echo Cohen's recommendation for a power level of .80 for MIS research. Thirty-two groups will yield four groups per cell and thus required a total of 240 subjects (16 X 10 = 160; + 16 X 5 = 80).

Students from a sophomore-level course entitled The Computer in Business (K201) were solicited by visiting 11 different K201 classes and asking them to sign up and participate in the study. Students were asked to complete a sign-up sheet in which they indicated the times they would be able to participate. From the sign-up sheets, random assignment of subjects to groups were made.

Isaac, et al. (1988), drawing on a background of experimental economics in an effort to further GDSS research, indicate that if an experiment is to be successful, subjects must have incentives to both: 1) show up to participate in an experiment and 2) make responsible actions while participating in the experiment. Motivation for students to sign up to participate in the experiment included: class credit (15 points for a required class exercise -- not extra credit), opportunity to learn more about group interaction, and training and use of "cutting edge" computer technology. Dennis, et al. (1988a), in a discussion of important factors for GDSS researchers, reinforce the assertions of Isaac, et al. (1988) of the importance of providing subjects with performance incentives. Winniford (1988), in a discussion of incentives for group work experiments, stresses the need not only for an incentive mechanism, but also for having a quantifiable outcome which can be measured, so that the subjects' performance in the experimental session can be measured and appropriately rewarded. Students' motivation for performance in the experiment was a cash prize given to the best performing group (quantity and quality of ideas generated): The "best" group received $100.00. This prize was evenly split among the members of the "best" group, which Winniford indicates provides for a "cooperative" group atmosphere and should also have provided the desired incentive for performance.

4.3.2 Tasks

The repeated measures experimental design used for this study required each group to perform two comparable tasks: one with GDSS support and one without GDSS support. The two tasks used in the study were the Parking Problem and the Library Problem (see Appendix B.1 for the task descriptions). Both are what McGrath (1984) would classify as creativity tasks, which require the production of as many novel ideas as possible. Based on the categorization scheme developed by Lamm and Trommsdorff (1973) for creativity tasks used in idea generation studies, the tasks used in this study come under the classification of "means" tasks. Means tasks require group members to think of different ways to solve a problem which does not have just one predetermined solution. (The reason for the two different classifications is to define linkages to previous research.) According to Gallupe (1986), experimental tasks for GDSS research need to meet the following criteria (p. 516):

1) Face Validity: The task must look realistic and be interesting.

2) Content Validity: The task description must be accurate and consistent without errors in logic.

3) External Validity: The task must be applicable to actual organization decision situations.

4) The task must be appropriate for support by a computer-based GDSS.

The two main tasks used in this study met the above criteria.

The appropriateness of the tasks in this study is based on the following reasons:

1) Both tasks are of the same task type (creativity/means), unlike many of the previous idea generation experiments that mixed task types (which often required the use of different criteria to evaluate idea quality).

2) Both tasks have been used previously in idea generation studies (the Parking Problem by Jessup, et al., 1988; Connolly, et al., 1988; and the Library Problem by Brillhart and Jochem, 1964) and are based on real, existing problems often faced by a large number of students, as well as other people. Both tasks are more realistic in nature and therefore provide a higher degree of external validity than many of the tasks used in previous idea generation studies (e.g., the "thumbs" problem, "blindness" problem, or generating alternative uses for: bricks, hangers, corks, paper clips, toothbrushes, etc.; Zagona, et al., 1966; Lamm and Trommsdorff, 1973).

3) Both tasks address concerns which are pertinent to student populations (the subjects used in this study): They are often faced with difficulties in finding parking places and in attempting to locate materials in the university libraries only to find that the item(s) they need have been damaged or stolen. They are aware

of these problems and have a potential stake in their solution. Based on these factors, these tasks have a high degree of face validity.

4) Task consistency was supported by pilot testing (see Section 4.3.6 and Appendix F for further details) for task comparability, clarity, and understanding of the problem statements by the students, thus providing a strong case for the content validity of the tasks.

5) Idea generation for creativity/means tasks requires the production of as many ideas as possible by a group. The structured techniques used in this study (electronic brainstorming and brainstorming) are appropriate for this type of task.

4.3.3 Experimental Procedures

The experimenter script, checklist, and technical instructions for running the experimental sessions are given in Appendices A.1, A.2, and A.3, respectively. The step-by-step instructions for the experimental session are described in this section.

4.3.3.1 Pre-Experimental Activities:

1) Met student subjects at Business Building and transported to CWS Lab.
2) Provided subjects a brief overview of the experiment and had them sign a Consent Form and gave them their copy of the Consent Form to keep (see Appendix C.1).
3) Had students complete Pre-Session Survey (see Appendix C.2).

4.3.3.2 First Experimental Task:

1) Provided instructions for subjects in appropriate idea generation technique (as outlined in Figure 12; see Appendix B.2 for instructions that were distributed to subjects).

Electronic Brainstorming:

Brainstorming rules - Osborn's four rules
PLEXSYS topic commenter procedures

Facilitator/Experimenter role: Set up system, distributed problem and instructions, went over problem and instructions with subjects, ran system, monitored the idea generation process to ensure that no evaluation took place, and handled any questions or problems that occurred.

Brainstorming:

Brainstorming rules - Osborn's four rules
(Manual) Brainstorming procedures

Facilitator/Experimenter role: Distributed problem and instructions, went over problem and instructions with subjects, wrote down subject ideas on flipchart as suggested by subjects, monitored the idea generation process to ensure that no evaluation was taking place, and handled any questions/problems that occurred.

No Brainstorming Instructions:

No Brainstorming rules (Osborn's) were provided

Facilitator/Experimenter role: Distributed problem and directions, went over problem and directions with subjects, wrote down subject ideas on flipchart as suggested by subjects, and handled any questions or problems that occurred.

Electronic No Brainstorming Instructions:

Same as Electronic Brainstorming, but without Osborn's four rules and monitoring for evaluation.

Figure 12 - Procedures for Each Idea Generation Technique

(The instructions were provided both orally and as handouts to provide consistency and ensure that subjects had them for reference during the experiment. Subjects were encouraged to ask questions or for clarifications at any time during the sessions.)

2) Tested subject typing ability using a PC program that captured typing speed (words/minute), number of errors, and accuracy rate. This was done to help ensure that typing ability was not a confounding factor (this was done just prior to subjects' use of the technique with GDSS support).

3) Distributed practice problem to subjects. This was to provide the subjects an opportunity to practice the procedures (and get into a "creative frame"). They generated ideas on this problem for five minutes. This allowed the subjects an opportunity to use the technique and technology provided, making sure they understood the technique and instructions, as well as getting "warmed up" for the main task. They received a written copy of the problem and technique instructions, the instructions were read aloud, and any questions pertaining to the task or technique were answered. The tasks used for this were the Tea Bag Problem and the Vinyl Disk Problem (described in Appendix B.1). Each subject was given a Tea Bag/Vinyl Disk to assist them in their idea generation process.

4) Distributed main task description to subjects (either the Parking or the Library Problem); they received a written copy of the problem, the instructions were read aloud, and then any questions pertaining to the task or technique were answered. The subjects were given 20 minutes for idea generation.

5) Distributed the following two instruments to subjects: a technique evaluation instrument (Davis') with questions pertaining to overall evaluation of the technique, ease of use, and perceived usefulness (see Appendix C.3); and a post-session survey (see Appendix C.4).

6) Gave the subjects a five minute break. They were allowed to talk about anything but the session in which they were participating (they were also served milk and cookies!).

4.3.3.3 Second Experimental Task:

1) Moved subjects to the seating arrangement required for the second session (diagrams with alternative seating arrangements for each of the techniques and group sizes are shown in Appendix E).

2) Distributed instructions to the subjects for the appropriate idea generation technique. These instructions were read aloud and any questions were answered (see above).

3) Distributed the second warm-up task to subjects. They were given five minutes to generate ideas. Just as with the first session, this allowed them an opportunity to use the technique provided, to make sure that they understood the technique and instructions. The subjects again had an opportunity to ask about the task or technique. This task was the

other warm-up task (either the Tea Bag Problem or the Vinyl Disk problem -- whichever one was not used for the first task).

4) Distributed the second main task to the subjects (either the Parking or Library Problem -- whichever one was not used for the first task). They received a written copy of the problem, it was read aloud, and any questions pertaining to the task or technique were answered. The subjects were allowed 20 minutes (same as the first main task) for idea generation.

5) Distributed the same two surveys (same as used after the first task -- technique evaluation survey and post-session survey) for this specific technique and session.

6) Distributed the task background survey to gather information about the subjects' backgrounds pertaining to the two main tasks (the Library and Parking Problems) (see Appendix C.5).

7) Distributed the final survey, which asked the subjects to compare the two sessions (see Appendix C.6).

8) Interviewed and briefed the entire group about the purpose of the experiment and their involvement. The questions asked are included in Appendix A.4.

9) Thanked the subjects for their participation, asked them not to discuss the tasks or procedures used in the study with other students, and returned them to the Business School.

4.3.4 Data Preparation for Analysis

To facilitate the analysis of data from this study, all idea generation session outputs were written directly to computer diskettes (from sessions with GDSS support) or transcribed from paper and audio tape outputs to computer diskette (from sessions without GDSS support). Responses to the survey questions were recorded directly on computer media, thus the error rate for transcribing survey responses was zero for this study.

In order to perform statistical analysis on the data collected, trained raters were used to score the ideas generated by groups. Such scoring has been performed using trained raters since the early idea generation studies. Bouchard and Hare (1970) outlined procedures they used to ensure that the scoring process was uniform for all groups. The basic rule involves counting only statements that point to specific, concrete solutions to the given problem. Bouchard and Hare (1970; p. 52-53) provide guidelines pertaining to the following situations:

> Generalities: Statements which were too general were not counted because it was too difficult to determine the intent;
>
> Misunderstandings: When subjects misunderstood the problem, many ideas he[/she] gave would not follow directly from the problem (and therefore would not be counted);
>
> Lists: A general rule including a list of examples was given credit as only one idea. If, within the list, examples were explained rather than just mentioned, each explained example was counted as an idea. In a list of explained examples, the general rule was

counted with the first example as one idea. Each successive explained example was given one credit.

Based on the successful use of these procedures, and the resulting high interrater reliabilities, many idea generation researchers have decided to use just one rater (e.g., Bouchard and Hare, 1970; Bouchard, 1972b; Graham and Dillon, 1974).

Rating or coding of ideas in the recent GDSS literature has built on this foundation and adopted coding schemes which allow for complete categorization of proposed solutions into established categories (Connolly, et al., 1988; Valacich, et al., 1989; utilizing the work of Gettys, et al., 1987). These two studies used two trained raters with resulting interrater reliability ratings of 93% and 97%, respectively.

Two trained raters (doctoral students) were used in this study to perform the initial data preparation on all ideas the groups generated. They utilized procedures such as those previously used in other idea generation and GDSS studies (e.g., Bouchard and Hare, 1970; Gryskiewicz, 1980; Connolly, et al., 1988; Valacich, et al., 1989). The two raters independently evaluated transcripts of all ideas generated by the groups to make a determination of the type of each statement, based on a coding scheme (see Appendix D.1 for instructions and the coding scheme used by the raters). Interrater reliability was tested for the two raters. Based upon the results of the raters' evaluation, the following were determined for each group:

1) the number of ideas generated

2) the number of different ideas generated

3) the number of unique ideas generated.

A randomly ordered list of all different ideas for each task, as a result of the evaluation by the two raters, was distributed to the expert judges to use in providing their assessment of the quality of the ideas (three different judges were used for each task; instructions provided to the judges are in Appendix D.2).

4.3.5 Data Analysis

Given the likelihood of correlations between dependent variables, the use of univariate statistical procedures, such as ANOVA (analysis of variance) for comparisons was considered to be inappropriate. A set of univariate tests with one test per dependent variable would cause the probability of a Type I error to be greater than the significance level used. This creates a situation in which the set of univariate tests becomes "positively biased" so that the null hypothesis would be rejected too often. Another shortcoming of using multiple univariate tests is that as the number of dependent variables increases, the likelihood of encountering a significant difference just by chance also increases. Based upon the concerns expressed above, a multivariate technique, MANOVA (multivariate analysis of variance), was used instead of a univariate technique. However, univariate techniques will be used to follow-up when significant MANOVA effects occur.

4.4 Pilot Study

Pilot testing for this study encompassed 59 sessions with 38 groups over a three month period. As a result of pilot testing, and problems encountered with components of the GDSS, a number of changes were made to the design of the study, the tasks used, the number and length of sessions, the experimental procedures, and the GDSS support used in the study. Each of these areas will be addressed; for additional information about the results of the pilot study, see Appendix F.

4.4.1 Experimental Design

The initial experimental design for this pilot study provided for a partial replication of Gryskiewicz's (1980) idea generation technique research, as well as extending it to techniques with GDSS support. The design was a 2 X 3 full factorial with repeated measures. The independent variables were GDSS (GDSS and No GDSS) and structure support (brainstorming, brainwriting, and no instructions). Each five-person group was to participate in two separate idea generation sessions, one using GDSS support and one without GDSS support, two days apart.

After conducting several sessions there was little difference in the number of ideas generated in the sessions with GDSS support as opposed to the sessions without GDSS support. It was believed that this result was due to the small group size and the fact this group size (five) is often cited as optimal for interacting groups. Therefore, the benefits of GDSS support were probably not coming totally into effect at this level. It was decided to try some groups of larger sizes (seven and nine) to see if this belief could be upheld.

At approximately the same time that the issue of group size arose, several problems with the GDSS forced the discontinued use of one of its components, topic commenter (the GDSS-supported version of brainstorming). While topic commenter use was halted, running sessions with groups of two different sizes generated results that provided an indication that the benefits of the GDSS were coming into effect. Given these findings, group size was added as an independent variable, with two levels: groups of five and ten persons.

In conjunction with adding group size, it was decided that using three levels of structure would require too many subjects to conduct the study; therefore, one of the levels of structure, brainwriting, was dropped. This decision to keep brainstorming and no instructions was based on two factors: 1) the need to keep the "no instructions" treatment to provide a baseline measure for comparisons with groups with manual technique support and groups with GDSS support, and 2) the far more prevalent use of brainstorming, as opposed to brainwriting, by organizational groups, which was believed to provide stronger external validity for the study. While this loss of topic commenter, coupled with dropping brainwriting, left an invalid comparison of techniques for the pilot study (brainstorming and what was, in effect, electronic brainwriting), it did provide enough feedback to support the decision to bring group size into the design as an independent variable.

Given the continuing problems with topic commenter, and the desire to use a tool that provided subjects access to all ideas on the same screen that they used to enter ideas, a newly available tool in PLEXSYS, electronic discussion system, appeared to be the best option. Electronic brainstorming restricted the number of lines of text a subject could enter at one time (five line limit). While it allowed subjects to view ideas on the same screen, it was restricted in that it only provided access to a subset of the previously generated ideas. Topic commenter, on the other hand, provided access to all the previously generated ideas, but this access was on a separate screen and required the subjects to use function keys to access this separate screen. Electronic discussion system provided the best of both worlds: It allowed for the entering of ideas and viewing of all previously generated ideas on the same screen. Unfortunately, this tool was totally unreliable and never got past early testing. As a result of these problems, topic commenter was ultimately selected as the GDSS component to be used in the study, given its comparability to the brainstorming technique, and eventual improvement in reliability.

Therefore, based on the pilot testing, the research design as it was applied (a 2 X 2 X 2 full factorial with repeated measures -- with GDSS support, structure, and group size as independent variables) provides a strong foundation for comparisons of the variables with the most potential for impact on group idea generation.

4.4.2 Tasks

Since the original design was to build on and extend the work of Gryskiewicz (1980), it was decided to use the same task he had used in his study (the Tea Bag Problem). Since the pilot study utilized a repeated measures design, two comparable tasks were needed. After substantial searching, an adequate second task could not be found. Therefore, the Vinyl Disk task was created. Pilot testing revealed a strong degree of comparability for these two tasks, based on the number of ideas generated and the subjects' assessment of task difficulty.

Since many idea generation studies have used additional tasks to provide the subjects an opportunity to "warm-up" (both for the technique being used and to get subjects into a "creative" frame of mind), two more tasks were needed. The same search that failed to result in another task comparable to the Tea Bag Problem had provided some other good tasks. Two of these problems were the Parking Problem and the Library Problem. These problems were selected due to their strong face validity, given the interest in and understanding the (student) subjects had of these problems.

At this point the Tea Bag and Vinyl Disk Problems were used as the main tasks and the Parking and Library Problems were used as the warm-up tasks. After several sessions, observations and comments from students indicated a much greater interest in the two warm-up problems. This interest, based on their obvious involvement with these two issues, led to greater motivation and participation. Therefore, it was decided to switch the tasks around: The Tea Bag and Vinyl Disk Problems became the warm-up tasks, and the Parking and Library Problem the main tasks. This move provided two main tasks which meet the criteria outlined earlier, from Gallupe (1986), for tasks to be used in GDSS experiments. The two comparable tasks now used for the warm-up tasks also fulfill their role very well by providing subjects an opportunity to become familiar with the technique they are using, by giving them a chance to get into a "creative" frame, and by allowing them to generate ideas for tasks in which they have no involvement or personal stake.

4.4.3 Number and Length of Idea Generation Sessions

The original experimental procedures had subjects generating ideas for two main tasks, for 30 minutes per task (the same as Gryskiewicz, 1980), during two idea generation sessions (two days apart). The intent of the two sessions being two days apart was to try to reduce any learning effects for the second session that may have resulted from participation in the first session. From a theoretical viewpoint this approach was quite reasonable; however, from a pragmatic perspective there were a number of problems. One problem was caused by subject mortality: There were several occurrences when a subject showed up for the first session, but not for the second. This resulted in groups that could not be run, due to the missing group member, and incomplete data that could not be used. Scheduling groups presented additional problems. While the concern with learning effects was one of the reasons for using two sessions on two different days, a potential problem caused by this arrangement could be the recency that would result for subjects when responding to the Final Questionnaire, which asked subjects to compare the two sessions/techniques. The reason this becomes a problem is that it is to be administered after the second session, which could potentially bias subjects' responses to that session. Finally, given the need for two sessions, two days apart, coupled with the schedules of both the subject population (undergraduate students) and the research facility (the CWS Lab), groups could only be scheduled on a Monday-Wednesday or Tuesday-Thursday evening basis. This drastically limited the number of groups that could be run in a week, and would, therefore, require a substantial amount of time to run the necessary number of groups for the main study (between two and three months).

It was decided to run some groups that would do both the session with GDSS support and the session without GDSS support on the same day. In order to accomplish this cutback from two days to one day, the amount of time spent on the two main tasks was reduced from 30 minutes to 20 minutes each. This decision was made based upon the prevalent use of this time period in previous idea generation studies, and from observation and feedback from subjects that 30 minutes was a long time for the sessions. The concerns of having both sessions on the same day were lessened by the fact that many previous idea generation experiments have had subjects participate in up to four sessions back-to-back. A break was added between the two sessions to provide the students an opportunity to relax for a few minutes, get up and move around, and even have some milk and cookies!

Eight groups were run under this new configuration. Feedback from these groups indicated that doing both sessions on the same day was not a problem and, in fact, several of the subjects stated a preference for this approach. Based on the positive feedback from these sessions and the other constraints, two 20 minute idea generation sessions on the same day were selected as the optimal approach to be used for this study.

4.4.4 Instructions, Procedures, Task Descriptions, and Instruments

The pilot study provided the opportunity to refine experimental procedures, technique instructions, task descriptions, and data collection instruments. Based upon feedback from subjects, the technique instructions and task descriptions were clear and understandable, as were the questions on the data collection instruments. Experimental procedures were developed, expanded, and refined through the pilot testing process. As a result of the pilot study, it is believed that all instructions and task descriptions provided to the subjects were clear, complete, and understandable. Also, the experimental procedures used in the study were completely tested and refined.

4.4.5 Conclusions from Pilot Study

The final study had a number of changes made from its original conception. These changes, which have evolved as a result of the pilot testing, have made the study much stronger and provide for a greater opportunity for significant results and contribution to the knowledge in the field.

4.5 Summary

This chapter describes the experimental design and procedures used in the study. The experimental design used in this study was 2 X 2 X 2 completely randomized factorial with repeated measures. A completely counterbalanced design was used to provide sufficient control to reduce the potential impact of task effects, order effects, and learning effects.

It has been argued that students provide adequate surrogates for managers for GDSS research, and given the required sample size for this study, they provided an ample population from which to solicit volunteer subjects. Two hundred forty undergraduate students participated in the study, with their motivation provided by the opportunity to earn extra credit class points for their participation, and a cash prize for their performance.

Two comparable main tasks were used in this study. These tasks were found to meet the criteria recommended for experimental tasks to be used in GDSS research. Two additional tasks were used as warm-up tasks to provide subjects an opportunity to become familiar with the idea generation technique and to let the subjects get into a "creative frame" for the main task.

Detailed experimental procedures were developed and refined for all experimental activities. These procedures include: experimenter script and checklists, task descriptions, subject instructions, and data collection surveys. Methods for data collection and preparation for analysis were also developed and refined. Two trained raters were used to help determine idea counts (quantity) for each group, while six expert judges helped to provide an assessment of the quality of each idea for the groups.

A pilot study was conducted to help refine the experimental design, tasks, procedures, and data preparation and analysis procedures used in this study.

CHAPTER 5

RESULTS

5.0 Introduction

Chapters 1 through 4 have provided the necessary background information for this study. They have built the foundations, defined the variables, outlined the procedures, and stated the hypotheses to be investigated in this study. This chapter presents the results of the analysis of the data collected in this study, including the statistical testing of the hypotheses central to this study.

Background information pertaining to the subjects who participated in this study is presented, including demographic data, background in the problem areas, and the subjects' perceptions of computers, group work, and the study in which they were participating. Results of the procedures used to determine the quantity and quality of ideas generated is presented, along with interrater reliability for the expert judges who provided a quality rating for each idea. This is followed by the statistical testing of the hypotheses presented in Chapter 3. Two other items are addressed in this chapter: a further investigation of the relationship between the combined treatment factors, as well as of the impact of the potentially confounding factors: facilitator/experimenter effects, order effects, learning effects, task differences, time of day (of the experimental session) differences, and the use of a computerized survey tool to administer and collect survey data.

5.1 Background Information on Subject Groups

This section provides background information pertaining to the 240 subjects who participated in the study. Descriptive statistics are presented for all subjects, as well as the subjects' perceptions of computers, group work, and this study. Since all groups participated in a session with GDSS support and a session without GDSS support, no comparisons of groups along that dimension is necessary. However, since groups were randomly assigned to the other two independent variables, structure and group size, comparisons of these subgroups were made to ensure that individual differences of subjects in the subgroups were not a factor in the outcomes of this study.

5.1.1 Descriptive Statistics for Subject Groups

Table 5 presents basic demographic background data on all subjects. This data was collected at the start of the session using the Pre-Session Survey (see Appendix C.2). The subjects were randomly assigned to groups, and treatments to groups, to help ensure that individual differences would not have an impact on the outcome of the study. Individual t-tests were used to compare subgroup populations for each factor to verify that individual differences did not exist between the treatment subgroups (see Table 6; a Chi-Square test was used to assess gender differences). Results of these comparisons indicate that there were no statistically significant differences between treatment subgroups for any of these factors at an alpha level = 0.05.

Characteristic	Mean	Standard Deviation
Age	19.53 years	0.85
Gender: Male = 136 Female = 104		
Work Experience	7.09 months	7.15
GPA	3.06	0.46
Typing (Speed):	27.25 WPM	9.32
Typing (Accuracy):	94.99%	4.21
Typing (WPM*Acc):	25.99	9.24

Table 5 - **Demographic Data for All Subjects** (n=240)

5.1.2 Subjects' Background Pertaining to the Two Tasks

Subjects completed a short Task Background Questionnaire (see Appendix C.5) to provide information about their knowledge and personal experience with the two main tasks (Library and Parking Problems). This questionnaire was completed <u>after</u> the subjects had participated in both idea generation sessions. This was done so that questions about task areas would not cause/allow subjects to think about the problems prior to the start of each session. It is not believed that their participation in the session in any way biased their responses to these questions. Table 7 presents a summary of the responses for all subjects for the two tasks.

Comparisons for Subgroups on Demographic Characteristics Independent Variable: **Group Size**					
	Five (n=80)		Ten (n=160)		
	Mean	SD	Mean	SD	Signif.
Age:	19.42	0.71	19.58	0.92	p=0.16
Gender:	F: 41.3%	M: 58.8%	F: 44.4%	M: 55.6%	p=0.65
Work Exp.	6.24	0.66	7.51	7.68	p=0.16
GPA:	3.06	0.46	3.05	0.47	p=0.95
Typing (WPM):	27.09	9.48	27.33	9.27	p=0.85
Typing (Accur):	94.98	4.78	95.00	3.91	p=0.97
Typing (WP*AC):	25.87	9.50	26.05	9.14	p=0.89

Comparisons for Subgroups on Demographic Characteristics Independent Variable: **Structure**					
	Structure Provided (n=120)		No Structure Provided (n=120)		
	Mean	SD	Mean	SD	Signif.
Age:	19.58	0.84	19.47	0.87	p=0.37
Gender:	F: 45.0%	M: 55.0%	F: 41.7%	M: 58.3%	p=0.60
Work Exp.	6.88	7.40	7.29	6.92	p=0.66
GPA:	3.05	0.47	3.06	0.45	p=0.78
Typing (WPM):	27.38	9.16	27.13	9.52	p=0.84
Typing (Accur):	95.46	3.78	94.53	4.57	p=0.09
Typing (WP*AC):	26.21	9.05	25.76	9.47	p=0.70

Table 6 - **Comparisons of Subgroup Population Demographics**

1)	Do you have a car in Bloomington?	Yes: 130	(54.2%)
		No: 110	(45.8%)
2)	How often have you driven on-campus?		
	Never Driven on-campus:	11	(4.6%)
	Driven on-campus less than 10 times:	57	(23.8%)
	Driven on-campus several (> 10) times:	83	(34.6%)
	Drive on-campus all the time:	89	(37.1%)
3)	Familiarity with Parking Problem:		
	Personally experienced problem as a driver or passenger:	211	(87.9%)
	Experienced as pedestrian/bystander:	22	(9.2%)
	Have read/heard about the problem:	6	(2.5%)
	Have not heard/seen anything about the problem:	1	(0.4%)
4)	Familiarity with the libraries at IU:		
	Have never been in an IU library:	3	(1.3%)
	Have been to one IU library:	22	(9.2%)
	Have been to more than one IU library:	215	(89.6%)
5)	How often do you use the IU libraries?		
	Not at all:	5	(2.1%)
	Less than once a week:	50	(20.8%)
	About once a week:	48	(20.0%)
	Two - three times a week:	81	(33.8%)
	More than three times a week:	56	(23.6%)
6)	Have you ever faced the types of problems discussed at any of the IU libraries?		
	Never had any problems like that:	37	(15.4%)
	Never personally had such problems, but have heard of such problems:	44	(18.3%)
	Have experienced such problems as a library patron on one occasion:	41	(17.1%)
	Have experienced such problems as a library patron on more than one occasion:	81	(33.8%)
	Have experienced such problems as a library patron on several occasions:	38	(15.8%)

Table 7 - **Task Background Information for All Subjects** (n=240)

Examination of these responses indicates that the subjects were quite familiar with the two problems, with most having had at least some personal experience with both problems.

5.1.3 Subjects' Perceptions of Computers, Group Work, and this Study

In addition to the demographic information collected from the Pre-Session Survey, the subjects completed several questions that addressed their feelings toward computers, their attitudes and experience in working in groups and with the other group members present, and their perceptions and motivation pertaining to the study in which they were participating. Most of these questions were answered using a seven-point preference (Likert) scale. These questions are first discussed for the entire sample, then comparisons between the treatment subgroups are presented.

5.1.3.1 Working With Computers

Several questions addressed the issue of working with computers. Sixty-two percent of all the subjects reported being frequent users of computers; 37% reported having used computers from one to ten times, and one percent reported never having used computers. None of the subjects had previously used the GDSS (PLEXSYS) utilized in this study. Three questions addressed preferences for computers, using a seven-point preference scale (1 was "Strongly Disagree", 4 was "Neutral/ Undecided", and 7 was "Strongly Agree"):

	Mean	SD	Range
I like to use computers:	4.971	1.485	1 - 7
I would use computers even if it were not expected of me:	4.575	1.591	1 - 7
I don't care what people say, computers are not for me:	2.533	1.525	1 - 7

The responses to these questions indicated that a majority of the subjects have used computers and, on the average, perceive them in a relatively positive manner. The average typing score of over 27 words per minute, with an accuracy rate of nearly 95%, indicates that the use of keyboards for idea entry in the session with GDSS support should not have been a problem for most subjects (a Multivariate Analysis of Covariance, with typing score as a covariate, confirmed that typing ability did not significantly impact any of the dependent variables at an alpha level = 0.05). Since all of the subjects were enrolled in an introductory course entitled The Computer in Business, there was at least a minimal level of computer use and understanding that could be assumed for all subjects.

5.1.3.2 Working With Groups

Four questions assessed the subjects' general experience and preferences for working in groups, using a seven-point preference scale. For the first question, a rating of 1 was "Seldom work in groups", 4 was "Sometimes work in groups", and 7 was "Often work in groups"; for the other three questions the rating scales were: 1 was

"Strongly Disagree", 4 was "Neutral/Undecided", and 7 was "Strongly Agree":

	Mean	SD	Range
General level of experience in working in groups:	4.221	1.410	1 - 7
Generally, I like to participate in groups:	4.643	1.376	1 - 7
Generally, I am comfortable participating in groups:	4.654	1.376	2 - 7
Generally, I am not reluctant to talk in groups:	3.108	1.471	1 - 7

The responses to these questions indicate that, on the average, a majority of the subjects have had experience in working in groups, and are reasonably comfortable participating in groups.

5.1.3.3 Regarding this Particular Session

Subjects were asked four questions pertaining to the experimental session in which they were participating. They were asked if they had worked with any of the other members in their group. Only nine of the 240 subjects reported working with one or more of the other group members "a lot", while 19 subjects reported having worked once or twice with "some of those present". The remaining 212 subjects had not worked previously with any of the other group members. Further examination of the responses to this question indicates that no group contained more than two group members who responded as having worked "a lot" together or two group members who responded as having worked once or twice with "some of those present". Therefore, prior experience of group members working together should not have had a major impact on the group outcomes. Three additional questions addressed subjects' perceptions of the session in which they were about to participate, using a seven-point preference scale with 1 being "Very Successful/Motivated/ Significant", 4 was "Neutral/Undecided", and 7 was "Very Unsuccessful/Unmotivated/Insignificant":

	Mean	SD	Range
How **successful** do you expect the group to be at accomplishing the session outcomes?	4.829	0.964	2 - 7
How **motivated** are you to make this session a success:	5.083	1.083	1 - 7
How **significant** do you expect your personal contribution will be to the session outcomes?	4.888	0.972	2 - 7

The responses to the questions indicate that, on the average, most of the subjects viewed the session in which they were participating from a positive perspective in terms of their personal contributions, motivation, and assessment of the potential for success of their group.

5.1.3.4 Comparison Between Subgroups of Subjects' Perceptions

Just as with the demographic data discussed earlier (Section 5.2.1), there was no need to compare the groups who will have GDSS support with groups who will not have

GDSS support for these questions, since all subjects will participate in sessions with both types of support. However, since groups were randomly assigned to subgroups for the other independent variables, group size and structure, comparisons of these subgroups were made to ensure that individual differences were not a factor in the outcomes of this study. Tables 8 and 9 provide results of t-test comparisons made for the two treatment subgroups, group size and structure, respectively. The three questions pertaining to computer use were combined into one measure for this comparison by summing the three scores and obtaining their mean (the three responses had a reliability rating = 0.86 using Cronbach's alpha).

For group size there are two statistically significant differences (at an alpha level = 0.05) as shown in Table 8. These questions pertained to the subjects' perceptions of the experimental session in which they were participating. Of these two questions, one dealt with their motivation to make this session successful and the other with the significance of their individual contribution. In both cases this perception was lower for the larger groups, which is in line with much of the literature pertaining to group size. As groups increase in size from five to 10 persons, the individual motivation level and perception of potential per person contribution diminishes. This is especially true for additive tasks, such as idea generation.

Independent Variable: **Group Size**			
Question	Five (n=80)		Ten (n=160)
Computer use: (t = 1.80, p > 0.05)	Mean: SD:	5.23 1.16	4.89 1.44
Level of group work: (t = 0.03, p = 0.97)	Mean: SD:	4.23 1.51	4.22 1.36
I like to participate in groups: (t = -1.53, p = 0.13)	Mean: SD:	4.46 1.45	4.75 1.33
I am comfortable participating in groups: (t = -0.92, p = 0.36)	Mean: SD:	5.01 1.26	5.16 1.16
I am not reluctant to talk in groups: (t = -0.12, p = 0.90)	Mean: SD:	4.88 1.45	4.90 1.49
How successful do you expect the group to be? (t = 1.38, p = 0.17)	Mean: SD:	4.95 1.07	4.77 0.91
How motivated are you to make this session a success? (t = 2.47, **p = 0.01**)	Mean: SD:	5.33 1.09	4.96 1.06
How significant do you expect your contribution to be? (t = 3.31, **p = 0.001**)	Mean: SD:	5.18 0.90	4.74 0.98

Table 8 - **Comparisons for Subgroups on Subject Perceptions**

Independent Variable: **Structure**		
Question	Structure (n=120)	No Struct (n=120)
Computer Usage: (t = 0.25, p = 0.80)	Mean: 5.03 SD: 1.36	4.98 1.36
Level of group work: (t = 0.87, p = 0.39)	Mean: 4.30 SD: 1.45	4.14 1.37
I like to participate in groups: (t = 1.55, p = 0.12)	Mean: 4.79 SD: 1.43	4.52 1.32
I am comfortable participating in groups: (t = 0.38, p = 0.71)	Mean: 5.14 SD: 1.32	5.08 1.06
I am not reluctant to talk in groups: (t = 1.50, p = 0.14)	Mean: 5.03 SD: 1.50	4.75 1.44
How successful do you expect the group to be? (t = 0.60, p = 0.55)	Mean: 4.47 SD: 0.93	4.79 1.00
How motivated are you to make this session a success? (t = 1.37, p = 0.63)	Mean: 5.12 SD: 1.00	5.05 1.17
How significant do you expect your contribution to be? (t = -0.46, p = 0.64)	Mean: 4.86 SD: 1.00	4.92 0.95

Table 9 - Comparisons for Subgroups on Subject Perceptions

There were no statistically significant differences for the treatment subgroups based on structure (at an alpha level = 0.05). The results of this evaluation indicate that the random assignment of subjects to groups helped to remove any potential impact due to individual differences in this study, at least for the factors investigated.

5.2 Assessing Quantity and Quality of Ideas Generated by Groups

This section provides the results of the procedures used to determine the number of ideas generated by each group as well as to assess the quality of each idea. Group totals were then calculated along each dimension of quantity and quality to be used for hypothesis testing.

5.2.1 Quantity of Ideas

Two trained raters (doctoral students) were used to rate ideas for each problem using the idea categorization scheme outlined in Section 4.3.4. The procedure required each rater to independently identify whether or not a text string (as generated using the keyboard or orally) contained an idea, and if so, the specific content of that idea. To be classified as an idea, a text string had to provide a "concrete solution" to the problem. Since each of the 32 groups generated ideas for both tasks, there were 64 total lists of text strings generated. For each task, the classification of ideas was a four-step process:

1) An initial coding scheme was developed for each task from the 32 lists of ideas generated for that task. Ideas were identified based on the criteria prescribed, and were then assigned to one of the

logical categories. These categories were not established prior to the categorization process, but were created as a result of the ideas generated. For example, one of the categories for the parking problem dealt with issuing parking stickers, so any idea dealing with who should receive parking stickers, allocation of stickers, cost of stickers, etc., was then assigned to that category. This was not an exhaustive set of categories, but it did provide a substantial base from which the raters could work and build.

2) Once this scheme was developed the first rater evaluated all the text strings to determine which ones were ideas and then classified the ideas into categories. All ideas were printed out from computer files (the text strings from the session with GDSS support were stored directly in computer files, the text strings from the session without GDSS support were entered into files after each session). This rater also added new idea categories if he felt that a text string suggested an idea not belonging in any of the existing categories.

3) When the first rater finished rating the ideas, the second rater independently evaluated the lists of text strings and assigned the ideas to the appropriate categories (which included the categories added by the first rater). Again, if this rater felt an idea did not fit an existing category, a new category was created (very few new categories were added).

4) The updated schema of ideas went back to the first rater to allow him to see the new idea categories and determine if any text strings should be reclassified (very few reclassifications were made).

At this point, interrater reliability was assessed between the two raters. For the Library Problem, 1,840 text strings were evaluated and the raters independently agreed to the classification of 1,808 of the 1,840 strings (98.3%). There were 2,241 text strings generated for the Parking Problem and the raters agreed on the classification of 2,185 of the 2,241 strings (97.5%). The overall interrater reliability for the two raters for the two problems was

97.84% (3,993 / 4,081 text strings rated identically). The two raters then met to discuss the disagreements that existed between their two sets of ratings (the remaining 88 text strings). As a result of this meeting, the two raters agreed on the classification of all text strings (100%).

After the text strings had been classified, the three levels of quantity (total ideas, different ideas, and unique ideas) were assessed for each group. The 64 lists of text strings evaluated in the idea categorization process (two per group -- one for each task), were then analyzed to determine idea counts for each group. **Total ideas** included all the ideas generated by a group, including redundant ideas. If, for example, group members generated the same idea three times, it counted as three ideas toward the total number of ideas. However, all redundant ideas only counted as one **different idea**. Therefore, the number of different ideas refers to non-duplicate ideas. Across all groups there were 194 different ideas generated for the Library Problem, and 212 for the parking problem. **Unique ideas** were ideas that were only generated once by one of the 32 groups. There were 68 unique ideas generated for the Library Problem, and 65 for the Parking Problem. See Table 10 for the average number of ideas and other text string classifications for all 32 groups (divided between sessions with GDSS support and sessions without GDSS support). In Table 10, "non-solutions" refer to text strings that did not

Classification	Sessions with GDSS Support		Sessions without GDSS Support	
	Mean	SD	Mean	SD
Total Ideas	88.63	46.17	25.88	6.30
Different Ideas	46.00	17.68	22.56	5.69
Unique ideas	2.72	2.47	1.47	1.14
Total Quality	1094.66	366.12	573.69	137.28
Average Quality	24.33	2.63	25.55	1.77
Good Ideas	8.63	2.85	5.13	2.55
Non-Solutions	8.19	10.22	0.75	1.05
Critical Comments	0.25	0.44	0.53	1.30
Other Comments	0.94	2.06	3.50	4.46

Table 10 - **Average Idea Quantity and Quality for Sessions with GDSS Support and Sessions without GDSS Support** (averages per group)

meet the criteria for being an idea; "other comments" refers to text strings that were not ideas, non-solutions, or critical comments [e.g., supportive comments, clarifications, questions, off-the-topic comments, and uncodable text (see Section 4.3.4 for additional information about rating procedures)].

5.2.2 Quality of Ideas

Six expert judges were used to assess the quality of the ideas generated for each problem (six judges total: three per problem). The Library Problem judges were the Director of the Undergraduate Library, the Head of the Biology Library, and the Head of the Business/School of Public and Environmental Affairs Library. They averaged over five years each in their present positions, and over ten years experience working in libraries. The judges for the Parking Problem were the Manager of Parking Operations for the University, the Director of the Office of Space Management for the University, and the Deputy Director of the University Police Department. They averaged over twelve years in their respective positions. Both sets of judges were very familiar with the respective problems, have to deal with them on a regular basis, and welcomed any new suggestions or ideas.

Prior to assessing the quality of ideas from the main study, each judge was given a "practice set" of 20 randomly selected ideas generated during the pilot study. This was done to allow the judges an opportunity to use the procedures for rating ideas, and to ask for any clarifications or additional information they needed, as well as allowing an assessment of the potential reliability of the judges. After the main study ideas had been identified, randomly ordered lists of ideas were given to the judges. All six judges promptly completed and returned the ratings.

There were two criteria used to assess each idea: effectiveness and feasibility (see Section 4.3.4 for more information on the rating procedures). Interrater reliability was assessed for each criteria independently and for the combination of the two criteria. It was this combination that was used as the **quality score** for each idea. See Table 11 for interrater reliability scores (Cronbach's Alpha). These scores fall within acceptable ranges and are comparable to reliability scores reported in previous idea generation studies. Appendix G contains the lists of ideas given to each set of judges and the quality score provided by the judges' ratings.

After the quality score was determined for each idea, the three levels of quality (total, average, and number of good ideas) were calculated for each group. **Total quality** was calculated by summing the quality scores (the sum of the three judges' ratings for the two criteria) of all the different ideas generated by a group. For example, if a group generated 30 different ideas, the quality scores for

	Parking Problem		
Criteria:	Effectiveness	Feasibility	Combined
Alpha =	0.69	0.71	0.74

	Library Problem		
Criteria:	Effectiveness	Feasibility	Combined
Alpha =	0.54	0.70	0.57

Table 11 - **Interrater Reliability for Expert Judges**

each of those ideas would be summed to produce total quality. **Average quality** was derived by taking total quality and dividing it by the number of different ideas. Therefore, for the group that generated 30 different ideas, their average quality would be their total quality divided by 30. Finally, the number of **good ideas** was determined by the number of ideas whose quality score exceeded a pre-established criterion, or cut-off, point. That cut-off point was set at a quality score of 30 points, which was 50% of the maximum possible quality score of 60 points. Therefore, any ideas with a quality score of 31 or higher was classified as a "good" idea. This cut-off point resulted in 37 "good" ideas for the Library Problem and 38 "good" ideas for the Parking Problem. See Table 10 for the average quality scores for the sessions with GDSS support and the sessions without GDSS support.

5.3 Overview of Statistical Procedures

To test the hypotheses proposed in this study, statistical techniques were required which allowed for the comparison of group scores between treatments for the eight dependent variables. In deciding the most appropriate statistical technique, the first step was to determine to what degree these variables were correlated with one another. Table 12 presents the correlation matrix of the 16 dependent variables (two measurements for each of the eight dependent variables, one per task, given the repeated measures design). High correlations were found for all of these variables (the "lowest" maximum correlation for any variable was 0.44). To further support the strong relationship of the dependent variables, Bartlett's test of sphericity yielded a significance level less than 0.001. This result led to the rejection of the hypothesis that the dependent variables were independent.

Based on the strong correlations between the dependent variables, the use of univariate statistical techniques to individually evaluate each dependent variable was deemed inappropriate. Given the strong relationships between the dependent variables, the probability of a Type I error is increased. An additional problem with using univariate statistical techniques is that as the number of dependent variables increases, the probability of finding a significant difference by chance alone increases. Given these factors, the most appropriate statistical technique to

	TQNT1	TQNT2	DQNT1	DQNT2	UQNT1	UQNT2	TQUL1	TQUL2	AQUL1	AQUL2	GQUL1	GQUL2	PU1	PU2	SAT1	SAT2
TQNT1	---															
TQNT2	.250	---														
DQNT1	.799	.578	---													
DQNT2	.153	.956	.448	---												
UQNT1	.479	.013	.412	-.001	---											
UQNT2	.017	.199	.116	.248	.304	---										
TQUL1	.649	.721	.936	.586	.289	.113	---									
TQUL2	.124	.940	.421	.974	-.062	.192	.570	---								
AQUL1	-.332	.682	.118	.697	-.452	.111	.337	.730	---							
AQUL2	-.267	.669	.179	.679	-.449	.107	.341	.742	.964	---						
GQUL1	.303	.642	.657	.600	-.078	-.049	.789	.613	.489	.478	---					
GQUL2	-.074	.702	.116	.706	-.039	.223	.283	.755	.545	.567	.233	---				
PU1	.045	.060	.264	.047	.239	.039	.236	-.005	-.031	-.051	.347	-.233	---			
PU2	.117	.188	.364	.146	.393	-.009	.361	.140	.083	.087	.280	.027	.324	---		
SAT1	.361	.161	.443	.090	.268	.107	.357	.063	-.089	-.019	.263	-.088	.572	.161	---	
SAT2	.016	.098	.250	.047	.275	.011	.252	.060	.111	.145	.138	.002	.319	.789	.277	---

Variables:

TQNT1: Total Ideas (1st Session)
TQNT2: Total Ideas (2nd Session)
TQUL1: Total Quality (1st Session)
TQUL2: Total Quality (2nd Session)
PU1: Perceived Usefulness (1st Session)

DQNT1: Different Ideas (1st Session)
DQNT2: Different Ideas (2nd Session)
AQUL1: Average Quality (1st Session)
AQUL2: Average Quality (2nd Session)
PU2: Perceived Usefulness (2nd Session)

UQNT1: Unique Ideas (1st Session)
UQNT1: Unique Ideas (1st Session)
GQUL1: Good Ideas (1st Session)
GQUL2: Good Ideas (2nd Session)
SAT1: Satisfaction (1st Session)
SAT2: Satisfaction (2nd Session)

Table 12 - Correlation Matrix of Dependent Variables

evaluate the hypotheses proposed in this study was determined to be Multivariate Analysis of Variance (MANOVA).

MANOVA allows for the simultaneous evaluation of multiple dependent variables, with adjustments made for the correlations between the dependent variables. When a significant effect results using MANOVA, it is an indication that a significant difference exists between treatment groups for at least one dependent variable. Since MANOVA only indicates that this difference exists, follow-up procedures are required to determine the dependent variable(s) for which this difference exists. SPSS-X MANOVA with repeated measures was used for this analysis.

There are two assumptions required in order to appropriately use MANOVA: 1) The dependent variables have a multivariate normal distribution and 2) the variance-covariance matrices are homogeneous. To test the first assumption, normal plots and detrended normal plots for each dependent variable were generated and visually checked for deviations from normality. No significant deviations were observed, and thus it was felt that the first condition was met. To begin the assessment of the second assumption, a homogeneity-of-variance test, Cochran's C, was used. This univariate test evaluated the equality of variances for each variable independently. Fourteen of the sixteen variables had significance levels indicating no need to reject the hypothesis that the variance of the two groups were equal.

The next step was to simultaneously consider both the variances and covariances of the variance-covariance matrices. Box's M test provides a multivariate test for homogeneity of the matrices.

First attempts to run Box's M did not meet with success due to the existence of singular variance-covariance matrices for each of the four cells (created by the 2 X 2 between-subjects portion of the design). Dropping one independent variable from the analysis did not help; in this case the program did not run due to the existence of linear combinations among the variables. Average quality (total quality divided by the number of different ideas) was dropped, resulting in a Box's M significance level of 0.018. This result puts in question the homogeneity of matrices assumption. However, several authors have warned of the overly sensitive nature of Box's M and have cautioned against its use (e.g., Bray and Maxwell, 1985; Hayes, 1988). Given the difficulty obtaining this value of Box's M, its validity is called into question.

The issue then becomes, how robust is MANOVA _if_ there is a violation of the homogeneity assumption? Bray and Maxwell (1985) indicate that when sample sizes are equal all four test statistics (Hotelling's Trace, Pillai's Trace, Wilks' Lambda, and Roy's Largest Root) generated by MANOVA appear to be robust, unless sample sizes are small or the number of variables is large. Unfortunately, no guidance is given to clarify what qualifies as a "small" sample or "large number" of dependent variables (however, a sample size of 32 groups with eight dependent variables is likely to fall into one, if not both, of these categories). Olson (1976 and 1979) and Stevens (1979) have argued about the robustness of the different MANOVA test statistics, with Olson strongly championing Pillai's as the most robust. If it is likely that violations of the homogeneity assumption exists, then it is also likely that the different test statistics will yield different significance values, with Pillai's being the most robust. For the MANOVA run for this study, the F-values and significance levels for the three statistics reported (Pillai's, Hotelling's, and Wilks' statistics are generated by SPSS-X MANOVA) were identical for all main effects and interactions (seven effects in all). Given this outcome, it is unlikely that a significant violation of the homogeneity assumption exists, since otherwise different results from the different statistics would most likely have been obtained.

Pillai's Trace statistic will be reported for each effect, but as indicated, all three statistics yielded the same level of significance. The level of significance selected a priori to test main effects and interactions using MANOVA was an overall alpha level = 0.05.

SPSS-X also generated univariate F-test statistics for follow-up analysis of treatment group differences for each dependent variable. Two assumptions must be met in order to appropriately utilize these F scores. These assumptions, which are referred to as the "symmetry conditions", require: 1) the homogeneity assumption addressed earlier and 2) a spherical pattern for the common covariance matrix (equal variances on the diagonal and zero covariances off the diagonal). The second assumption was tested using Mauchly's sphericity test with a resulting significance level less than 0.001. This result indicates that the second assumption has been violated and that, unadjusted, the univariate F scores cannot be used. However, if this assumption is violated, adjustments can be made to the degrees of freedom, and new p-values calculated with the adjusted degrees of freedom. SPSS-X provides the Huynh-Feldt Epsilon which was used to adjust the degrees of freedom and calculate new p-values. The original degrees of freedom for the univariate F-ratios were 1 and 28. With the adjustment, the new degrees of freedom became 1 and 4 (28 multiplied by the Huynh-Feldt Epsilon of 0.14187 = 3.972). Univariate F-ratios were then used, with p-values recalculated and reported for the new degrees of freedom.

When considering the use of follow-up procedures to further investigate significant MANOVA results, the potential for the same types of problems previously cited with the use of univariate statistical techniques must be addressed (e.g., increased probability of a Type I error and likelihood of finding significant results by chance alone). To overcome many of these problems, adjustments to the overall alpha level are recommended. One approach is based on the "Bonferroni Method" (Bray and Maxwell, 1985) to adjust the alpha value: The new alpha value is derived by dividing the overall alpha level (0.05) by the number of dependent variables being evaluated (eight). For this study the new alpha level would be 0.00625. Reducing the alpha level to this point would result in an increase in the level of a Type II error on each individual test. Batra (1989), in a similar situation (using univariate t-tests on nine dependent variables to follow-up on MANOVA results) reached a compromise between Type I and Type II errors by setting the alpha level for the individual comparisons at 0.01. This approach, compromising between Type I and Type II errors, was adopted for this study with the selection of an alpha level = 0.01 for all follow-up tests.

5.4 Hypothesis Testing

This section presents the results of the statistical analysis performed to test the hypotheses proposed in Chapter 3. Each hypothesis is restated, and the statistical technique(s) used in testing the hypothesis is described along with the results of the test. In this evaluation, the group was the unit of analysis, and all comparisons are based on a per person basis (e.g., total number of ideas generated, per person, for the group). While information for each test is presented in this section, SPSS-X MANOVA printouts for each main effect and interaction are provided in Appendix H.1. P-values reported for the follow-up tests are reported as ranges (i.e., $p < 0.01$), as opposed to specific values (i.e., $p = 0.01$), due to the adjustment to the degrees of freedom which required that the F-scores be evaluated from tables, as opposed to the p-values generated from SPSS-X.

5.4.1 GDSS Main Effect

It was hypothesized that groups would perform better in the sessions in which they were provided GDSS support as opposed to the session without GDSS support by:

HA1: Generating more ideas:
1) **Total ideas**
2) **Different ideas**
3) **Unique ideas;**

HA2: Of higher quality:
1) **Total quality**
2) **Average quality**
3) **Number of good ideas;**

HA3: Being more satisfied with the idea generation process;

HA4: Perceiving the idea generation technique to be more useful.

This main effect was tested using MANOVA, at an overall alpha level = 0.05 (with 8 and 21 degrees of freedom). This result indicated that there was a significant difference between the two groups, for at least one of the dependent variables. In order to determine what these differences

Pillai's Trace = 0.89	F value = 21.50	$p < 0.001$

were, follow up univariate F-tests were utilized. These results were tested at an alpha level = 0.01 with modified degrees of freedom (as discussed in Section 5.3). These results are presented in Table 13. Means and standard deviations for groups with GDSS support and groups without GDSS support, for all dependent variables, are presented in Table 14.

Overall, groups generated significantly more **total ideas** ($p < 0.001$) and **different ideas** ($p < 0.001$) for the sessions with GDSS support as opposed to the sessions without GDSS support. Groups also generated ideas of significantly higher **total quality** ($p < 0.001$) and generated more **good ideas** ($p < .01$), as rated by the expert judges, for the sessions with GDSS support. Finally, groups were more **satisfied** with the idea generation process for the sessions with GDSS support than the sessions without GDSS support ($p < .01$).

Figures 14 - 21 illustrate the performance of groups for sessions with GDSS support and the sessions without GDSS support for each of the eight dependent measures (these diagrams include group size).

5.4.2 Structure Main Effect

It was hypothesized that groups provided with structure for support, in the form of Osborn's brainstorming instructions, would outperform groups that were not provided with structure (instructions), by:

HB1: Generating more ideas:
1) Total ideas
2) Different ideas
3) Unique ideas;

HB2: Of higher quality:
1) Total quality
2) Average quality
3) Number of good ideas;

	Hypothesis	F value	p-value	:GDSS > w/o GDSS	Hypoth. Supported
HA1	Total Quantity of Ideas	172.48	$p < 0.001$	yes	yes
	Number of Different Ideas	110.56	$p < 0.001$	yes	yes
	Number of Unique Ideas	10.61	$p < 0.05$	yes	no
HA2	Total Quality of Ideas	113.79	$p < 0.001$	yes	yes
	Average Quality of Ideas	5.17	$p < 0.10$	no	no
	Number of Good Ideas	21.66	$p < 0.01$	yes	yes
HA3	Satisfaction w/ the Idea Generation Process	43.56	$p < 0.01$	yes	yes
HA4	Perceived Usefulness of the Idea Generation Technique	8.21	$p < 0.05$	yes	no

Table 13 - **GDSS Main Effect** Univariate F Follow-up Tests

(F-ratios with 1 and 4 degrees of freedom)
(Hypotheses tested for significance at an alpha level = 0.01)

Dependent Variable:	Session with GDSS Support		Session without GDSS Support	
	Mean	SD	Mean	SD
Quantity:				
Total Ideas:	11.50	3.80	3.72	1.19
Different Ideas:	6.25	1.77	3.23	0.95
Unique Ideas:	0.33	0.25	0.20	0.15
Quality:				
Total Quality:	150.99	42.58	82.58	25.54
Average Quality:	3.70	1.42	3.85	1.38
Good Ideas:	1.22	0.46	0.76	0.44
Satisfaction:	5.80	0.49	4.92	0.75
Perceived Usefulness:	22.19	1.51	20.92	2.44

Table 14 - Means and Standard Deviations for **Sessions with GDSS Support and Sessions without GDSS Support** (on a per person basis)

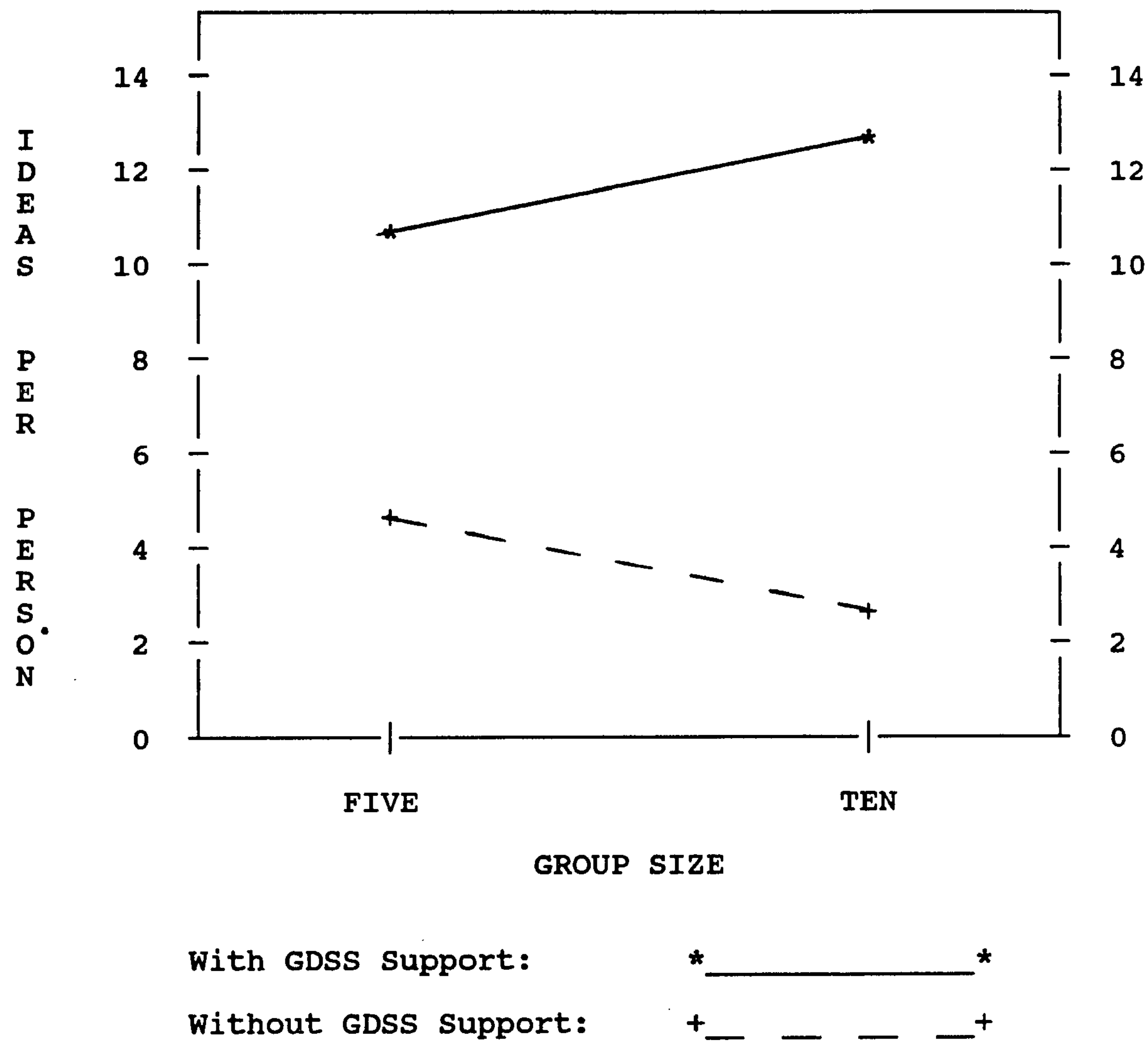
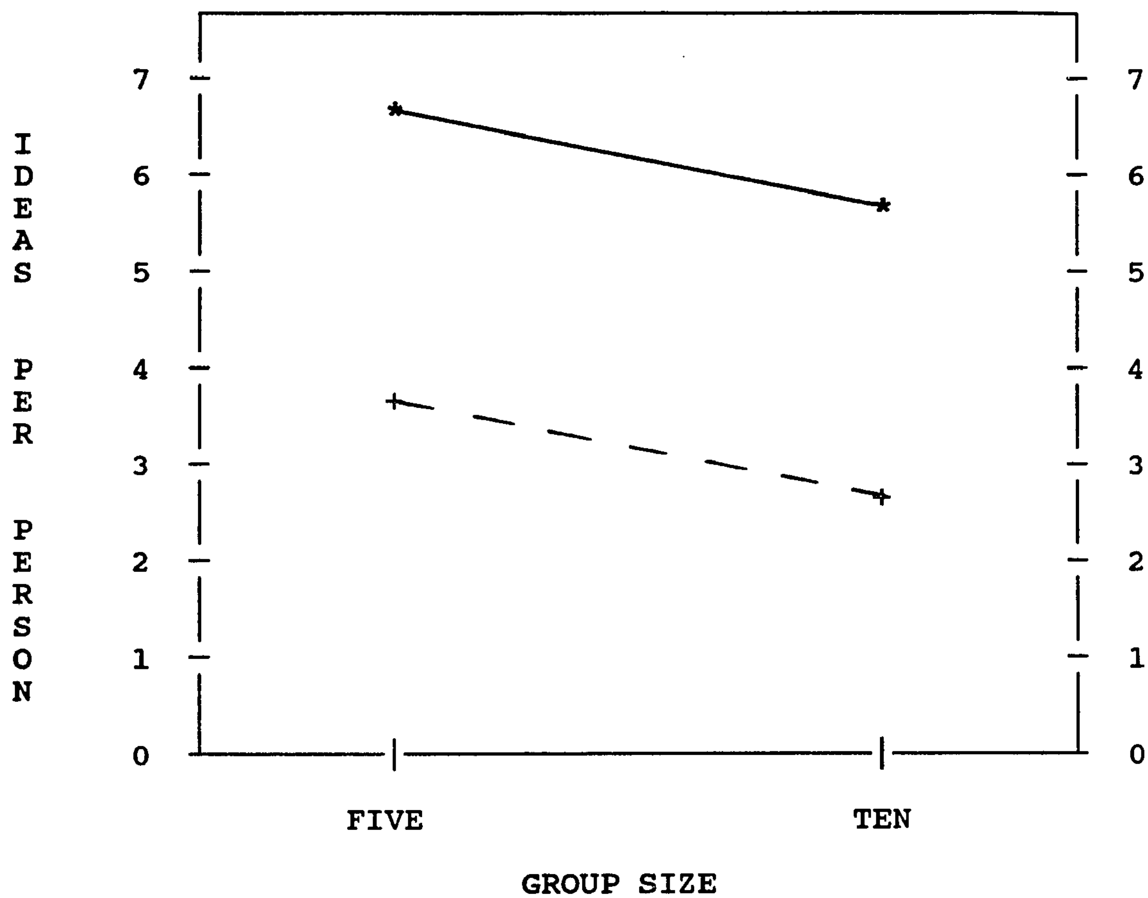


Figure 13

TOTAL IDEAS: Groups with GDSS Support vs. Groups without GDSS Support (Group sizes = 5 and 10)



With GDSS Support: *______________*

Without GDSS Support: +__ __ __ __+

Figure 14

DIFFERENT IDEAS: Groups with GDSS Support vs. Groups without GDSS Support (Group sizes = 5 and 10)

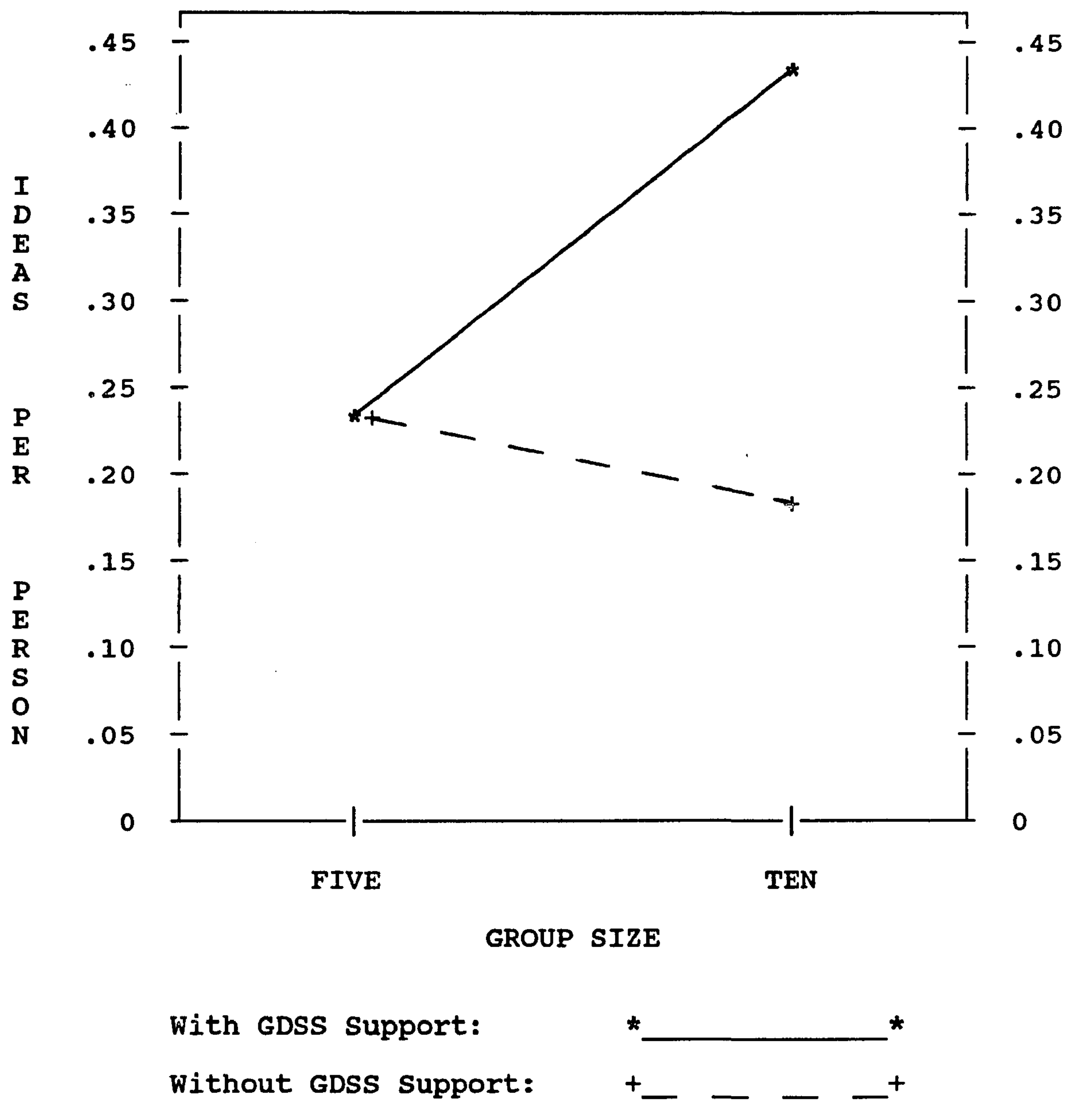


Figure 15

UNIQUE IDEAS: Groups with GDSS Support vs. Groups without GDSS Support (Group sizes = 5 and 10)

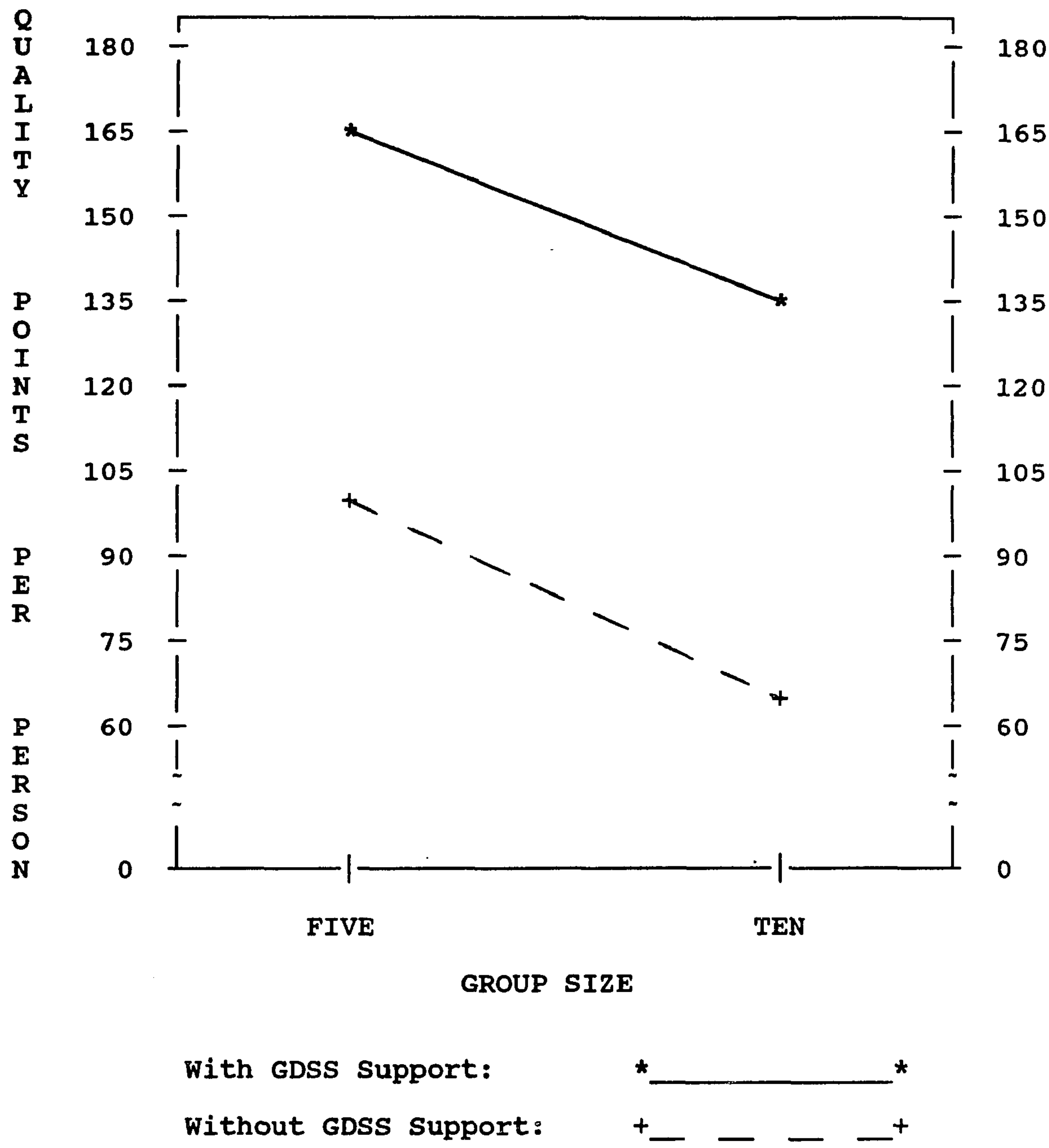


Figure 16

TOTAL QUALITY: Groups with GDSS Support vs. Groups without GDSS Support (Group sizes = 5 and 10)

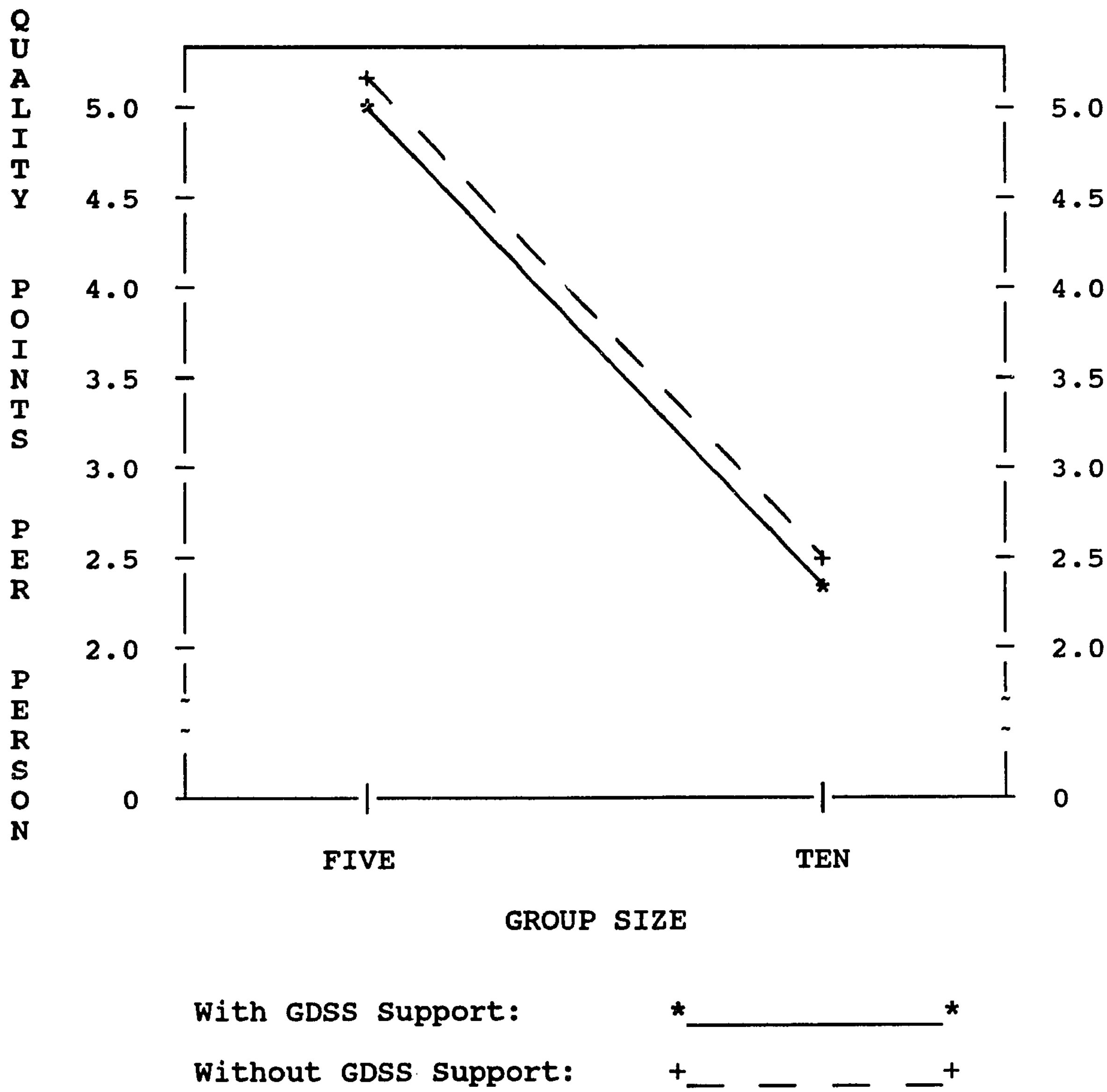


Figure 17

AVERAGE QUALITY: Groups with GDSS Support vs. Groups without GDSS Support (Group sizes = 5 and 10)

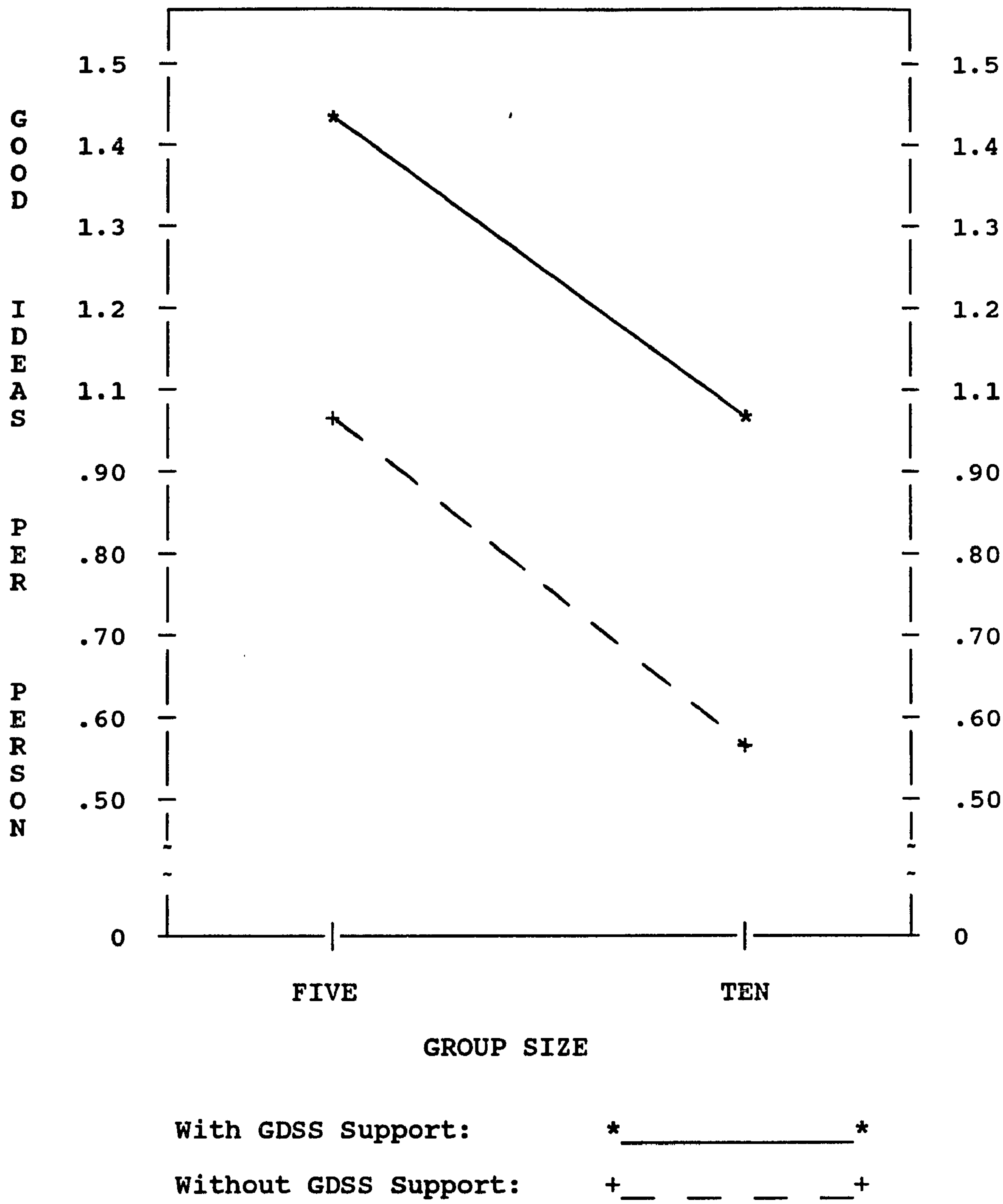


Figure 18

GOOD IDEAS: Groups with GDSS Support vs.
Groups without GDSS Support
(Group sizes = 5 and 10)

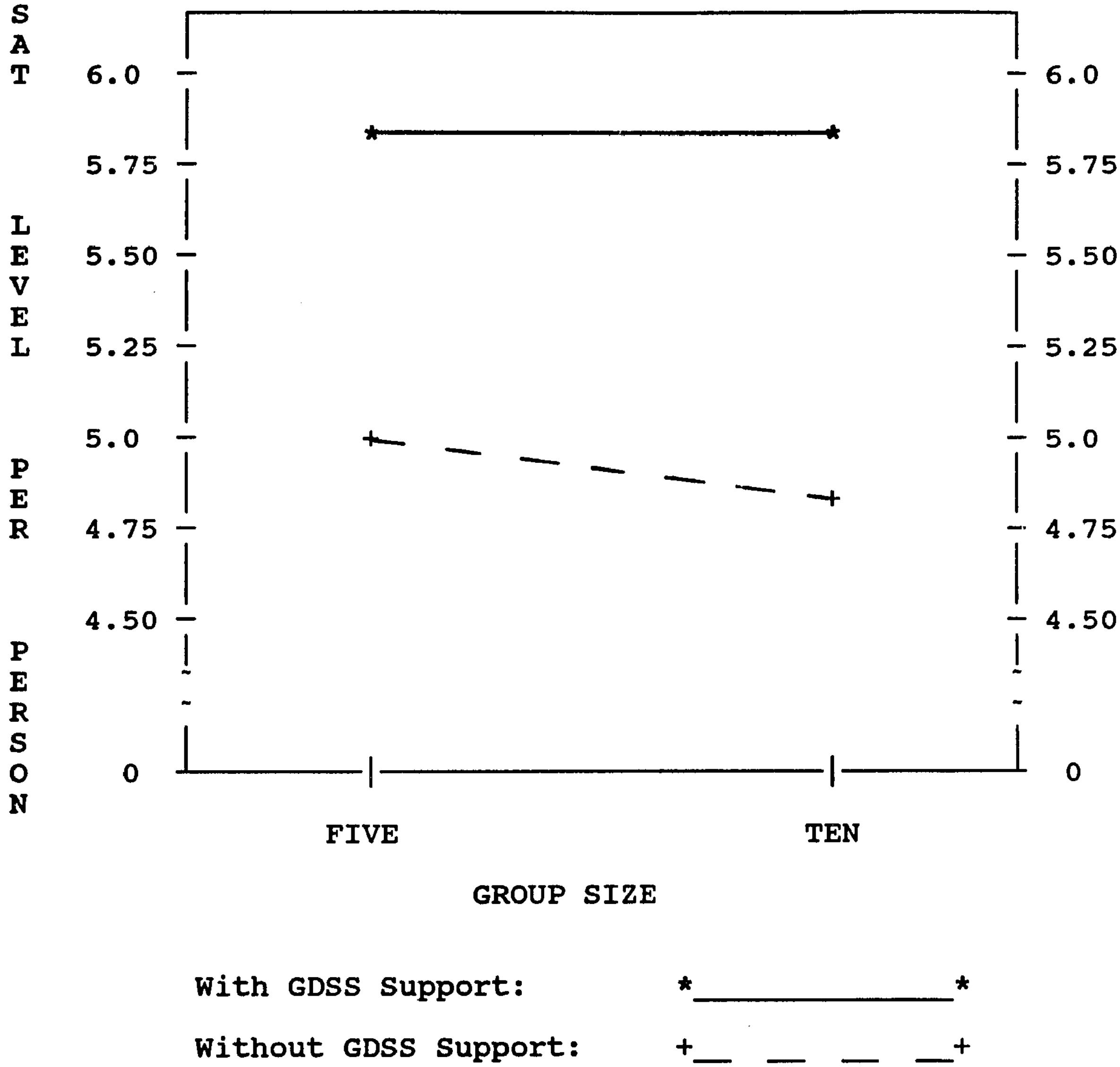


Figure 19

SATISFACTION: Groups with GDSS Support vs. Groups without GDSS Support (Group sizes = 5 and 10)

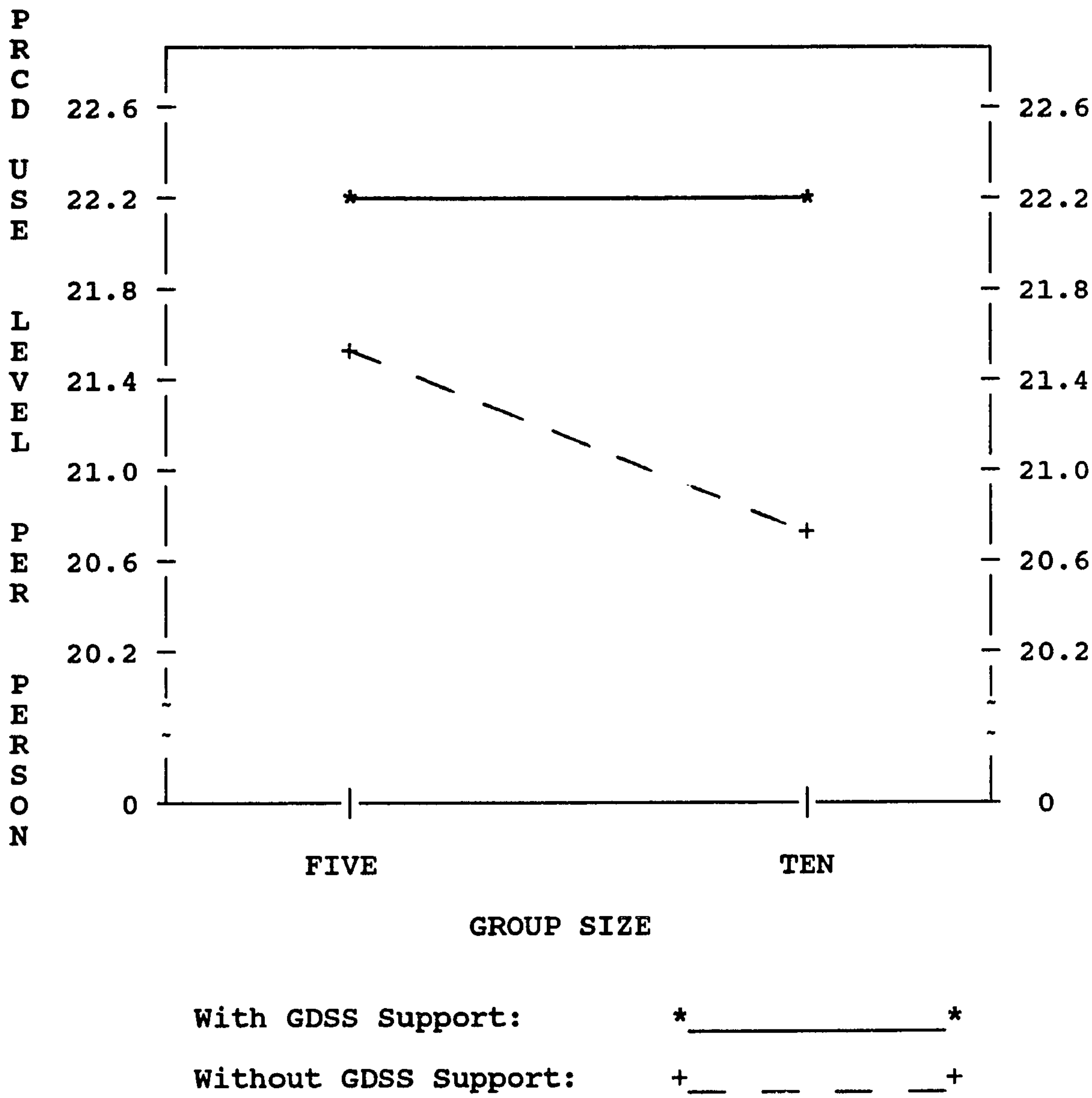


Figure 20

PERCEIVED USEFULNESS: Groups with GDSS Support vs. Groups without GDSS Support (Group sizes = 5 and 10)

HB3: Being more satisfied with the structured idea generation process;

HB4: Perceiving the structured idea generation technique to be more useful.

This main effect was tested using MANOVA, at an overall alpha level = 0.05 (with 8 and 21 degrees of freedom). This result indicated that there was not a significant difference between the two groups. The main effect was not significant

Pillai's Trace = 0.32	F value = 1.26	p = 0.32

and subsequent inspection of univariate F-tests indicated that no significant relationships existed at an alpha level = 0.01. These results are presented in Table 15. Means and standard deviations for groups provided with structure and those without structure, for all dependent variables, are presented in Table 16. Figure 22 illustrates the performance of groups for sessions with structure support and groups without structure support for **different ideas** (this one figure is representative of the relationship that exists for groups with structure and groups without structure; therefore, it was deemed unnecessary to provide additional figures).

While there were no significant differences, it is interesting to observe that groups with structure appear to outperform those without structure on a per capita basis except for average quality (same as GDSS) and number of good ideas.

Hypothesis		F value	p-value	:Struct > w/o Struct	Hypoth. Supported
HB1	Total Quantity of Ideas	0.31	$p > 0.25$	yes	no
	Number of Different Ideas	1.33	$p > 0.25$	yes	no
	Number of Unique Ideas	9.57	$p > 0.05$	yes	no
HB2	Total Quality of Ideas	0.83	$p > 0.25$	yes	no
	Average Quality of Ideas	0.46	$p > 0.25$	no	no
	Number of Good Ideas	0.02	$p > 0.25$	no	no
HB3	Satisfaction w/ the Idea Generation Process	1.94	$p < 0.25$	yes	no
HB4	Perceived Usefulness of the Idea Generation Technique	2.48	$p < 0.25$	yes	no

Table 15 - **<u>Structure</u> Main Effect** Univariate F Follow-up Tests

(F-ratios with 1 and 4 degrees of freedom)
(Hypotheses tested for significance at an alpha level = 0.01)

Dependent Variable:	Groups with Structure Support		Groups without Structure Support	
	Mean	SD	Mean	SD
Quantity:				
Total Ideas:	7.83	4.56	7.39	5.12
Different Ideas:	4.96	2.06	4.52	2.11
Unique Ideas:	0.34	0.22	0.19	0.17
Quality:				
Total Quality:	121.00	49.27	112.58	49.16
Average Quality:	3.75	1.47	3.80	1.34
Good Ideas:	0.98	0.56	1.00	0.45
Satisfaction:	5.48	0.75	5.23	0.78
Perceived Usefulness:	22.00	2.05	21.11	2.12

Table 16 - Means and Standard Deviations for **Groups with Structure Support and Groups without Structure Support** (on a per person basis)

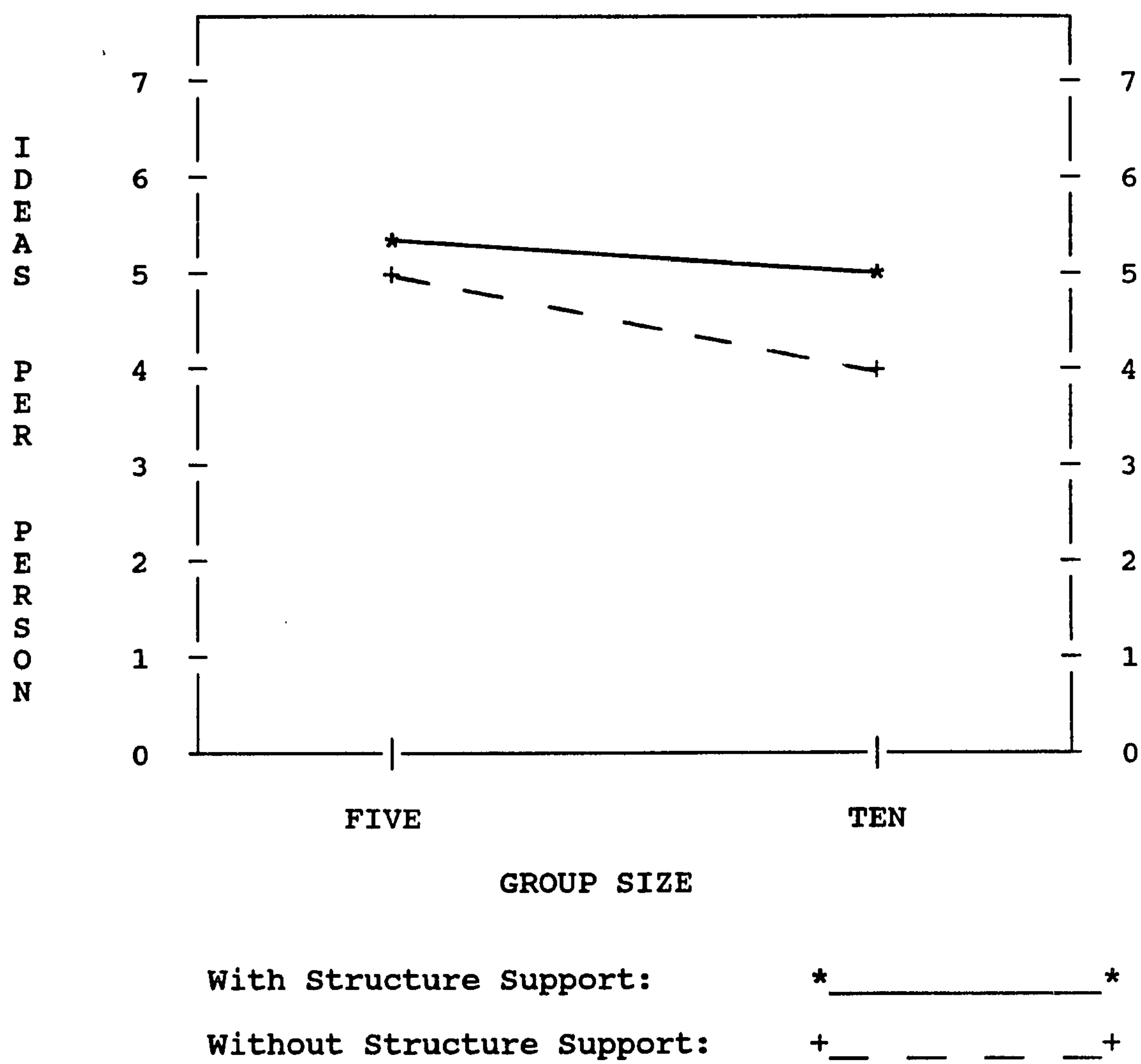


Figure 21

DIFFERENT IDEAS: Groups with Structure Support vs. Groups without Structure Support (Group sizes = 5 and 10)

5.4.3 Group Size Main Effect

While there were no hypotheses pertaining to a main effect for group size, the results of the MANOVA analysis are reported to provide a complete picture of the statistical results. This result indicates that a significant difference did exist between the two levels of group size, five and ten persons, at an alpha level = .05 (with 8 and 21 degrees of freedom). Univariate F-tests

Pillai's Trace = 0.99	F value = 479.36	p < 0.001

showed that the dependent variable **average quality of ideas** had a p-value < 0.01. Inspection of cell means indicated that groups of five had higher average quality per person than ten-person groups. Table 17 provides the results of the univariate analysis, and Table 18 provides means and standard deviations, for all dependent variables, for the two levels of group size (five- and ten-person groups).

5.4.4 Interaction for GDSS Support and Structure Support

Given the anticipated additive nature of the relationship between GDSS support and structure support, no hypotheses pertaining to their interaction were put forth. However, the results of the statistical tests are reported. No significant effect was found for the interaction at the alpha level = 0.05 (with 8 and 21 degrees of freedom); nor were any of the univariate F-tests significant at the alpha

Pillai's Trace = 0.25	F value = 0.88	p = 0.55

Dependent Variables	F value	p-value	GS: (5) > (10)
Total Quantity of Ideas	0.04	p > 0.25	no
Number of Different Ideas	6.99	p < 0.10	yes
Number of Unique Ideas	2.59	p < 0.25	no
Total Quality of Ideas	13.01	p < 0.025	yes
Average Quality of Ideas	1021.50	p < 0.001	yes
Number of Good Ideas	20.06	p < 0.025	yes
Satisfaction with the Idea Generation Process	0.39	p > 0.25	yes
Perceived Usefulness of the Idea Generation Technique	0.16	p > 0.25	yes

Table 17 - **Group Size Main Effect** Univariate F Follow-up Tests

(F-ratios with 1 and 4 degrees of freedom)

Dependent Variable:	Group Size = 5		Group Size = 10	
	Mean	SD	Mean	SD
Quantity:				
Total Ideas:	7.53	4.16	7.68	5.46
Different Ideas:	5.25	2.09	4.23	1.96
Unique Ideas:	0.23	0.19	0.31	0.23
Quality:				
Total Quality:	133.48	51.00	100.10	41.29
Average Quality:	5.12	0.36	2.43	0.26
Good Ideas:	1.21	0.54	0.77	0.35
Satisfaction:	5.41	0.74	5.30	0.80
Perceived Usefulness:	21.67	2.20	21.44	2.06

Table 18 - Means and Standard Deviations for *Group Size* = 5 and *Group Size* = 10 (on a per person basis)

level = 0.01. Table 19 presents results of these tests. Table 20 provides means and standard deviations, for all variables, for the GDSS support - structure support interaction.

5.4.5 Interaction between GDSS Support and Group Size

A significant effect is reported for the GDSS - Group Size interaction at an alpha level = 0.05 (with 8 and 21 degrees of freedom). Inspection of the univariate F-tests

Pillai's Trace = 0.52	F value = 2.86	p = 0.026

revealed that none of the variables were significantly different at alpha level = 0.01 level. The reason for a significant MANOVA effect, with no significant univariate effects, is based on the adjustments made to the degrees of freedom (see Section 5.3). Recall that there was a significant GDSS main effect (see Section 5.5.1). Since this is an ordinal interaction (the GDSS treatment is superior at both levels of group size), the primacy of the GDSS main treatment effect over the treatment without GDSS support remains (Glass and Hopkins, 1984). Table 21 provides the results of these tests. Table 22 provides the means and standard deviations, for each dependent variable, for the GDSS - group size interaction.

While the results of the MANOVA indicated a significant interaction between GDSS Support and group size, this did not answer the specific research questions of interest in the study. The key issue is whether or not GDSS support

Dependent Variables	F value	p-value
Total Quantity of Ideas	0.10	p > 0.25
Number of Different Ideas	0.61	p > 0.25
Number of Unique Ideas	1.70	p > 0.25
Total Quality of Ideas	0.48	p > 0.25
Average Quality of Ideas	0.31	p > 0.25
Number of Good Ideas	0.48	p > 0.25
Satisfaction with the Idea Generation Process	1.16	p > 0.25
Perceived Usefulness of the Idea Generation Technique	0.001	p > 0.25

Table 19 - **GDSS Support and Structure Interaction Effect** Univariate F Follow-up Tests

(F-ratios with 1 and 4 degrees of freedom)

Dependent Variables		With GDSS Support		Without GDSS Support	
		Structure		Structure	
		Provided	Not Prov.	Provided	Not Prov.
Quantity:					
Total Ideas:	Mn	11.81	11.19	3.84	3.59
	Sd	2.84	4.64	1.05	1.34
Different Ideas:	Mn	6.59	5.92	3.34	3.12
	Sd	1.52	1.99	0.89	1.03
Unique Ideas:	Mn	0.43	0.23	0.26	0.15
	Sd	0.26	0.20	0.14	0.14
Quality:					
Total Quality:	Mn	157.43	144.55	84.56	80.60
	Sd	39.25	46.02	25.38	26.37
Average Quality:	Mn	3.69	3.71	3.80	3.90
	Sd	1.56	1.38	1.42	1.38
Good Ideas:	Mn	1.25	1.19	0.72	0.80
	Sd	0.60	0.28	0.37	0.50
Satisfaction:	Mn	5.85	5.74	5.11	4.72
	Sd	0.54	0.45	0.76	0.71
Perceived Usefulness:	Mn	22.65	21.74	21.36	20.48
	Sd	1.61	1.30	2.28	2.59

Table 20 - Means and Standard Deviations for **Groups with <u>GDSS Support</u> and <u>Groups without</u> <u>GDSS Support</u>, for <u>Structure Provided</u> and <u>Structure Not Provided</u>** (on a per person basis)

Dependent Variables	F-value	p-value
Total Quantity of Ideas	8.89	$p < 0.05$
Number of Different Ideas	1.09	$p > 0.25$
Number of Unique Ideas	10.61	$p < 0.05$
Total Quality of Ideas	0.24	$p > 0.25$
Average Quality of Ideas	0.08	$p > 0.25$
Number of Good Ideas	0.02	$p > 0.25$
Satisfaction with the Idea Generation Process	0.63	$p > 0.25$
Perceived Usefulness of the Idea Generation Technique	0.29	$p > 0.25$

Table 21 - **GDSS Support and Group Size Interaction** Effect Univariate F Follow-up Tests

(F-ratios with 1 and 4 degrees of freedom)

Dependent Variables		Session with GDSS Support		Session without GDSS Support	
		Group Size		Group Size	
		Five	Ten	Five	Ten
Quantity:					
Total Ideas:	Mn	10.54	12.46	4.53	2.91
	Sd	3.90	3.56	1.13	0.53
Different Ideas:	Mn	6.61	5.89	3.89	2.57
	Sd	2.11	1.33	0.81	0.54
Unique Ideas:	Mn	0.23	0.43	0.23	0.18
	Sd	0.22	0.24	0.16	0.13
Quality:					
Total Quality:	Mn	166.10	135.88	100.85	64.31
	Sd	51.36	24.95	21.59	13.04
Average Quality:	Mn	5.05	2.34	5.19	2.51
	Sd	0.43	0.28	0.28	0.20
Good Ideas:	Mn	1.44	1.01	0.99	0.55
	Sd	0.53	0.23	0.45	0.29
Satisfaction:	Mn	5.84	5.79	5.03	4.81
	Sd	0.57	0.42	0.71	0.80
Perceived Usefulness:	Mn	22.19	22.20	21.15	20.68
	Sd	1.87	1.11	2.43	2.51

Table 22 - Means and Standard Deviations for **Sessions with <u>GDSS Support</u>** and **Sessions <u>without GDSS Support</u>** for **<u>Group Sizes</u> of <u>Five</u> and <u>Ten Persons</u>** (on a per person basis)

will maintain the same per person level of performance as group size increases from five to ten, for quantity and quality of ideas, as well as maintain the same level of preference for the perceived usefulness of the idea generation technique and maintain the same level of satisfaction with the idea generation process. It is also believed that groups without GDSS support will not be able to maintain the same level of performance. For evaluation of this key issue, the following hypotheses were stated (see Section 3.3 for diagrams of the hypothesized relationships):

HAC1: Quantity of Ideas:

A: Groups with GDSS support will generate an equal number of ideas, per group member, regardless of group size (whether in groups of five or ten persons).

B: Groups without GDSS support will generate more ideas, per group member, in smaller groups (groups of five persons) as opposed to larger groups (groups of ten persons).

HAC2: Quality of ideas:

A: Groups with GDSS support will generate ideas of equal quality, per group member, regardless of group size (groups of five or ten persons).

B: Groups without GDSS support will generate ideas of higher quality, per group member, in smaller groups (groups of five) as opposed to larger groups (groups of ten).

HAC3: Satisfaction with the idea generation process:

A: Groups using GDSS support will have a higher level of satisfaction with the idea generation process, per group member, in larger groups (groups of ten) than in smaller groups (groups of five).

B: Groups not using GDSS support will have a <u>higher</u> level of satisfaction with the idea generation process, per group member, in smaller groups (groups of five) than in larger groups (groups of ten).

HAC4: Perceived Usefulness of the idea generation technique:

A: Groups with GDSS support will perceive the idea generation technique to be <u>more</u> useful, per group member, in larger groups (groups of ten) than in smaller groups (groups of five).

B: Groups without GDSS support will perceive the idea generation technique to be <u>more</u> useful, per group member, in smaller groups (groups of five) than in larger groups (groups of ten).

To test these hypotheses a series of t-tests were performed. For those groups which had GDSS support, results were compared between five and ten-person groups. The same procedure was followed for groups without GDSS support. The goal was to determine if the performance, perceived usefulness, and satisfaction levels were maintained, on a per person basis, as group size increased. A significance level of alpha = 0.01 was set for each comparison (see the discussion of significance level in Section 5.3 of this chapter. See Figures 14 - 21 for the comparisons between the sessions with GDSS support and the sessions without GDSS support, for groups of five and ten persons. Tables 23 and 24 report the results of these comparisons for each dependent variable.

For performance levels to be maintained, the associated p-values would have to be > 0.05. If this were the case, the expected distribution of these p-values should be

Hypothesis		t-value (df)	p-value	GS: (5) > (10)	Hypoth. Supported
HAC1 (A)	Total Quantity of Ideas	-1.45 (30)	p = 0.16	no	yes
	Number of Different Ideas	1.15 (30)	p = 0.26	yes	yes
	Number of Unique Ideas	-2.52 (30)	p = 0.02	no	yes
HAC2 (A)	Total Quality of Ideas	2.12 (21)	p = 0.05	yes	yes
	Average Quality of Ideas	21.29 (30)	p < 0.001 *	yes	no
	Number of Good Ideas	2.85 (20)	p = 0.01	yes	yes
HAC 3 (A)	Satisfaction w/ the Idea Generation Process	0.24 (30)	p = 0.40	yes	no
HAC 4 (A)	Perceived Usefulness of the Idea Generation Technique	-0.02 (30)	p = 0.49	no	no

Table 23 - **GDSS Support** and **Group Size** Interaction Effect Univariate Follow-up t-Tests for **Groups with GDSS Support**

(* - Significant at the alpha < 0.01 level)

Hypothesis		t-value (df)	p-value	GS: (5) > (10)	Hypoth. Supported
HAC 1 (B)	Total Quantity of Ideas	5.20 (21)	**p < 0.001 ***	yes	yes
	Number of Different Ideas	5.40 (30)	**p < 0.001 ***	yes	yes
	Number of Unique Ideas	0.84 (30)	p = 0.41	yes	no
HAC 2 (B)	Total Quality of Ideas	5.51 (30)	**p < 0.001 ***	yes	yes
	Average Quality of Ideas	0.79 (15)	p = 0.44	yes	no
	Number of Good Ideas	3.39 (30)	**p = 0.002 ***	yes	yes
HAC 3 (B)	Satisfaction w/ the Idea Generation Process	0.65 (30)	p = 0.26	yes	no
HAC 4 (B)	Perceived Usefulness of the Idea Generation Technique	0.74 (30)	p = 0.22	yes	no

Table 24 - GDSS Support and Group Size Interaction Effect Univariate Follow-up t-Tests for Groups without GDSS Support

(* - Significant at the alpha < 0.01 level)

uniform: half the p-values > 0.50 and half the p-values < 0.50. There is concern raised since the p-values for the six hypothesized equalities result in only one of the six p-values being > 0.50. To assess the validity of these results, a sign test was performed on the p-values for the six hypotheses pertaining to quantity and quality of ideas. The sign test yielded a p-value of 0.109, which does not result in a rejection of the null hypothesis that these p-values could be drawn from a uniform distribution, which provides support for the validity of the results obtained from the t-tests.

For groups with GDSS support there was a significant difference for only one of the eight hypotheses. This difference occurred for **average quality** of ideas, where groups of five outperformed groups of ten, on a per person basis. This finding is in line with the results of the group size analysis, where **average quality** was the only statistically significant difference with the smaller groups (of five) outperforming the larger groups (of ten). There were no statistically significant differences between any of the group means, on a per person basis, for any of the remaining dependent variables pertaining to performance (quantity and quality of ideas) between five and ten-person groups. This supports five of the GDSS hypotheses for the ability of GDSS support to maintain the per person level of performance as group size increases from five to ten.

For the comparisons based on preference, **satisfaction** and **perceived usefulness**, neither hypothesis was supported. Both were hypothesized to have higher levels of preference for larger groups (of ten), as opposed to smaller groups (of five). While larger groups did not have a higher preference, there was no statistically significant difference between the two groups, indicating that the preference level was approximately the same for the different sized groups. This indicates that as group size increased from five to ten persons, there was no decrease in the level of satisfaction or perceived usefulness for sessions with GDSS support.

For the groups without GDSS support, half of the group means were significantly different, supporting those hypotheses that indicated group performance, on a per person basis, would decrease as group size increased. Per person performance dropped significantly for the groups without GDSS support for the **total quantity** of ideas and **number of different ideas**, as well as the **total quality** and **number of good ideas**. No significant differences were found for the remaining dependent variables: **number of unique ideas**, **average quality of ideas**, **satisfaction** with the idea generation process, and **perceived usefulness** of the idea generation technique.

5.4.6 Interaction between Structure Support and Group Size

A nonsignificant effect was reported for the structure - group size interaction at an alpha level = 0.05

(with 8 and 21 degrees of freedom). Inspection of the

Pillai's Trace = 0.22	F value = 0.74	p = 0.657

univariate F-tests revealed no dependent variable comparisons that were significant at an alpha level = 0.01. Results of the univariate analysis are presented in Table 25. Table 26 presents the means and standard deviations, for each dependent variable, for the structure - group size interaction.

While the results of the MANOVA and univariate tests indicate that no significant interaction exists between structure and group size, this result does not answer the specific questions of interest in the study. The key issue is whether or not structure support will allow for only a small, nonsignificant decline in per person performance level as group size increased from five to ten persons for quantity and quality of ideas, satisfaction with the idea generation process, and perceived usefulness of the idea generation technique. It is also believed that groups without structure provided will not be able to maintain the same level of performance and that there would actually be a significant difference between groups of five and ten persons. Based on this issue, the following hypotheses will be evaluated:

HBC1: Quantity of ideas:

A: Groups with structure provided will generate <u>fewer</u> ideas per group member, in larger groups (groups of ten) than in smaller groups (groups of five).

Dependent Variables	F-value	p-value
Total Quantity of Ideas	0.33	p > 0.25
Number of Different Ideas	0.03	p > 0.25
Number of Unique Ideas	0.38	p > 0.25
Total Quality of Ideas	0.08	p > 0.25
Average Quality of Ideas	2.31	p < 0.25
Number of Good Ideas	0.78	p > 0.25
Satisfaction with the Idea Generation Process	0.17	p > 0.25
Perceived Usefulness of Idea Idea Generation Technique	1.17	p > 0.25

Table 25 - **Structure Support and Group Size Interaction** Effect Univariate F Follow-up Tests

(* - significant at the alpha < 0.01 level)

Dependent Variables		Session with Structure Support		Session without Structure Support	
		Group Size		Group Size	
		Five	Ten	Five	Ten
Quantity:					
Total Ideas:	Mn	7.53	8.13	7.54	7.24
	Sd	3.56	5.49	4.80	5.57
Different Ideas:	Mn	5.44	4.49	5.06	3.98
	Sd	2.07	1.99	2.16	1.97
Unique Ideas:	Mn	0.29	0.40	0.16	0.21
	Sd	0.19	0.24	0.17	0.18
Quality:					
Total Quality:	Mn	138.99	103.01	127.96	97.19
	Sd	49.57	43.22	53.40	40.47
Average Quality:	Mn	5.16	2.33	5.09	2.52
	Sd	0.36	0.25	0.37	0.24
Good Ideas:	Mn	1.25	0.72	1.18	0.82
	Sd	0.61	0.35	0.47	0.36
Satisfaction:	Mn	5.50	5.46	5.33	5.14
	Sd	0.64	0.87	0.85	0.73
Perceived Usefulness:	Mn	22.43	21.58	20.91	21.30
	Sd	2.04	2.04	2.15	2.14

Table 26 - Means and Standard Deviations for **Sessions with Structure Support** and **Session without Structure Support**, for **Group Sizes of Five and Ten Persons** (on a per person basis)

B: Groups without structure provided will generate significantly fewer ideas, per group member, in larger groups (groups of ten) than in smaller groups (groups of five).

HBC2: Quality of ideas:

A: Groups with structure provided will generate ideas of lower quality, per group member, in larger groups (groups of ten) than in smaller groups (groups of five).

B: Groups without structure provided will generate ideas of significantly lower quality, per group member, in larger groups (of ten) than in smaller groups (groups of five).

HBC3: Satisfaction with the idea generation process:

A: Groups with structure provided will have a higher level of satisfaction with the idea generation process, per group member, for smaller groups (groups of five) than for larger groups (groups of ten).

B: Groups without structure provided will have a significantly lower level of satisfaction with the idea generation process, per group member, for larger groups (groups of ten) than for smaller groups (groups of five).

HBC4: Perceived Usefulness for the idea generation technique:

A: Groups with structure provided will have a higher level of perceived usefulness, per group member, for smaller groups (groups of five) than for larger groups (groups of ten).

B: Groups without structure provided will have a significantly lower level of perceived usefulness, per group member, for smaller groups (groups of five) than for larger groups (groups of ten).

To test these hypotheses a series of t-tests were performed. For those groups with structure support, results were compared between five- and ten-person groups. The same procedure was followed for groups without structure support. The goal was to determine if there was a significant drop in performance and preference for groups without structure, on a per person basis, as group size increased. A significance level of alpha = 0.01 was set for each comparison (see the discussion on significance level in Section 5.3 of this chapter). Tables 27 and 28 report the results of these comparisons for each dependent variable.

For groups with structure support there was a significant difference found between group means, on a per person basis, for the **average quality** of ideas and the number of **good ideas** generated with the smaller groups (of five) outperforming the larger groups (of ten) for both variables. Thus, support is provided for the remaining six hypotheses that there would not be a significant difference, on a per person basis, between groups provided with structure support as group size increased from five to ten. For the groups without structure provided the only significant difference for group means was for the **average quality of ideas**, with smaller groups having the higher average. All other differences were not significant; therefore, the other hypotheses which proposed that a difference would exist for groups without structure were not supported.

5.4.7 Three-Way Interaction (GDSS, Structure, and Group Size)

Three-way interactions are not common, and one was not hypothesized in this situation. The results of statistical tests for the three-way interaction are reported. No

Hypothesis		t-value (df)	p-value	GS: (5) > (10)	Hypoth. Supported
HBC1 (A)	Total Quantity of Ideas	-0.37 (30)	p = 0.36	no	yes
	Number of Different Ideas	1.32 (30)	p = 0.10	yes	yes
	Number of Unique Ideas	-1.45 (30)	p = 0.08	no	yes
HBC2 (A)	Total Quality of Ideas	2.19 (30)	p = 0.02	yes	yes
	Average Quality of Ideas	25.86 (30)	**p < 0.001 ***	yes	no
	Number of Good Ideas	3.02 (24)	**p < 0.006 ***	yes	no
HBC 3 (A)	Satisfaction w/ the Idea Generation Process	0.14 (30)	p = 0.45	yes	yes
HBC 4 (A)	Perceived Usefulness of the Idea Generation Technique	1.17 (30)	p = 0.12	yes	yes

Table 27 - **Structure Support and Group Size Interaction Effect** Univariate Follow-up t-Tests for **Groups with Structure Support**

(* - Significant at the alpha < 0.01 level)

Hypothesis		t-value (df)	p-value	GS: (5) > (10)	Hypoth. Supported
HAC 1 (B)	Total Quantity of Ideas	1.35 (30)	p = 0.43	yes	no
	Number of Different Ideas	1.49 (30)	p = 0.07	yes	no
	Number of Unique Ideas	-0.81 (30)	p = 0.21	no	no
HAC 2 (B)	Total Quality of Ideas	1.84 (30)	p = 0.04	yes	no
	Average Quality of Ideas	23.29 (30)	**p < 0.001 ***	yes	yes
	Number of Good Ideas	2.43 (30)	p = 0.01	yes	no
HAC 3 (B)	Satisfaction w/ the Idea Generation Process	0.67 (30)	p = 0.25	yes	no
HAC 4 (B)	Perceived Usefulness of the Idea Generation Technique	-0.51 (30)	p = 0.30	yes	no

Table 28 - **Structure and Group Size Interaction Effect** Univariate Follow-up T-Tests for **Groups without Structure Support**

(* - significant at the alpha < 0.01 level)

significant effect was found for the interaction at an alpha level = 0.05; nor were any of the univariate F-tests

Pillai's Trace = 0.26	F value = 0.89	p = 0.54

significant at an alpha level = 0.01. Results of the univariate tests are presented in Table 29.

5.5 Further Investigation of the Relationships between the Four Support Techniques (BS, EBS, NI, and ENI)

This study has investigated the combined impact of two independent variables: GDSS support and structure support. The combination of these two variables has been referred to as **technique support.** While hypotheses have been tested evaluating the overall impact of these two variables, it is of interest to better understand how the four combinations of these variables compare with one another [Brainstorming (BS), Electronic Brainstorming (EBS), No Instructions (NI), and Electronic No Instructions (ENI)].

Post-hoc analysis utilizing multiple comparisons of these techniques will help to provide a better understanding of the individual and combined effects of the two treatments. The issue is, which factor(s) best improve performance for idea generation? Is it, for example, the addition of structure, such as Osborn's Brainstorming instructions? Or is it the benefits provided by the introduction of the GDSS?

By comparing these four levels of technique support, some inferences can be drawn as to which factor(s) are most

Dependent Variables	F value	p-value
Total Quantity of Ideas	0.57	$p > 0.25$
Number of Different Ideas	0.01	$p > 0.25$
Number of Unique Ideas	0.42	$p > 0.25$
Total Quality of Ideas	0.14	$p > 0.25$
Average Quality of Ideas	1.24	$p > 0.25$
Number of Good Ideas	1.74	$p > 0.25$
Satisfaction with the Idea Generation Process	3.00	$p < 0.25$
Perceived Usefulness of the Idea Generation Technique	0.21	$p > 0.25$

Table 29 - **GDSS Support, Group Size, and Structure Interaction** Effect Univariate F Follow-up Tests

(* - significant at the alpha < 0.01 level)

important in supporting the idea generation process. To investigate this relationship, a one way analysis of variance (ANOVA) was performed for each dependent variable. For this analysis, technique support was treated as an independent variable with four levels. Scheffe's multiple comparison procedure was selected to test for differences between the treatment means due to its conservative nature. These tests were evaluated at an alpha level = 0.01, as were all other follow-up analyses (see Section 5.3). Table 30 provides means for each of the dependent variables for each of the four treatments. All comparisons are made on a per person basis (e.g., number of ideas per person for each group).

Tables 31A - 31F display the results of the multiple comparisons procedure. Each table has both sets of treatments displayed across the top and left-hand side. If a significant difference exists between the means, from one to three letters will appear in the appropriate boxes ("C" is for combined means over both group sizes, "F" is for groups size of five, and "T" is for group size of ten). The existence of a letter in the box indicates that the treatment on the left-hand side has a mean significantly higher than the treatment on the top. Results will be briefly discussed for each dependent variable, with the emphasis on the combined (group size) mean scores.

Significant one way ANOVA results for both **total quantity** of ideas and **number of different ideas** (both with

Dependent Variables	BS	EBS	NI	ENI
Quantity:				
Total Ideas:	3.84	11.81	3.59	11.19
Different Ideas:	3.34	6.59	3.12	5.92
Unique Ideas:	0.26	0.43	0.15	0.23
Quality:				
Total Quality:	84.56	157.43	80.60	144.43
Average Quality:	3.80	3.69	3.90	3.71
Good Ideas:	0.72	1.25	0.80	1.19
Satisfaction:	5.11	5.85	4.72	5.74
Perceived Usefulness:	21.36	22.65	20.48	21.74

Table 30 - **Group Means for BS, EBS, NI, and ENI Treatments**
(on a per person basis)

tqnt	BS	EBS	NI	ENI
BS				
EBS	FTC		FTC	
NI				
ENI	FTC		FTC	

Table 31A - Multiple Comparisons for **Total Quantity** (significant at alpha = .01)

dqnt	BS	EBS	NI	ENI
BS				
EBS	TC		FTC	
NI				
ENI	TC		TC	

Table 31B - Multiple Comparisons for **Different Ideas** (significant at alpha = .01)

uqnt	BS	EBS	NI	ENI
BS				
EBS	T		TC	
NI				
ENI				

Table 31C - Multiple Comparisons for **Unique Ideas** (significant at alpha = .01)

tqul	BS	EBS	NI	ENI
BS				
EBS	TC		FTC	
NI				
ENI	TC		TC	

Table 31D - Multiple Comparisons for **Total Quality** (significant at alpha = .01)

aqul	BS	EBS	NI	ENI
BS				
EBS				
NI	T			
ENI				

Table 31E - Multiple Comparisons for **Average Quality** (significant at alpha = .01)

gqul	BS	EBS	NI	ENI
BS				
EBS	C		C	
NI				
ENI	TC		T	

Table 31F - Multiple Comparisons for **Good Ideas** (significant at alpha = .01)

sat	BS	EBS	NI	ENI
BS				
EBS			TC	
NI				
ENI			C	

Table 31G - Multiple Comparisons for **Satisfaction** (significant at alpha = .01)

pu	BS	EBS	NI	ENI
BS				
EBS				
NI				
ENI				

Table 31H - Multiple Comparisons for **Perceived Usefulness** (significant at alpha = .01)

$p < 0.001$) are evidenced by significant differences between the treatments with GDSS support (EBS and ENI) and the treatments without GDSS support (BS and NI) (Tables 31A and 31B). Similar results were found for **total quality** ($p < 0.001$; Table 31D). However, for **unique ideas** only EBS and NI significantly differed from one another ($p=0.009$). While for **good ideas**, EBS differed significantly from BS and NI, and ENI from just BS ($p=0.0018$; Table 31F). For **satisfaction**, the only significant difference was EBS and ENI differing from NI ($p < 0.001$; Table 31G). There were no significant differences found for **average quality** ($p=0.9729$; Table 31E) or **perceived usefulness** ($p=.0291$; Table 31H).

Table 32 provides a rank order comparison of the four treatment groups, for performance (quantity and quality of ideas) and preference (perceived usefulness and satisfaction). Treatment means and an indication of significant differences are provided to demonstrate the relationship between the treatment groups (significant differences are indicated by a "**" underneath the treatment that is significantly different from another treatment, designated by "*". If more than one difference exists, then "++" and "+" will also be displayed. For example, for total number of ideas, EBS is significantly different from BS and NI, and ENI is significantly different from BS and NI).

The comparisons provided in this section provide additional evidence of the relationship between GDSS support and the attainment of better outcomes, both in terms of

Dependent Variable	Treatment Group Comparisons						
Total Number of Ideas	EBS	>	ENI	>	BS	>	NI
Means:	11.8	>	11.2	>	3.8	>	3.6
Significant:	**		++		*+		*+
Number of Different Ideas	EBS	>	ENI	>	BS	>	NI
Means:	6.6	>	5.9	>	3.3	>	3.1
Significant:	**		++		*+		*+
Number of Unique Ideas	EBS	>	BS	>	ENI	>	NI
Means:	0.43	>	0.25	>	0.23	>	0.15
Significant:	**						*
Total Idea Quality	EBS	>	ENI	>	BS	>	NI
Means:	157.4	>	144.6	>	84.56	>	80.6
Significant:	**		++		*+		*+
Average Idea Quality	NI	>	BS	>	ENI	>	EBS
Means:	3.9	>	3.8	>	3.70	>	3.69
Significant:							
Number of Good Ideas	EBS	>	ENI	>	NI	>	BS
Means:	1.25	>	1.19	>	0.8	>	0.72
Significant:	**		++		*+		*+
Satisfaction	EBS	>	ENI	>	BS	>	NI
Means:	5.85	>	5.74	>	5.11	>	4.72
Significant:	**		++				*+
Perceived Usefulness	EBS	>	ENI	>	BS	>	NI
Means:	22.65	>	21.74	>	21.36	>	20.48
Significant:							

Table 32 - **Rank Ordering of *Treatment Groups* by Performance and Preference**

performance and preference. What is less clear, but still evident, is the gain provided by the support of structure, over groups without structure provided, whether in combination with GDSS or not. The only possible (and very weak) exception to this is for the **average quality of ideas**, in which it could be speculated that GDSS support provided the power/freedom to "throw out anything that comes to mind" AT THE COST of providing some easily screened "junk" (it is this "junk" that would bring down the average quality). The comparisons presented in this section provide additional support for the superiority provided by GDSS support and provide a clearer picture as to the relationship of the four support techniques.

5.6 Potential Problems: Facilitation, Order, Task, and Time Effects

There are many factors which may confound results of an experimental study; examples of these include facilitator effects, order effects, learning effects, task effects, or time (of day) effects. Facilitator effects can have a major impact when more than one facilitator is involved in running group sessions. Since one facilitator ran all sessions, there should not be any comparative facilitator effects in this study. Order effects and learning effects can have a substantial impact in situations where multiple sessions occur (such as in this study). Task effects can also be very important in impacting performance, especially if one task is easier, more interesting, or more applicable than the other(s). Likewise, the time of day an experimental session is conducted has been shown to impact the performance of subjects in experimental studies. These factors were statistically evaluated at an alpha level = 0.01, the same alpha level used for all follow-up analyses (see Section 5.3).

In this study two tasks were used (the Library Problem and the Parking Problem). A completely counterbalanced design was employed to reduce the potential for order effects and reduce the impact of learning effects. Of the 32 groups, 16 performed the Library Problem first, and then the Parking Problem second; this was reversed for the other 16 groups. The two tasks were quite similar in terms of overall group performance, based on the number of different ideas, unique ideas, and good ideas generated for each task:

Group Performance Factor	Parking Problem	Library Problem
Number of different ideas	212	194
Number of unique ideas	65	68
Number of good ideas	38	37

Another way the task can impact performance is if one task is felt to be more difficult than the other (in this case of two tasks). In order to assess task difficulty, the subjects were asked to rate "how easy" it was to generate ideas for each task, immediately after each of the two sessions (question 7, Post-Session survey; see Appendix

C.4). Two matched pairs t-tests were performed to evaluate task effects: the first for session order and the second for the two tasks. The results of the first t-test yielded a p-value of 0.140, indicating that, at an alpha level = 0.01, there was no statistically significant difference in the subjects' perception of task difficulty for the order in which they performed the tasks. The second t-test, for the two tasks, yielded a p-value of 0.092, indicating that, at an alpha level = 0.01, there was no statistically significant difference in the subjects' perception of task difficulty for the two different tasks.

The time of day an experimental session occurs has been shown to have an impact on the results of the performance of a subject in an experimental study. Subjects participated in this study during one of three different time blocks: 1) early afternoon (starting before 3:00 P.M.) (n=10), 2) late afternoon/early evening (starting after 3:00 P.M. and before 6:00 P.M.) (n=9), and 3) evening (starting after 6:00 P.M.) (n=13).

To assess the impact of these three effects (order, task, and time of day), individually and jointly, a separate MANOVA was run with these three effects treated as independent variables (two levels for order and task, and three levels for time). While there were no significant multivariate or univariate results for any of the interactions, all three main effects were significant at an alpha level = 0.05. This indicates that at least one of the eight dependent variables is affected by these factors, however, no significant effects were found to exist at an alpha level = 0.01. The lack of significant univariate results, given significant main effects, is likely due to the adjustments made to the degrees of freedom. Although none of these effects were significant, each will be briefly addressed.

The task main effect was further evaluated by use of the univariate F scores which revealed a significant effect for the **number of good ideas** at an <u>alpha level</u> = <u>0.05</u> (with 1 and 4 degrees of freedom). Examination of cell means indicated that there were more good ideas generated by the groups for the Parking Problem than the Library Problem. While there were approximately the same number of ideas classified as "good ideas" for each problem (38 for the Parking Problem, 37 for the Library Problem), one potential explanation for this result is that almost every group seemed to "hit upon" a standard set of "good ideas" for the Parking Problem. However, "good ideas" for the Library Problem were more uniformly distributed. Given the counterbalanced design where each task was performed by an equal number of groups for each treatment, and the significant GDSS main effect for number of good ideas, it is unlikely that this difference had an impact on the results of the study.

The time of day main effect was further evaluated by use of the univariate F scores which indicated a significant effect for **average quality of ideas** at an alpha level = 0.10 (with 1 and 4 degrees of freedom). This finding may have been caused by the inconsistent results pertaining to average quality of ideas. Results for this dependent variable are contradictory to those for most of the other dependent variables. For example, Table 32 (Section 5.5) displays performance ordering for the four support techniques (BS, EBS, NI, ENI); for six of the other seven dependent variables, NI was last (and next to last on the other). A number of the NI groups were run in the afternoon, and it was the NI groups that had a higher score for average quality of ideas. As also indicated in Section 5.5, the higher scores for NI groups may possibly be the result of the lack of support (both GDSS and structure) which may have led to fewer ideas being generated and more "filtering" of ideas occurring during idea generation. Therefore, it is unlikely that the time of day an experimental session was run had an impact on the results of this study.

The order main effect was further evaluated by use of the univariate F scores indicating a significant effect for **perceived usefulness** at an alpha level = 0.05 level (with 1 and 4 degrees of freedom). Examination of cell means indicated that there was a higher rating of perceived usefulness for the first session (idea generation technique used). This may be due, in part, to the existence of structure provided the first session -- either through the use of a structured technique or just the structure imposed by the experimental conditions. This may have led to the perception that the first technique was more useful, when compared to the unstructured processes in which the subjects may have been use to participating. Despite this result, a significant main effect for perceived usefulness did occur for GDSS support (although, only at the $p < 0.05$ level), therefore, it is unlikely that this factor had an impact on the results of the study.

One other potential confounding effect encountered in this study was the use of a computerized survey tool to administer and collect questionnaire responses from the subjects. Since all subjects used this tool for all questionnaires, there should be no impact based on differential treatment. However, the potential for bias is introduced by using a new or unfamiliar medium to administer questionnaires. To assess this impact a study was conducted to investigate the potential bias of collecting survey data on-line (Fellers, et al., 1989). The results of this study showed that little to no bias was introduced by the use of the computerized survey tool. This was especially true for the preference (Likert) scale questions, the type of questions used to assess self-reported participant **satisfaction** with the idea generation process and the **perceived usefulness** of the idea generation technique.

Results of this study indicate that, if anything, the subjects were more motivated to respond using the computerized survey tool, which may have led to a more accurate assessment of the questions being addressed.

5.7 Post-Hoc Analysis of Key Dependent Variables

The use of MANOVA was predicated on the belief that the appropriate assumptions were met for its use. The presence of three dependent variables for each of two measures (quantity and quality) may have contributed to some of the difficulties encountered. A simplified analysis of the key variables in the study was performed by dropping two variables for both quantity and quality from the analysis (total number of ideas, number of unique ideas, total quality of ideas, and average quality of ideas). An analysis was then run with the four remaining dependent variables, one per hypothesis set: **number of different ideas, number of good ideas**, **perceived usefulness**, and **satisfaction**. This analysis first yielded a Box's M with a significance level of 0.311, supporting the homogeneity assumption. Significant main effects were encountered for size ($p = 0.006$) and GDSS ($p < 0.001$). While Mauchly's sphericity test still yielded a significance level less than 0.001, the Huynh-Feldt adjustment was 0.54132 (as opposed to 0.14187 previously), thus resulting in adjusted degrees of freedom of 1 and 15 (as opposed to 1 and 4). Analysis of the adjusted univariate F scores revealed GDSS main effects for three dependent variables at a p-value < 0.001 (**number of**

different ideas, number of good ideas, and **satisfaction** with the idea generation process) with the fourth, **perceived usefulness**, with a p-value < 0.01. The only other significant univariate F is from the size main effect, with smaller groups generating more **good ideas** (per person) than larger groups (p-value < 0.001).

5.8 Summary

This chapter presented the results of the statistical testing of the hypotheses for this study. This was preceded by a presentation of the demographic data for the subject pool. Comparison of treatment subgroups indicated that there were minor differences between subgroups, and the differences that existed were not unexpected (e.g., expected personal contribution -- ten-person group members as opposed to five-person group members). Procedures used to determine idea quantity and quality scores were detailed, and the interrater reliability was reported for the quality judgments.

MANOVA was used to simultaneously test the eight dependent variables over the three independent variables. Analysis of hypotheses provided support for most GDSS main effects. However, main effects for structure support were not supported. Further evaluation indicated that as group size increased from five to ten, GDSS support enabled ten-person groups to perform at the same per person level as five-person groups (no loss in per person productivity); in contrast, losses did occur for groups without GDSS support as size increased. Multiple comparison evaluation provided additional reinforcement of the superiority of the techniques with GDSS support. Finally, several factors were considered and rejected for their possible nuisance impacts on the outcome of the study.

The convergent validity of the post-hoc analysis reported in Section 5.7 supports and validates the analysis presented in this chapter. In both analyses GDSS has been shown to make a significant difference in the **number of different ideas, good ideas**, the **perceived usefulness** of the technique, and **satisfaction** with the idea generation process. These arguments have been made based on the original proposed path of analysis (appropriate use of MANOVA). This has been supported and strengthened by the simplified analysis that strongly suggests that the potential statistical weaknesses involved were not operating in this analysis.

CHAPTER 6

DISCUSSION AND CONCLUSIONS

6.0 Introduction

This chapter presents a discussion and summary of the findings from the experiment and their implications. Results of the hypothesis testing are presented, by independent variable, encompassing each of the dependent variables. Implications for research and practice are presented, along with suggestions for future research. Finally, limitations and assumptions of the study are presented.

6.1 Discussion of Results

This section presents a discussion of the results of the statistical analysis for this study. Multivariate Analysis of Variance (MANOVA) was used to test for significant main effects at an alpha level = 0.05, and univariate follow-up tests were conducted at an alpha level = 0.01. Results are presented for each of the hypothesized main effects and interactions.

6.1.1 GDSS Main Effect

It was hypothesized that groups would perform significantly better when provided with GDSS support, as opposed to when they were not provided with GDSS support, for each of the two task outcomes variable classes (quantity and quality of ideas). Groups were also hypothesized to display a preference towards the techniques with GDSS support for the two group outcomes: satisfaction with the group idea generation process and perceived usefulness of the idea generation techniques. The eight dependent variables are listed in Table 33, along with the resulting p-values from their evaluation, the direction of the effect, and whether or not the hypothesis for that variable was supported. Results show that GDSS support enabled groups to generate significantly more **total ideas**, as well as more **different ideas**, than when they were without GDSS support. Groups also generated more **unique ideas** with GDSS support, but this result was not statistically significant at an alpha level = 0.01 ($p < 0.05$). This result is in line with most of the previous literature reporting that GDSS support enabled groups to generate more ideas than groups without GDSS support.

In this study, when groups had GDSS support they generated ideas of significantly higher **total quality**, which is in line with generating more total ideas, but more importantly, they also generated more **"good" ideas**. Ideas were classified as "good" based on the assessment of three expert judges for each task. While final solution quality is often a part of GDSS studies, few studies have assessed the quality of individual ideas. For another assessment of quality, **average quality**, when groups had GDSS support they had lower average quality, but not significantly, than when they were without GDSS support. This may be partially attributed to the fact that when groups had GDSS support

	Hypothesis	p-value	GDSS > w/o GDSS	Hypoth. Supported
HA1	Total Quantity of Ideas	$p < 0.001$	Yes	Yes
	Number of Different Ideas	$p < 0.001$	Yes	Yes
	Number of Unique Ideas	$p < 0.05$	Yes	No
HA2	Total Quality of Ideas	$p < 0.001$	Yes	Yes
	Average Quality of Ideas	$p < 0.10$	No	No
	Number of Good Ideas	$p < 0.01$	Yes	Yes
HA3	Satisfaction with the Idea Generation Process	$p < 0.01$	Yes	Yes
HA4	Perceived Usefulness of the Idea Generation Technique	$p < 0.05$	Yes	No

Table 33 - **GDSS Main Effect Hypotheses**

they generated significantly more ideas and average quality is calculated by dividing total quality by the number of different ideas.

Given these significant results in favor of GDSS support for quantity and quality of ideas, the question then becomes, what is there about GDSS support that leads to consistently improved performance? Bostrom and Anson (1988a) suggest several potential benefits of GDSS that may lead to improved performance: simultaneity, anonymity, and easy and efficient access to ideas of others. The subjects who participated in this study were asked, through both open-ended questions and in the post-experimental discussion, to describe which session (the one with GDSS support or the one without GDSS support) they felt was more productive, why it was more productive, and which session was more satisfying for them. A majority of these responses were in line with Bostrom and Anson's proposed benefits (simultaneity, anonymity, and easy and efficient access to the ideas of others).

To better understand the impact of each of these factors -- simultaneity, anonymity, and the easy and efficient access of the ideas of others -- the subjects were asked to assess the impact of five factors on the productivity of the sessions with GDSS support, using a seven-point scale (1 was "Highly Negative", 4 was "No Impact", and 7 was "Highly Positive"). The subjects' assessments are shown in Table 34. It can be seen from this assessment that all these factors are perceived to have a positive impact -- particularly the equal opportunity for all group members to participate -- which can be thought of as a function of the combined benefits of simultaneity and anonymity.

Factor	Mean	SD
Anonymity (n=235)	5.74	1.40
Simultaneity (n=239)	5.65	1.34
Electronic Recording of Information on Computer System (n=240)	5.90	1.27
Rapid/Easy Access to Comments of Others (n=239)	5.94	1.30
Equal Opportunity to Participate (n=239)	6.45	0.95

Table 34 - **Subjects' Assessment of the Impact of the Benefits Provided by GDSS on the Productivity of Idea Generation**

By providing easy and efficient access to the ideas of others, GDSS support allows the group members to take full advantage of simultaneity and anonymity. GDSS support provides simultaneous access to the ideas of others to allow for the most efficient exchange of ideas, thus providing for greater stimulation during the idea generation process. This access is also provided in an easy-to-read manner -- greatly facilitating a group member's ability to utilize the information to which he/she has access.

By providing a means for all group members to generate ideas simultaneously, GDSS support overcomes the problem of production blocking, heralded by Diehl and Stroebe (1987) as the major detrimental factor hindering interacting group performance. The ability for all group members to enter ideas simultaneously provided a number of benefits. First, the obvious advantage of each group member not having to "wait his/her turn", as was the case in groups without GDSS support. This enabled group members to enter an idea as soon as it occurred to them. It also enabled group members not to lose the ideas that are often forgotten while listening to another person talk. Several group members reported this happened frequently in the sessions without GDSS support -- which not only led to significantly fewer ideas being generated, but also decreased the satisfaction level of the group members who often became frustrated from the inability to generate ideas as they occurred.

Another advantage of simultaneity was the reduction of dominance by one or two people. It was quite common for one or two group members to dominate a session without GDSS support (dominate, in this situation, means generating most of the ideas, frequently "jumping in" with ideas before others could finish articulating an idea, and even trying to influence the direction of the group, in terms of the categories or types of ideas generated). While in the sessions without GDSS support there tended to be dominant group members, in the sessions with GDSS support everyone had equal opportunity to participate. (It could be argued that in the sessions without GDSS support everyone had an equal opportunity to participate; however, from both comments and observations, it was apparent that almost everybody was more comfortable participating in the sessions with GDSS support).

Simultaneity also gave each and every group member the opportunity to be more than just a bystander: they were given the opportunity to become actively involved. Some commented on how "dull" the sessions without GDSS support were when compared to using the GDSS. Some expressed a concern about "interrupting others in the group" during sessions without GDSS support when they had an idea. Another comment indicated that using the GDSS allowed group members to contribute more ideas, enabling them to believe that "they had accomplished more." Still others commented on being able to get their ideas out before they "had a chance to judge their own ideas." Some group members indicated that being able to generate an idea at any time fueled their creativity and stimulated more ideas. It was also felt that "ideas didn't go in one direction"; instead, group members could pursue different lines of thought, and keep their train of thought focused on the task. Each individual could work at his/her own pace and not feel pressured by others. This increased opportunity for involvement brought some different responsibilities, as expressed by one group member who indicated that he "had to think instead of letting others do the work." This same group member felt that this increased opportunity for involvement enabled him to be more productive since he indicated: "I concentrate better by myself."

Another advantage of GDSS support was the anonymity provided by the system. Numerous participants commented on how they enjoyed the ability to generate an idea without the fear of that idea, or of themselves, being evaluated by the other group members. Anonymity was viewed as especially valuable when working with people they did not know. This was generally the case in this study, and often may be true in newly formed work groups. Others commented on the fact that the system relieved the pressure of "having to contribute" often imposed in groups. Many of the group members stated that they did not like to work in groups due to the problems and pressures that can occur; however, they felt that the session with GDSS support allowed them to participate and be more productive than they might have been otherwise. Another group member added that people tended to give more honest answers when in the session with GDSS support, and that "influence by others was minute." Anonymity was also felt to create a relaxed atmosphere as it "took away barriers to communication."

While most comments were positive about the effect of anonymity, there were some mixed emotions associated with anonymity. Some people wanted everyone to know which ideas they generated, so that they could take credit for their ideas. Others felt that anonymity allowed people to "say things just to be humorous"; yet others felt that "a little humor is a good thing!". An alternative view was that the GDSS allowed for the expression of "crazy ideas without embarrassment - often these crazy ideas can be developed if they are shared." Given that ideas were not connected to the group member who suggested the idea in the sessions with GDSS support, a reduction in the "amount of stress" also reduced the pressure to perform, allowing for a more enjoyable session.

Another benefit of the GDSS was the electronic recording and display of ideas which allowed for easy access to the ideas of others, both on the main viewing screen at the time the idea was generated, and at any time on the individual group member's screen. This access made it easy for group members to have access to the ideas of others when desired; yet if a group member wanted to concentrate on generating ideas, he/she did not have to be distracted by the ideas of others. Therefore, the GDSS support provides the best of both situations: Individual involvement with the ability to access the ideas of others.

In addition to the task outcomes of idea quantity and quality, two group outcomes were assessed: group member satisfaction with the group idea generation process and perceived usefulness of the idea generation technique. While techniques with GDSS support were perceived to be more

useful ($p < 0.05$), this result was not statistically significant at an alpha level = 0.01. However, group members were significantly more **satisfied** with the session with GDSS support than the session without GDSS support.

The main reasons for the higher level of satisfaction for the sessions with GDSS support have been previously expressed: simultaneity, anonymity, and easy and efficient access to the ideas of others. Based on the group members' comments, these factors allowed them to be more actively involved, productive, comfortable, creative, and satisfied with the idea generation process. Previous GDSS research has had inconsistent findings with respect to group member satisfaction. These inconsistencies may have resulted from such factors as the particular GDSS used, the inappropriate match of task to technology, or the assessment of satisfaction for the use of several components of the GDSS.

While there were many positive comments about the sessions with GDSS support, there were a number of negative comments as well. Some of these comments pertained to the user-system interface, particularly the requirement of typing ideas instead of generating them orally. While in the minority, several group members did comment that their typing skills hindered their ability to generate ideas. One comment indicated that the group member was: "Having to concentrate more on typing than on idea generation." There were also a few comments from group members who did not like reading the ideas off the screen, as opposed to hearing them generated orally. Along those same lines, some group members commented that they preferred the session without GDSS support because it allowed them to hear all the ideas that were generated, which permitted explanation of the idea by the person who suggested it. This oral presentation/explanation process provided a better means of building on the ideas of others ("piggybacking"), and yet allowed the person who generated the idea to get "credit" for it. Others indicated that they did not feel like a member of a group in the session with GDSS support; instead, they felt that they were addressing the problem on their own.

To gain a better understanding of the impact of these concerns (e.g., typing ability, not hearing the ideas of others), the subjects' responses were obtained to four questions concerning the impact of these potential restrictions imposed by use of the GDSS. These questions were part of the EBS and ENI Technique Evaluation Questionnaire (see Appendix C.3). Subjects responded to these questions using a seven-point preference scale (1 was "Strongly Disagree", 4 was "Neutral/Undecided", and 7 was "Strongly Agree"). The subjects' assessments are shown in Table 35 ("MN" is the mean, "SD" the standard deviation, and "MD" the mode). Inspection of Table 35 indicates that most of these factors were perceived as <u>not</u> having a negative impact on the idea generation process. One factor, not having the ability to hear ideas of others, was the most important of these factors, but it was still not viewed, overall, as being a hindrance to the idea generation process. This factor may be influenced by the fact that most people have a preference for accessing information in either visual or verbal (or auditory) form (Bell-Grendler, 1986), and the information provided to group members from the GDSS was presented strictly in a visual form.

Potential Restriction	EBS (n=120)	ENI (n=120)
The amount of information I could enter at one time using the computer system limited my contribution of ideas	MN: 2.49 SD: 1.55 MD: 2.00	MN: 2:63 SD: 1.52 MD: 2.00
My typing ability greatly hindered my ability to use the computer system	MN: 2.39 SD: 1.66 MD: 1.00	MN: 2.42 SD: 1.68 MD: 1.00
Not hearing others orally generate ideas hindered my ability to generate new ideas or build on the ideas of others	MN: 3.67 SD: 1.98 MD: 2.00	MN: 3.41 SD: 1.96 MD: 1.00
It was difficult to read the ideas as they were displayed on the computer screen	MN: 2.74 SD: 1.72 MD: 2.00	MN: 2.79 SD: 1.66 MD: 1.00

Table 35 - **Subjects' Assessment of the Impact of the Potential Restrictions Imposed by GDSS for Idea Generation**

While there were some negative comments about the sessions with GDSS support, and some group members who preferred the sessions without GDSS support, overall the sessions/techniques with GDSS support were perceived to be superior to the sessions/techniques without GDSS support.

This is confirmed by the subjects' responses to questions on the Final Questionnaire that asked them to compare the two sessions (techniques) in which they had participated. Overall, every question was answered more positively in favor of the session with GDSS support than the one without GDSS support (these are responses from the Final Questionnaire, see Appendix C.6).

The results of the GDSS main effect hypothesis testing yielded several statistically significant results for the superiority of idea generation techniques with GDSS support over techniques without GDSS support. Based on feedback from group members, these findings are primarily the result of the benefits provided by GDSS support, namely, simultaneity, anonymity, and the easy and efficient access to the ideas of others.

6.1.2 Structure Main Effect

It was hypothesized that groups provided with structure (by providing groups with Osborn's brainstorming instructions) would perform significantly better than groups without such support (groups that were not given Osborn's instructions) for each of the eight dependent variables as listed in Table 36. None of these hypotheses was supported. This contradicts previous idea generation research that has shown significant advantages for groups provided structure over those not provided such support. A plausible explanation for this lack of results focuses on the context of the study: idea generation.

Hypothesis		p-value	Strc > w/o Strc	Hypoth. Supported
HB1	Total Quantity of Ideas	$p > 0.25$	Yes	No
	Number of Different Ideas	$p > 0.25$	Yes	No
	Number of Unique Ideas	$p < 0.05$	Yes	No
HB2	Total Quality of Ideas	$p > 0.25$	Yes	No
	Average Quality of Ideas	$p > 0.25$	No	No
	Number of Good Ideas	$p > 0.25$	No	No
HB3	Satisfaction with the Idea Generation Process	$p < 0.25$	Yes	No
HB4	Perceived Usefulness of the Idea Generation Technique	$p < 0.25$	Yes	No

Table 36 - **Structure (Strc) Main Effect Hypotheses**

This study was billed as an "Idea Generation Study" when subjects were recruited, and the purpose of the study was briefly explained to them (not specifics, but enough information so that they could determine whether or not they wanted to participate). The subjects were also given minimal information during the introduction to the actual experimental sessions. As such, the resulting focus was on just generating ideas, not evaluating alternatives or reaching a final decision/solution.

One of the major advantages provided by structure is the separation of the stages or steps in problem solving or decision making processes. For idea generation, the advantage of providing structure is to separate the idea generation process from subsequent steps (e.g., idea organization, alternative evaluation, voting, and selection). Since this study focused on just one step, idea generation, the tendency for group members wanting to "move along" to the next step, or the usual pressure to reach a final solution, did not exist.

Additional evidence of this notion is provided by the fact that an average of less than one critical comment was generated per group, out of an average of nearly 70 text strings generated (which resulted in an average of nearly 35 different ideas per group). While the groups provided with structure were instructed <u>not</u> to criticize, the groups without structure were not instructed to criticize or evaluate.

While the introduction of structure did not significantly impact idea production in this study, previous idea generation research, both with GDSS and prior to the introduction of GDSS technology, has shown the significant impact of structure and evaluative tone on idea generation. What these findings may be underscoring is the importance of "setting the frame" (or mood, tone, etc.) for an idea generation session (or any group interaction). Given the emphasis of this study on idea generation, the "frame" was set to "generate ideas" -- not evaluate -- which opens up a number of interesting research questions to pursue (Section 6.4 addresses future research directions).

While none of the results for the structure main effect were significant, groups with structure appear to outperform those without structure on a per capita basis except for **average quality** and **number of good ideas**. In fact, groups with structure did generate more **unique ideas** than the groups without structure at an alpha level = 0.01 (this was the only evaluation that even approached significance). The brainstorming instructions provided may have prompted group members to generate more unique or original ideas by instructing them that: "Freewheeling is welcome. The wilder the idea, the better." (See the instructions for brainstorming and electronic brainstorming, Appendix B.2.)

The results of the structure main effect hypothesis testing yielded no statistically significant results. While structure did not have a significant impact in this study, a number of opportunities exist for future research in this area.

6.1.3 GDSS and Group Size Interaction

Results of the MANOVA analysis detected a main effect for the GDSS - group size interaction at an alpha level = 0.05. While this main effect was significant, none of the univariate follow-up tests revealed any significant effects at an alpha level = 0.01 (most likely due to the adjustment necessitated in the degrees of freedom and resulting p-values). These results, however, did not specifically address the research questions pertaining to the impact of GDSS on the idea generation process as group size increased. The key question was whether or not GDSS support would maintain the same per person level of performance as group size increased from five to ten persons, for the quantity and quality of ideas generated. It was also hypothesized that as group size increased from five to ten persons, the perceived usefulness of the idea generation techniques and satisfaction with the group idea generation process would increase as well. While it was hypothesized that GDSS <u>would</u> be able to maintain these same levels of performance, it was believed that groups without GDSS support <u>would</u> <u>not</u> be able to maintain the same level of performance.

To test these hypotheses a series of t-tests was performed to compare the performance and preference levels of five-person to ten-person groups, for sessions both with

GDSS support and without GDSS support. The results of these tests are presented for each of the eight dependent variables in Table 37, along with the resulting p-values from the evaluation, and whether or not the hypothesis for that variable was supported. Results show that for the groups with GDSS support there were no significant differences between the performance and preference levels of the two different-sized groups. This provides support for the ability of the GDSS to maintain the same level of per person performance and preference as group size increases from five to ten persons. While preference levels were not significantly higher for larger groups, as predicted, these levels also were not significantly less than for five person groups. This indicates that the preference levels did not significantly decrease as group size increased.

Only two of the six performance factors (**unique ideas** and **average quality**) were maintained for groups without GDSS support. As group size increased, both preference variables had decreasing scores, but not significantly.

While previous idea generation studies have demonstrated declining levels of performance as group size increased, both overall and on a per person basis, this study is among the first to provide empirical confirmation for the ability of GDSS to maintain the same per person level of performance for interacting groups performing idea generation tasks. The benefits provided by GDSS described

	Hypothesis	Signif. Level	Supported
HAC1	Total Quantity of Ideas:		
	GDSS: Performance (5 = 10)	p = 0.156	Yes
	No GDSS: " (5 > 10)	p = 0.000	Yes
	Number of Different Ideas:		
	GDSS: Performance (5 = 10)	p = 0.258	Yes
	No GDSS: " (5 > 10)	p = 0.000	Yes
	Number of Unique Ideas:		
	GDSS: Performance (5 = 10)	p = 0.017	Yes
	No GDSS: " (5 > 10)	p = 0.409	No
HAC2	Total Quality of Ideas:		
	GDSS: Performance (5 = 10)	p = 0.046	Yes
	No GDSS: " (5 > 10)	p = 0.000	Yes
	Average Quality of Ideas:		
	GDSS: Performance (5 = 10)	p = 0.510	Yes
	No GDSS: " (5 > 10)	p = 0.439	No
	Number of Good Ideas:		
	GDSS: Performance (5 = 10)	p = 0.010	Yes
	No GDSS: " (5 > 10)	p = 0.002	Yes
HAC3	Satisfaction with the Idea Generation Process:		
	GDSS: Performance (5 < 10)	p = 0.813	No
	No GDSS: " (5 > 10)	p = 0.522	No
HAC4	Perceived Usefulness of the Idea Generation Technique:		
	GDSS: Performance (5 < 10)	p = 0.982	No
	No GDSS: " (5 > 10)	p = 0.446	No

Table 37 - **GDSS Support and Group Size Interaction Hypotheses**
(Performance/Preference on a per person basis)

in Section 6.1.1 -- simultaneity, anonymity, and the easy and efficient access to the ideas of others -- most likely contributed to maintaining the same level of performance by overcoming the dysfunctional characteristics inherent in interacting groups, particularly as group size increased.

6.1.4 Structure Support and Group Size Interaction

Results of the MANOVA analysis indicated that there was not a significant structure support - group size interaction at an alpha level = 0.05. This was confirmed by the fact that none of the univariate follow-up tests revealed any significant effects at an alpha level = 0.01. While these results were not significant, they did not specifically address the research questions pertaining to the impact of providing structure on the idea generation process as group size increased. The key question was whether or not structure support would allow for only a small, nonsignificant decline in the per person performance level as group size increased from five to ten persons, for the quantity and quality of ideas generated, as well as only small declines in perceived usefulness of the idea generation techniques and satisfaction with the group idea generation process. While it was hypothesized that by providing groups with structure they would be afforded only a minor decline in the level of performance, it was believed that groups without structure support would have a significant decline in the per person level of performance and preference.

To test these hypotheses a series of t-tests was performed to compare the performance and preference levels of five-person to ten-person groups, for both groups with structure support and groups without structure support. The results of these tests are presented for each of the eight dependent variables in Table 38, along with the resulting p-values from the evaluation, and whether or not the hypothesis for that variable was supported. Results show that for the groups with structure support, there were significant differences between the performance levels of the two different-sized groups for only two dependent variables: the **average quality** of ideas and the **number of good ideas** generated. This provides support for the ability of structure support to maintain a level of per person performance with only a minor decline. However, for groups without structure support there was a significant difference only for the **average quality** of ideas. Thus support for the different performance and preference levels was not significantly different as hypothesized.

While there were no significant differences for six of the eight dependent variables for groups provided with structure support, the fact that there were also no differences for seven of the eight dependent variables for groups without structure support indicates that it is unlikely that the impact of structure support made this difference. It is more likely that the use of GDSS support,

Hypothesis		Signif. Level	Supported
HBC1	Total Quantity of Ideas: Strct: Performance (5 > 10) No Strct: " (5 >> 10)	 p = 0.716 p = 0.874	 Yes No
	Number of Different Ideas: Strct: Performance (5 > 10) No Strct: " (5 >> 10)	 p = 0.196 p = 0.148	 Yes No
	Number of Unique Ideas: Strct: Performance (5 > 10) No Strct: " (5 >> 10)	 p = 0.156 p = 0.424	 Yes No
HBC2	Total Quality of Ideas: Strct: Performance (5 > 10) No Strct: " (5 >> 10)	 p = 0.037 p = 0.076	 Yes No
	Average Quality of Ideas: Strct: Performance (5 > 10) No Strct: " (5 >> 10)	 p = 0.000 p = 0.000	 No Yes
	Number of Good Ideas: Strct: Performance (5 > 10) No Strct: " (5 >> 10)	 p = 0.006 p = 0.021	 No No
HBC3	Satisfaction with the Idea Generation Process: Strct: Performance (5 > 10) No Strct: " (5 >> 10)	 p = 0.890 p = 0.508	 Yes No
HBC4	Perceived Usefulness of the Idea Generation Technique: Strct: Performance (5 > 10) No Strct: " (5 >> 10)	 p = 0.250 p = 0.613	 Yes No

Table 38 - **Structure (Strct) Support and Group Size Interaction Hypotheses**
(Performance/Preference on a per person basis)

provided in half of the sessions under each of these conditions, led to the somewhat even distribution of performance across the groups. Furthermore, based on the minimal amount of evaluation that took place in this study, the effect of providing structure has been found to be minor. Therefore, the hypotheses pertaining to the advantages of structure support for maintaining group performance and preference as group size increased were not supported.

6.2 Limitations

There are a number of limitations encountered when conducting laboratory experiments, mainly non-generalizability of results (external validity), experimenter bias, and subject representativeness (Campbell and Stanley, 1969).

The generalizability of results from this study is basically limited to the domains of the task (creativity) and subjects (college students) involved in the study. By utilizing the Library and Parking Problems, the study does achieve a greater degree of face validity and external validity in that these tasks are indicative of the type of tasks faced by universities and other organizations. And while using zero-history groups of students is not the same as using professionals, they do possess the domain knowledge necessary to address the problems and -- given their involvement with the problems -- can be viewed as potential stakeholders in the solution of the problems. This is the type of problem that may be assigned to a task force, assembled just to address this problem, in an organization.

While the laboratory setting is decidedly different from the "real world", significant efforts were made to reduce experimenter bias in this study. While potential subjects were given enough information to decide whether or not they wanted to participate in the study, no information about the goals of the study or the variables being measured was provided until after the session was completed. Students who volunteered were randomly assigned to groups, and groups to treatments. Strict procedures were enforced to ensure that all experimental groups received the same treatment: Written instructions were provided for each technique, written problem descriptions were distributed for each task, the experimenter/facilitator used a detailed script that had been developed and refined through the pilot testing process, and it was followed exactly. Checklists had been created to ensure that each necessary step was completed before moving on to the next step. The same experimenter/facilitator ran all sessions.

There were three other types of limitations imposed in this study, by: the experimental situation, the two main tasks used, and the technology. Restrictions imposed by the experimental controls included the set length of time for idea generation, the restriction of communications channel use (during GDSS sessions the group members were instructed not to talk), and the use of, or lack of, structure (groups either followed the brainstorming instructions or they did not).

There were limitations imposed by the two tasks used in the study, the Parking Problem and the Library Problem, although both are clearly creativity tasks, problems for which there is not one best known answer, there was a limited solution space (number of potential solutions) for each task. Future studies should search for, or create, tasks with a larger potential number of solutions to provide for better assessment of the capabilities of GDSS to support idea generation.

Limitations imposed by the technology included the rate at which ideas were displayed on the main viewing screen. The length of time an idea remained on the main viewing screen was a function of the amount of activity by the group and the length of the ideas entered (the screen could display up to 24 lines of text at time). Groups often engaged in spurts or bursts of intense activity during idea generation, which were often followed by idea droughts. When a group was very active, an idea may have been displayed on the main viewing screen for only seconds; when a group was in a lull, an idea could stay on the screen for a prolonged period of time. Since this was not controlled, its impact on the outcome of this study is not known. However, since all group members had access to all ideas from their own machines, the impact is probably not as great as if the main viewing screen had provided the only opportunity for group members to see the ideas of others. To ensure that this is not a factor in future studies, researchers may want to control the length of time that an idea stays displayed on the screen (e.g., for a minimum period of time before it is replaced with other ideas; this would allow for a more uniform display of ideas on the screen).

One final limitation of the study is based on the selection of dependent measures. In an attempt to bridge two streams of research, the thirty-plus years of investigation pertaining to idea generation and the evolving area of GDSS, this study measured eight dependent variables. The use of a number of highly correlated variables presented some minor problems for statistical analysis (see Section 5.3), as well as interpretation of results. One dependent variable, **average quality**, has presented particularly contradictory results, when compared with the other dependent variables, and its inclusion in future studies should be considered quite carefully.

6.3 Implications for Practice

Group involvement in most organizational decision making, problem solving, and planning processes is becoming more prevalent. One of the first steps in most of these processes is the generation of ideas or alternatives. From this study, GDSS support has been shown to significantly improve the idea generation process.

Interacting work groups are often time consuming and unproductive due to the many dysfunctional characteristics inherent in group interactions. Although there are shortcomings of groups, their interaction can bring a rich mixture of knowledge, skills, and information that is necessary to address the increasingly complex and broad-ranging problems encountered in today's organizational climate. This group interaction is often desired and necessary for many tasks, such as idea generation. Research has shown that individuals working alone, when their ideas are pooled, will perform significantly better than groups. What is needed is a way to maximize the best of both needs: the rich mixture provided by combining the advantages of groups while maintaining the performance advantage of individuals. This new form of information technology, GDSS, is one approach that has shown some promise in addressing this need.

The results of this study support the hypotheses that groups with GDSS support will generate more ideas, of higher quality, and be more satisfied with the idea generation process than groups without GDSS support. This study has also provided support for the hypothesis that -- when groups have GDSS support -- as group size increases, the level of performance, on a per person basis, is maintained. Through simultaneity, anonymity, and the easy and efficient access to the ideas of others, GDSS provides the advantages of individual performance, while providing access to the ideas of others to stimulate the idea generation process.

One of the problems encountered by the introduction of new technologies, such as GDSS, into organizations is that their introduction may often be met with resistance by some organizational members. Management may be interested in utilizing new technologies to improve performance or the task accomplishment aspects of a given job or task, while workers are often as concerned about the quality of their work life as they are with task accomplishment. Much of the previous GDSS research has provided mixed results with group members' satisfaction with GDSS-supported group processes; in contrast, this study has provided support for the hypothesis that those using GDSS support were more satisfied with the group idea generation process than those not utilizing GDSS support. This satisfaction with the group process, in addition to the improved performance opportunities, can lead to greater acceptance and use of the technologies.

Many of the negative comments pertaining to the sessions with GDSS support stemmed from the lack of oral communication. Completely prohibiting oral communication, as was done in the sessions with GDSS support, is not the way that meetings are carried out in organizations, nor is it the way that GDSS support has been utilized in field studies. Further, the use of GDSS to address organizational problem solving and decision making should not be as strictly administered as was the case in the tightly controlled experimental conditions of this study. For example, oral communication to supplement GDSS-supported communication may be desired to discuss the ideas after the generation process has been completed. With the combination of GDSS-supported communication and oral communication, the potential exists for even greater satisfaction of group members.

6.4 Future Research

One of the objectives of any research study is to identify future areas for research, and while this study has provided some useful information about the impact of GDSS support on groups of different sizes, it has also raised additional questions that need to be addressed. A few of these issues will be presented here.

While the impact of structure was not significant in this study, different idea generation techniques need to be evaluated, both in terms of automated techniques (e.g., electronic brainstorming and electronic brainwriting) and other manual techniques (e.g., brainstorming and brainwriting). Also, based on the lack of impact of structure in this study, another area of interest may be on the type of direction or instruction given to groups. Additionally, the performance of real groups versus nominal groups (pooled individuals) should be assessed to see if the advantages of technology will allow real groups to perform as well, or better, than nominal groups.

While this study focused on zero history groups of students generating ideas for creativity tasks, future research needs to include ongoing, real groups, addressing real organizational problems. Different types of tasks (e.g., planning, decision making, problem solving) should be addressed using both ad hoc (zero history) and established groups. Additionally, the generation of ideas should be evaluated as one step in a larger problem solving or decision making process.

In addition to different types of groups, future research needs to include different-sized groups, mainly larger groups. This study provides evidence of GDSS support maintaining the per person performance level as groups increased from five to ten, but what happens with larger groups of 15, 20 or more?

The impact of the presence of other group members, in terms of both time and space, provide additional areas for future research. While there has been some initial research addressing the issue of proximity of group members (Jessup, et al., 1988), additional research needs to investigate the impact of the physical location of group members. Do groups perform comparably when all group members are in the same physical location (room), as opposed to dispersed in separate (different physical) locations? What is the impact on preference (e.g., satisfaction) and other issues such as group cohesion, conflict, and membership for different configurations? Another important issue pertains to the time frame for group member participation. What is the impact on group performance when the "group" does not work on a task together, but rather spread out over time (e.g., group members work on the task at different points in time, yet have access to the ideas/information previously generated/utilized by other "group" members)? Both of these issues will become very pertinent as GDSS technology disseminates into organizations and the ability to hold group meetings where all group members do not have to be present at the same location, or even at the same time, becomes a more common occurrence.

Additionally, this study has indicated a number of GDSS benefits that impact group performance (e.g., simultaneity and anonymity). But the question remains as to which factor(s) make the most difference, and for which types of tasks, groups, or differences among the individual group members? Investigations that individually control and manipulate these factors could lead to a better understanding of how and why groups provided with GDSS support outperformed groups without GDSS support.

The investigation of the impact of individual differences on the idea generation process is another important area to be considered. The comments expressed in Section 6.1.1 pertaining to "hearing the ideas of others expressed verbally" points to representation systems (e.g., auditory, visual) as one individual difference factor that should be investigated. Other such factors as creative ability, communications apprehension, and approaches to problem solving provide additional individual difference variables for investigation.

Finally, the findings from this study concerning group members' satisfaction with the idea generation process contradict much of the previous GDSS research. Much of this research has assessed group member satisfaction with a problem solving or decision making process that has used several components of a GDSS to support the several steps necessary in these processes. The results of this study, coupled with the high level of satisfaction reported by group members for the use of GDSS support for idea generation in field study research (e.g., Nunamaker, et al., 1987; Vogel, et al., 1987), lead to the possible conclusion that what may be dissatisfying with the GDSS is the next step (or subsequent steps) after the idea generation process. This next step often involves the categorization of the ideas just generated -- this is a difficult process at best and GDSS support for this process is not nearly as efficient or effective as it is for processes like idea generation. Additional research is needed to determine better ways of meeting this critical need if GDSS support is to become widely accepted and used.

6.5 Concluding Comments

This study examined the performance of five- and ten-person groups for idea generation. Half of the groups were provided with structure (Osborn's brainstorming instructions) to facilitate the idea generation process, and half were not provided with structure. Each group performed two tasks: one with GDSS support and one without GDSS support. Results of this study indicate that when groups had GDSS support they generated more total ideas and different ideas, ideas of higher total quality, and more good ideas than they did without GDSS support. Group members were also more satisfied with the idea generation process when using a technique with GDSS support, as opposed to the session without GDSS support. Additionally, the use of techniques with GDSS support allowed group members to maintain the same level of performance as group size increased from five to ten, while performance declined for groups without GDSS support. However, the impact of providing structure to support idea generation was found to be negligible in this study.

Group member responses to questions led to the identification of a number of GDSS benefits that they believe led to this higher level of performance and preference. These performance and preference enhancing factors include: simultaneity, anonymity, and easy and efficient access to the ideas of others. These factors helped to overcome the problems traditionally associated with interaction groups, such as production blocking and evaluation apprehension.

These findings are important to GDSS researchers as part of an emerging line of experimental and field research attempting to identify factors that lead to successful implementation and use of GDSS. These findings are important to practitioners since they provide support for the notion that this new type of information technology may provide improved task accomplishment, but may do so without the potential loss of quality of work life often associated with the introduction of new technologies like GDSS.

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APPENDICES

APPENDIX A.1

EXPERIMENTER SCRIPT

IDEA GENERATION STUDY EXPERIMENTER SCRIPT

I. INTRODUCTION

"Thank you for your willingness to participate in this study. You will be participating in two group idea generation sessions. One of these sessions will use a computer-supported idea generation technique, the other will use a noncomputer-supported technique. But before we get started I need to have you sign a consent form. This is done for all studies at IU. Please take time to read the form before you sign it. If you have any questions I will be glad to answer them for you now or at any time during the session. I will be collecting the consent forms, but I will also be giving you a copy to keep."

Pass out two copies of CONSENT FORM and pens. Collect signed forms and put them in the folder for the group (label folder with group number, date and time).

II. PRE-SESSION SURVEY

"While this study is on group idea generation, each group is composed of a number of individuals. Each individual brings a different set of abilities, traits, experiences, and skills to the group. In order for us to find out more about each of you as an individual I would like you to complete a survey with a number of questions about your personal background. Please take time to read the instructions and respond as best you can. This survey asks you for some background information, your experience with computers, your experience in working with groups and your expectations for this session. At the top of each form is a place for participant number. I ask that you use this number for each item that is filled out. This number will allow us to track the responses of an individual for the materials completed before, during and after the sessions. It also provides anonymity for each of you in that nobody knows who participant one or two is, as opposed to using your name."

Assign participant numbers by starting at one end of the room and assigning them in order as you go around the room (numbers 1 - 5/ 10). Write down the group number on the board. [If you are using PHreD (CES?) then participant and group numbers will be automatically generated by the system (see the PHreD Facilitators Manual and Users Guide for additional information). Also, instead of distributing surveys manually, as indicated in this script, distribution will be carried out through PHreD. One more thing to keep in mind when using PHreD: participants <u>must</u> use the same station for <u>every</u> survey; otherwise the participant number will be different since it is taken directly from the machine.]

Pass out PRE-SESSION SURVEY. Collect and put in group's folder. (Check to see that each form is complete and that the participant and group numbers are correct).

III. FIRST SESSION INTRODUCTION

"As I indicated, today you will participate in two group idea generation sessions. In each session you will be generating ideas to provide potential solutions to a couple of problems. The first problem is a warm-up exercise to help familiarize you with the technique that you will be using today. You will generate ideas for this problem for five minutes. After that you will then generate ideas for the second problem for 20 minutes.

[The sessions may be in either order: computer-supported session first or the noncomputer-supported session first; then the other session second]

IV. COMPUTER-SUPPORTED TASK (This may be the first/second task)

"For this session we are going to use:

1) a computer-supported idea generation technique called Electronic Brainstorming (EBS); or
2) an electronic idea generation system (EIG).

But before we get started on the two problems, there is one more task I need you to complete. Please make sure that you are at a Personal Computer that has "TYPE" displayed across the screen (if not, simply type "T" to start the program). We want to have you do a practice typing exercise and test before we get started. Since we are using computer keyboards in this study, we want to get an assessment of each person's typing ability. Press the ENTER key, this will bring up a main menu. There is an arrow that is currently pointing at the first option (TOURING THE KEYBOARD), move that arrow down four options (with the "down arrow") to TYPING TEST and press ENTER. This will bring up a screen display with a number of options at the bottom, a diagram of a keyboard in the upper left and a number of boxes that will contain some feedback about your typing performance in the upper right. There should be an arrow pointed at the first option, START TEST. Before we start, make sure that you are seated comfortably, take a look at the keyboard and make sure that you are familiar with all the keys. The program will display some text on the screen and you are to type it in just as it is shown (if upper case - hit shift key, special characters, etc.). The program will not display what you type on the screen, but will put an up arrow underneath any character that you type incorrectly. You cannot go back and correct it - just go on. Just simply type at your normal, comfortable pace - don't try and type real fast to see how fast you can type, or real slow so as not to make any mistakes - just type at your normal rate. This is a one minute test. We are going to go through this twice: once so that you can become familiar with the program and get warmed up, a second time so that I can come around to record some information from the screen. When you are ready, you may hit the ENTER key and begin. (After first run) Any questions? (if so, answer, if not) Go ahead and start again, when you are done, I'll be around to collect some information for each of you" (the ESCAPE key will get you back to the menu if they get stuck or into the wrong program).

When they are completed, collect information from each screen pertaining to their typing speed (WPM), accuracy rate (%), and number of errors. Ask each participant for their participant number and record their scores accordingly. (If you are using PHreD, then do not ask them for participant number, but just record their scores starting with the first person and going around the room.) Then bring each machine up on PLEXSYS.

"Before we get started I want to go over the instructions of how we are going to use the computer-supported technique."

Pass out appropriate instructions (either EBS or ENI).

"Lets go through these instructions together. You will be using a technique called (EBS, EIG). We will follow these instructions (cover basics - read through rules 1 - 3 for EBS and 1 & 2 for EIG, look for recognition). Please stop me at any time if you have any questions. Before we get into the specifics of how the system is used (rest of the instructions), I will distribute the problem for this session. We will use your first idea from this problem to walk through how to use the system."

Pass out first task description (tea bag/vinyl disk).

"Read through the problem description (pass out appropriate task prop (tea bag/vinyl disk)) - what we want you to do is to come up with alternative uses for the (TB/VD), this is what is called a "uses" task (answer any questions about task). Let's go back and finish the instructions for (EBS, EIG) (go over rest of system specific instructions by having them enter their first idea). Let's enter the first idea together to make sure each of you understand how to use the system (give them task and system specific instructions). We will now generate ideas for five (5) minutes. If at any time you have a problem or question, raise your hand and I will be around to help you. (at 5 minutes have them stop). Time is up. If you are entering an idea, please finish it; otherwise please stop (system specific stop)."

"Before we move on to the second task, are there any questions on how to use the system? Is everybody comfortable in using the system?"

Pass out the second task (parking/library problem).

"Read through the problem description - let me know if you have any questions. We will generate ideas for twenty (20) minutes. If you have a problem or question, raise your hand and I'll be around to help you. (Half way through the session remind them of the "rules" we are following; at 20 minutes have them stop). Time is up. If you are entering an idea, please finish it; otherwise please stop (system specific stop)."

For the EBS sessions, monitor comments to ensure that no evaluative comments are being made. If such comments are detected, remind them of the instructions which ask them not to do any evaluation of ideas.

V. POST-SESSION SURVEY (COMPUTER-SUPPORTED TASK)

"I would like to have you complete a couple of short surveys about this session. Please take the time to read the instructions and answer the questions as best you can. There are no right or wrong answers, we are interested in your opinion, your impressions of the session. The first questionnaire asks for your impressions of the (EBS, EIG) you used in three areas: an overall assessment of the system, an assessment of how easy you felt the system was to use, and your perception of how useful you feel it would be to use this system for any future work groups in which you would be a member (such as in class groups, work groups, etc.). Please put your participant number on the top of the form."

Pass out EASE/USEFULNESS survey. Make sure that the participant number is on the form when you collect them. Put in group's folder.

"The other questionnaire asks for your overall impressions about the group idea generation session in which you just participated. Just this last session using (EBS, EIG) for the (parking/library problem). Any questions about the task pertain to the main task (parking/library) that you just addressed. Again, there are no right or wrong answers, we are only interested in your opinion. Please be sure to put your participant number on the form."

Pass out POST-SESSION SURVEY (make sure that it has "task 1/2" written on it). Verify participant numbers. Collect and put in group's folder.

"At this point we will be taking a five minute break. Feel free to get up and stretch, use the facilities, etc. There are milk and cookies for anyone who would like some. I would ask that during this break that you not talk about the session in which you are participating, please feel free to discuss anything else that you want to, but not this session. Thanks."

VI. SECOND SESSION INTRODUCTION

"For this session you will again generate ideas for solutions to two problems. The first task is a warm-up exercise to help familiarize you with the technique that we will be using. We will generate ideas for this problem for five minutes. After that we will then generate ideas for solutions to the second problem for 20 minutes.

VII. NONCOMPUTER-SUPPORTED TASK (May be the first/second task)

For this session we will be using:

1) a manual idea generation technique (NI) (which is also referred to as "IG" - idea generation in this script); or
2) an electronic idea generation technique (ENI) (which is also referred to as "EIG" - electronic idea generation in this script)."

But before we get started I want to go over the instructions of how we are going to use this technique."

Pass out appropriate instructions (either BS or NI).

"Let's go through these instructions together. You will be using a technique called (BS, skip if NI). We will follow these instructions (cover basics - read through rules to be used, look for recognition). Please stop me at any time if you have any questions. I will distribute the problem for this session."

Pass out first task (tea bag/vinyl disk).

"Read through the problem description (pass out appropriate task prop (tea bag/vinyl disk)) - what we want you to do is to come up with alternative uses for the (TB/VD), this is what is called a "uses" task (answer any questions). (They will generate orally, facilitator will backtrack and then write down on flipchart - don't forget to turn on the tape recorder! It is very important for the facilitator to be as "responseless" to all ideas and comments, yet responsive to all ideas). We will now generate ideas for five (5) minutes. (At five minutes have them stop). Time is up."

"Before we move on to the second task, are there any questions on how to use the technique? Is everybody comfortable in using this technique?"

Pass out the second task (parking/library problem).

"Read through the problem description - let me know if you have any questions. You will generate ideas for twenty (20) minutes. If you have a problem or question, raise your hand. (Half way through the session remind them of the "rules" we are following; at 20 minutes have them stop). Time is up.

For the BS sessions, monitor comments to ensure that no evaluative comments are being made. If such comments are detected, remind them of the instructions which ask them not to do any evaluation of ideas. For both sessions, you may need to remind them that it is an idea generation session - not a conversation about ideas (or other things).

VIII. POST-SESSION SURVEY (NONCOMPUTER-SUPPORTED TASK)

"I would like to have you complete a couple of short surveys about this session. Please take your time to read the instructions and answer the questions as best you can. There are no right or wrong answers, we are interested in your opinion, your impressions of the session. The first questionnaire asks for your impressions of the (BS, IG) you used in three areas: an overall assessment of the system, an assessment of how easy you felt the system was to use, and your perception of how useful you feel it would be to use this system for any future work groups in which you would be a member (such as in class groups, work groups, etc.). Please put your participant number on the top of the form."

Pass out EASE/USEFULNESS assessment. Make sure that the participant number is on the form when you collect them. Put in group's folder.

"The other questionnaire asks for your overall impressions about the group idea generation session in which you just participated. Just this last session using (BS, IG) for the (parking/library problem). Any questions about the task pertain to the main task (parking/library) that you just addressed. Again, there are no right or wrong answers, we are only interested in your opinion. Please be sure to put your participant number on the form."

Pass out POST-SESSION SURVEY (make sure that it has "task 1/2" written on it). Verify participant numbers. Collect and put in group's folder.

IX. TASK BACKGROUND SURVEY

"I would like to get some feedback from you pertaining to your personal experience with the two main tasks that we discussed, the library and parking problems."

Pass out TASK BACKGROUND INFORMATION SURVEY. Verify participant numbers. Collect and put in group's folder.

X. FINAL SURVEY

"I would like to have you fill out one final questionnaire that compares and contrasts the two idea generation sessions in which you participated. Before you start, take a minute and think about the first session you participated in and how it compares to the second session. (Take them back through each session, in the order in which they participated, e.g., in the computer-supported session you each sat at a PC, entered ideas using the keyboard, had access to ideas as they were generated on the main screen and at any time on your own screen. In the noncomputer-supported session you were all seated around the table, generated ideas orally, we backtracked and wrote the ideas on the flipcharts and then taped the sheets to the wall so that you could have access to the ideas the group had generated) Again, take time to read the instructions and answer the questions as best you can. I would ask that you read these questions carefully since some are asked in one direction or manner, and some in the other. Again, please make sure that your participant number is on the form."

Pass out FINAL QUESTIONNAIRE. Verify that the participant number is on the form. Collect and put in group's folder.

[If PHreD is used, a PHreD evaluation survey would/could be done at this point]

XI. DEBRIEFING SESSION

Debrief the entire group. Ask them about the two sessions (go with the flow, but address preferences, likes and dislikes pertaining to the two sessions, techniques, tasks, etc.), make sure to ask the questions that are on the posthoc question sheet.

Then provide an explanation of the purpose of the study.

Parting remarks: "Again, thanks for your participation in the study. Hopefully, it has been both fun and a learning experience. I would ask that you not talk with other students specifically about these sessions or the tasks we used. The reason that I ask you not to talk about these sessions with other students is that we will be running this study and others that use the same or similar tasks over the rest of this semester. If you talk with others about the tasks, then they will think about potential ideas immediately. If they know what the tasks are and think about potential solutions, then when they participate they will not be "generating new ideas" but rather "dredging up old ideas" that they have already thought about. That is not what we want people to do. So I would greatly appreciate your help in this area. Also, the fact that the group that does the best does get that cash prize - so I think it is to your advantage not to talk to others about the tasks or the session! Thank you again and good luck!!!"

APPENDIX A.2

EXPERIMENTER CHECKLIST

EXPERIMENTAL PROCEDURES CHECKLIST - IDEA GENERATION STUDY

GROUP NUMBER: ______________ DATE: ___________ TIME: _______

TASK NUMBER ONE: _______________ TECHNIQUE: ______________

TASK NUMBER TWO: _______________ TECHNIQUE: ______________

ITEM/STEP	TECHNIQUES	COMPLETED
Introduction	all	______
Consent Form	all	______
Pre-Session Survey	all	______
Typing Test	before Exx	______
Technique Instr.	each	______
First Task	all	______
Second Task	all	______
Ease of Use	each	______
Post Session Survey	all	______
* * BREAK * *		
Technique Instr.	each	______
First Task	all	______
Second Task	all	______
Ease of Use	each	______
Post Session Survey	all	______
Task Survey	all	______
Final Survey	all	______
Debriefing	all	______

APPENDIX A.2

PLEXSYS TECHNICAL INSTRUCTIONS

EXPERIMENTER PROCEDURES (CHECKLIST)
FOR RUNNING TOPIC COMMENTER

1) Start the appropriate number of user PC's with GO n (where n is the user number) (or NEW n) for the session.

2) Delete any files that may be in the SAVELAST directory using the CLEAR SYSTEM menu option.

3) Delete any previous TOPIC COMMENTER output.

4) Create TOPIC COMMENTER window title (or make sure this structure is still in place):

   Idea Generation Study

   with sub-entry titles:

   First Session (so this is the first window title displayed)
   Second Session (the second window title displayed)

5) Initialize logging capabilities by entering CLOG command (this will put file MAX.LOG in PUBLIC directory to allow logging to work. This file is deleted by CLEAR SYSTEM option and must be put out each time).

6) To run: Start TOPIC COMMENTER and send the submenu for "Idea Generation Study" (the First Session and Second Session windows).

7) Start the appropriate users (if only the appropriate number of PC's are at the PLEXSYS LOGO screen, then START ALL USERS, if additional PC's are at the LOGO screen, then start only the appropriate users).

8) Have participants access the First Session window for the first task (walk them through how to open first window (F10) for the warm-up task, enter their first idea (F2 and ENTER), and how the ideas will come up on the main screen (have the main screen off until each person has typed in an idea, then have them press F2 and point out the change in the color of the text on their screens (white to yellow), then turn on the main viewing screen (and collecting) so that they can see the ideas of others. Point out that they won't be able to see all the ideas since they will scroll; at this point show them how to access the ideas from their machine (F8) (and page up/down) and then F8 to enter more ideas. Check for recognition, questions, let them go; then move onto task number two (and window number two (Second

Session). Scroll the ideas from the first task up on the main viewing screen so that they will not be displayed on the screen while they are starting in on the second task.).

9) At the end of the session, have them exit by first closing the Second Session window (F10) and then exiting TOPIC COMMENTER (ALT-F9). At this point, exit TOPIC COMMENTER by pressing ALT-F9 twice. The system will ask for a file name (use the group number - such as GROUP07.OUT) (the default will be IDEA_GEN.OUT in case a name is not entered). This file will contain the output from both windows (sessions) separated by header information.

10) Exit TOPIC COMMENTER. Go to MISC TOOLS MENU and select the COLLECT LOG FILES option. This will create the log files for each participant. Exit PLEXSYS and go to the SAVELAST directory. There should be a .LOG file for each user and the .OUT file for the group. (it is advantageous to rename the .OUT file using the group number, if not already done, and rename the log files to provide a group number and user number identifier (e.g., G07TOP6.LOG - for user 6) to provide unique filenames for the group/session.

11) Copy the files to diskette (or harddisk); verify that the file have been successfully copied.

12) Delete files from SAVELAST.

APPENDIX A.4

QUESTIONS FOR POST-HOC INTERVIEWS

QUESTIONS FOR POST-HOC INTERVIEWS

1) "We used two different idea generation techniques, (EBS, ENI) and (BS, NI), which of the two techniques did you like to best?"

2) "Why?"

3) "Was there anything else that you liked, or disliked about that technique? The other technique?"

4) "Which technique do you think you spent more time looking at the ideas of others?"

5) "You were involved in two different group interactions, one in which you sat around a table with a group of people and verbally generated ideas. In the other session you were separated from the group and working on your own on a PC. Which of the two settings did you prefer?"

6) "Why?"

7) "In this session you generated ideas for two main tasks: the Library Problem and the Parking Problem. Was one of the two problems easier to generate ideas for than the other, or were they about the same degree of difficulty?"

8) "How about the two warm-up tasks (Tea Bag and Vinyl Disk)?"

9) "Which session was more fun?"

APPENDIX B.1

TASK DESCRIPTIONS

- Tea Bag Problem
- Vinyl Disk Problem
- Parking Problem
- Library Problem

TEA BAG PROBLEM DESCRIPTION

In the production of intermediate and final goods some organizations run into the situation of having excess production capacity or not having enough capacity. These types of situations present challenges for organizations as they must make decisions about how to best solve this problem. The tea industry is currently facing such a dilema.

Most people know what a tea bag looks like. Many of us handle them every day. The gauze-like paper pouch contains bits of tea leaves. When placed in a teapot, hot water passes through the bag and the tea can brew. The bag permits the tea to diffuse without dispensing the leaves throughout the water. The bag can be retrieved and the strength of the tea maintained.

The tea industry has spare capacity for producing tea bags. More can be produced than is currently needed for the consumption of tea. The current demand underutilizes the resources that are presently dedicated to tea bag production. Instead of cutting back production and the number of jobs, or reallocating these resources, the industry would like to take advantage of this spare capacity to generate additional revenues.

How else might tea bags be used?

Be specific, complete and concise - yet you need to provide enough information so that someone else can fully understand your idea without requiring further explanation.

To help get you started, here is an idea:

You could put pre-measured amounts of detergent into the bags so that you wouldn't have to measure detergent for each load. Just toss them into the washer with the clothes and you're all ready to go.

VINYL DISK PROBLEM DESCRIPTION

In the production of intermediate and final goods some organizations run into the situation of having excess production capacity or not having enough capacity. These types of situations present challenges for organizations as they must make decisions about how to best solve this problem. The music recording industry is currently facing such a dilema.

Most people know what an album looks like. Many of us play albums every day. The 12 inch grooved vinyl disk has been the prevalent recording media used by the music recording industry for a number of years. Year after year the number of albums sold had risen steadily. Given the growing market, the music recording industry had steadily increased its production capabilities for vinyl disks.

However, recently the widespread acceptance of both cassette tapes and compact disks (CDs) has drastically reduced the sales of albums. Now that the demand for musical recordings on albums has dropped dramatically, the industry has excess capacity for vinyl disk production. Instead of cutting back this production and reducing the number of jobs in this area the industry would like to find additional uses for vinyl disks.

How else might vinyl disks be used?

Be specific, complete and concise - yet you need to provide enough information so that someone else can fully understand your idea without requiring further explanation.

To help get you started, here is an idea:

You could attach a polishing material to one side of the disk. Play the disk in the normal way (with the polishing side up) and polish whatever needs polishing.

THE PARKING PROBLEM

You have probably tried to find a place to park around the IU campus and know that it is not always easy. Even if you don't have a car on campus, you probably have witnessed such problems. This is especially true when you are late for class, an appointment or a ball game. The question put forth to you today is:

What can be done to help reduce the parking problem at IU?

Be specific, complete and concise - yet you need to provide enough information so that someone else can fully understand your idea without requiring further explanation.

THE LIBRARY PROBLEM

Don't you hate it when you go to the library to do a report and the one key book or magazine you need has been stolen or torn up? The IU libraries have been plagued with books being mutilated, articles cut out, pages ripped away, and other materials being stolen. The question put forth to you today is:

What can be done to help reduce these problems for the libraries?

Be specific, complete and concise - yet you need to provide enough information so that someone else can fully understand your idea without requiring further explanation.

APPENDIX B.2

IDEA GENERATION TECHNIQUE INSTRUCTIONS

- Electronic Brainstorming
- Brainstorming
- No Instructions
- Electronic No Instructions

INSTRUCTIONS FOR ELECTRONIC BRAINSTORMING

You are to generate as many ideas as you can to provide solutions to two problems. Time is important. You will have five minutes to complete the first task and twenty minutes to complete the second task. You are to follow the instructions listed below. It is important that the time be used as effectively as possible.

Instructions for Electronic Brainstorming

1. There will be no talking during this session.

2. Each person will use a Personal Computer (PC) connected to an Electronic Brainstorming System (EBS) called Topic Commenter.

3. The following rules are to be used:

    a. Criticism is ruled out. Adverse judgement of ideas must be withheld.

    b. Freewheeling is welcomed. The wilder the idea, the better. It is easier to tame down than to think up. Do not be afraid to enter anything that comes to mind. This will stimulate more and better ideas.

    c. Quantity is wanted. The greater the number of ideas, the greater the likelihood of producing one which is innovative. Come up with as many as you can.

    d. Combination and improvement are sought. You can use ideas previously suggested to build upon or join together into still better ideas.

    e. If you get stuck, use the ideas of others to stimulate your thinking.

4. When told to begin, enter your idea directly into the EBS via the PC keyboard. The F2 key stores (saves) the idea. When this is done the color of the letters you have entered changes from white to a greenish yellow. Use the "ENTER" key to add a blank line before entering the next idea. Enter only one idea at a time. Remember to press the F2 key after each idea, then "ENTER" to add a blank line.

5. To see all ideas that have been generated by the group, press the F8 key. This displays all the ideas that have been generated so far. Before you can enter another idea, press F8 again. You may access this list of ideas as often as you want. If you get stuck, use this list of ideas to stimulate your thinking.

6. Proceed with steps 4 and 5 until you are told to stop.

INSTRUCTIONS FOR BRAINSTORMING

You are to generate as many ideas as you can to provide solutions to two problems. Time is important. You will have five minutes to complete the first task and twenty minutes to complete the second task. You are to follow the instructions listed below. It is important that the time be used as effectively as possible.

As is often done in Brainstorming sessions, all ideas you generate will be written on a flip chart by the facilitator. This person will do nothing but record your ideas. The ideas will also be recorded using a tape recorder.

Instructions for Brainstorming

The following rules are to be used:

1. Criticism is ruled out. Adverse judgement of ideas must be withheld.

2. Freewheeling is welcomed. The wilder the idea, the better. It is easier to tame down than to think up. Do not be afraid to suggest anything that comes to mind. This will stimulate more and better ideas.

3. Quantity is wanted. The greater the number of ideas, the greater the likelihood of producing one which is innovative. Come up with as many as you can.

4. Combination and improvement are sought. You can use ideas previously suggested to build upon or join together into still better ideas.

5. If you get stuck, use the ideas of others to stimulate your thinking.

Generate ideas until you are told to stop.

INSTRUCTIONS FOR IDEA GENERATION

You are to generate as many ideas as you can to provide solutions to two problems. Time is important. You will have five minutes to complete the first task and twenty minutes to complete the second task. You are to follow the instructions listed below. It is important that the time be used as effectively as possible.

As is often done in idea generations sessions, all ideas you generate will be written on a flip chart by the facilitator. This person will do nothing but record your ideas. The ideas will also be recorded using a tape recorder.

If you get stuck, use the ideas of others to stimulate your thinking.

Generate ideas until you are told to stop.

INSTRUCTIONS FOR ELECTRONIC IDEA GENERATION

You are to generate as many ideas as you can to provide solutions to two problems. Time is important. You will have five minutes to complete the first task and twenty minutes to complete the second task. You are to follow the instructions listed below. It is important that the time be used as effectively as possible.

Instructions for Electronic Idea Generation

1. There will be no talking during this session.

2. Each person will use a Personal Computer (PC) connected to an Electronic Idea Generation System called Topic Commenter.

3. When told to begin, enter your idea directly into the Electronic Idea Generation system via the personal computer keyboard. The F2 key stores (saves) the idea. When this is done the color of the letters you have entered changes from white to a greenish yellow. Use the "ENTER" key to add a blank line before entering the next idea. Enter only one idea at a time. Remember to press the F2 key after each idea, then "ENTER" to add a blank line.

4. To see all ideas that have been generated by the group, press the F8 key. This displays all the ideas that have been generated so far. Before you can enter another idea, press F8 again. You may access this list of ideas as often as you choose to. If you get stuck, use this list of ideas to stimulate your thinking.

5. Proceed with steps 3 and 4 until you are told to stop.

APPENDIX C.1

CONSENT FORM

- Researcher's Copy
- Student's Copy

INDIANA UNIVERSITY

SCHOOL OF BUSINESS
Bloomington/Indianapolis

Operations and Systems Management
Graduate School of Business
Indiana University
Tenth and Fee Lane
Bloomington, Indiana 47405
Telephone: (812) 335-8449
Jack W. Fellers
(335-7781)

CONSENT FORM

A study on group idea generation is being undertaken that requires participation in two sessions. I understand that my participation in this study is strictly voluntary and that I may withdraw at any time without prejudice. Participation in this study will require approximately 1 hour for the first session and 2 1/2 hours for the second session. Additionally, I realize that the discussions in the second session will be videotaped. The only persons with access to these tapes will be the researcher and a set of judges. The video tapes will not be used for any other purpose than research and the identity of the subjects will not be known to anyone other than the researcher. All information collected about my behavior will be kept strictly confidential. I agree to fill out both preliminary and final questionnaires. I understand that my participating in this study will not in any way present personal risk to me. I also understand that I may ask questions of the researcher at the time I sign this document, or at any time during the study, pertaining to issues that I do not understand. I also agree not to discuss the procedures or outcomes of this experiment until the study has been completed. One copy of this consent form will be kept by the researcher, I will keep the other copy to do with as I please. Therefore, I do voluntarily agree to participate in this study.

______________________________ ______________________
Signature Date

____
Print Name

student's copy

INDIANA UNIVERSITY

SCHOOL OF BUSINESS
Bloomington/Indianapolis

Operations and Systems Management
Graduate School of Business
Indiana University
Tenth and Fee Lane
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CONSENT FORM

A study on group idea generation is being undertaken that requires participation in two sessions. I understand that my participation in this study is strictly voluntary and that I may withdraw at any time without prejudice. Participation in this study will require approximately 1 hour for the first session and 2 1/2 hours for the second session. Additionally, I realize that the discussions in the second session will be videotaped. The only persons with access to these tapes will be the researcher and a set of judges. The video tapes will not be used for any other purpose than research and the identity of the subjects will not be known to anyone other than the researcher. All information collected about my behavior will be kept strictly confidential. I agree to fill out both preliminary and final questionnaires. I understand that my participating in this study will not in any way present personal risk to me. I also understand that I may ask questions of the researcher at the time I sign this document, or at any time during the study, pertaining to issues that I do not understand. I also agree not to discuss the procedures or outcomes of this experiment until the study has been completed. One copy of this consent form will be kept by the researcher, I will keep the other copy to do with as I please. Therefore, I do voluntarily agree to participate in this study.

______________________________ ____________________
Signature **Date**

____
Print Name

researcher's copy

APPENDIX C.2

PRE-SESSION SURVEY

PRE-SESSION PARTICIPANT SURVEY   Group Number:________________

Participant Number:___________

Regarding your personal background:

1. Age: ______ years

2. Sex: ______

3. What is the total number of months that you have been employed full-time? (This means months spent as a full-time employee. Part-time jobs do not count. But do count summer jobs if you worked at them full-time).

   _______ months

4. What is your cumulative Grade Point Average (GPA)? _______

Regarding your experience with computers:

5. How well do you type (check one)?

   ___ Hunt and peck
   ___ Rough or casual typing
   ___ Good typing (around 30 wpm error-free)
   ___ Excellent typing

6. How many times have you used computer terminals or personal computers for any kind of application?

   ___ Never
   ___ Once or twice
   ___ Three to ten times
   ___ Frequently

7. Have your ever used PLEXSYS (this computer system) to support a group session?

   ___ No
   ___ Yes ====> How many times? ______ sessions

8. I like to use computers?

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

9. I like to use computers.

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

10. I would use computers even if it were not expected of me.

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

11. I don't care what people say, computers are not for me.

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

Regarding your general experience with groups:

12. Generally, what is your level of experience in working in groups?

	Seldom Work in Groups	Sometimes Work in Groups	Often Work in Groups
(circle one)	1-----2-----3-----4-----5-----6-----7		

13. Generally, I like to participate in groups.

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

14. Generally, I am comfortable while participating in groups.

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

15. Generally, I am reluctant to talk in groups (suggest ideas, express opinions, ask or respond to questions).

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

Regarding this particular session:

16. How much experience have you had working with those present at this session? (choose one)

___ First time working with those present
___ Worked once or twice with some of those present
___ Worked once or twice with most or all those present
___ Work a lot with one or some of those present
___ Work a lot with most or all of those present

17. How successfully do you expect the group to be able to accomplish the session outcomes (generation of ideas)?

	Very Un-Successful	Neutral/ Undecided	Very Successful
(circle one)	1-----2-----3-----4-----5-----6-----7		

18. How motivated are you to make this session a success?

	Very Un-Motivated	Neutral/ Undecided	Very Motivated
(circle one)	1-----2-----3-----4-----5-----6-----7		

19. How significant do you expect your personal contribution will be to the session outcomes?

	Very In-Significant	Neutral/ Undecided	Very Significant
(circle one)	1-----2-----3-----4-----5-----6-----7		

THANK YOU FOR YOUR COOPERATION AND INPUT.
HAVE A GOOD SESSION!!!

APPENDIX C.3

TECHNIQUE EVALUATION INSTRUMENTS

- Electronic Brainstorming
- Brainstorming
- No Instructions
- Electronic No Instructions

* **Overall Evaluation**, part A of this instrument, was not reported in this study given the desire to specifically examine the perceived usefulness portion of this instrument.

* **Perceived Ease of Use**, part B of this instrument, was not reported given the questionable appropriateness of this measure for the techniques without GDSS support.

* **Perceived Usefulness** was calculated by first summing the scores for the four questions in part C of the Technique Evaluation Instrument for all group members. This sum was then divided by the number of members in the group to arrive at a group mean.

* **System Features**, part D of the instrument for EBS and ENI only, provided additional feedback pertaining to specific characteristics of the GDSS. Responses to these questions were reported in Chapter 6 when addressing potential limitation imposed by the GDSS.

TECHNIQUE EVALUATION for ELECTRONIC BRAINSTORMING

Group Number:________________
Participant Number:__________

The following questions pertain to your overall evaluation of the Electronic Brainstorming system. In general, please provide your overall assessment of the utility of this technique for use in future group activities.

A. OVERALL EVALUATION

Using the Electronic Brainstorming system in a group I'm involved in would be:

	Extremely Good	Neither	Extremely Bad
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Harmful	Neither	Extremely Beneficial
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Wise	Neither	Extremely Foolish
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Negative	Neither	Extremely Positive
(circle one)	1-----2-----3-----4-----5-----6-----7		

EBS/1

B. PERCEIVED EASE OF USE EBS/2

The following questions pertain to your evaluation of the use of the Electronic Brainstorming system. In general, please provide your overall assessment of how easy you believe this technique was to learn and use.

For these questions please use the following scale:

Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

1---------2--------3--------4--------5--------6---------7

1. Learning to use the Electronic Brainstorming system was easy for me:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

2. I found it easy to get the Electronic Brainstorming system do what I want to do:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

3. It was easy for me to become skillful at using the Electronic Brainstorming system:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

4. I found the Electronic Brainstorming system easy to use:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

The following questions pertain to your evaluation of the use of the Electronic Brainstorming system. In general, please provide your overall assessment of how useful you believe this technique would be to support activities for a group in which you would be working.

For these questions please use the following scale:

Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

1---------2--------3--------4--------5--------6---------7

1. Using the Electronic Brainstorming system would improve my work group performance:

   Extremely Unlikely — Neither — Extremely Likely

   (circle one) 1-----2-----3-----4-----5-----6-----7

2. Using the Electronic Brainstorming system in my work group would increase our productivity:

   Extremely Unlikely — Neither — Extremely Likely

   (circle one) 1-----2-----3-----4-----5-----6-----7

3. Using the Electronic Brainstorming system would enhance the effectiveness of my work group:

   Extremely Likely — Neither — Extremely Unlikely

   (circle one) 1-----2-----3-----4-----5-----6-----7

4. I would find the Electronic Brainstorming system useful in my work group:

   Extremely Unlikely — Neither — Extremely Likely

   (circle one) 1-----2-----3-----4-----5-----6-----7

D. SYSTEM FEATURES

The following questions evaluate the features of the Electronic Brainstorming system. Please use the following scale to respond to these questions:

Strongly Disagree — Neutral/ Undecided — Strongly Agree

1-----2-----3-----4-----5-----6-----7

1. The amount of information I could enter at one time using the Electronic Brainstorming system limited my expression of ideas:

   Strongly Disagree — Neutral/ Undecided — Strongly Agree

   1-----2-----3-----4-----5-----6-----7

2. My typing ability greatly hampered my ability to use the Electronic Brainstorming system:

   Strongly Disagree — Neutral/ Undecided — Strongly Agree

   1-----2-----3-----4-----5-----6-----7

3. Not hearing others orally generate ideas hindered my ability to generate new ideas or build on the ideas of others:

   Strongly Disagree — Neutral/ Undecided — Strongly Agree

   1-----2-----3-----4-----5-----6-----7

4. It was difficult to read the ideas of others as they are displayed on the computer screen:

   Strongly Disagree — Neutral/ Undecided — Strongly Agree

   1-----2-----3-----4-----5-----6-----7

TECHNIQUE EVALUATION for the BRAINSTORMING TECHNIQUE

Group Number:________________
Participant Number:__________

The following questions pertain to your overall evaluation of the Brainstorming technique. In general, please provide your overall assessment of the utility of this technique for use in future group activities.

A. OVERALL EVALUATION

Using the Brainstorming technique in a group I'm involved in would be:

	Extremely Good	Neither	Extremely Bad
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Harmful	Neither	Extremely Beneficial
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Wise	Neither	Extremely Foolish
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Negative	Neither	Extremely Positive
(circle one)	1-----2-----3-----4-----5-----6-----7		

BS/1

B. PERCEIVED EASE OF USE BS/2

The following questions pertain to your evaluation of the use of the Brainstorming technique. In general, please provide your overall assessment of how easy you believe this technique was to learn and use.

For these questions please use the following scale:

Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

1---------2--------3--------4--------5--------6---------7

1. Learning to use the Brainstorming technique was easy for me:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

2. I found it easy to get the Brainstorming technique do what I want to do:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

3. It was easy for me to become skillful at using the Brainstorming technique:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

4. I found the Brainstorming technique easy to use:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

C. PERCEIVED USEFULNESS

The following questions pertain to your evaluation of the use of the Brainstorming technique. In general, please provide your overall assessment of how useful you believe this technique would be to support activities for a group in which you would be working.

For these questions please use the following scale:

Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

1---------2---------3---------4---------5---------6---------7

1. Using the Brainstorming technique would improve my work group performance:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

2. Using the Brainstorming technique in my work group would increase our productivity:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

3. Using the Brainstorming technique would enhance the effectiveness of my work group:

Extremely Likely — Neither — Extremely Unlikely

(circle one) 1-----2-----3-----4-----5-----6-----7

4. I would find the Brainstorming technique useful in my work group:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

TECHNIQUE EVALUATION for the IDEA GENERATION TECHNIQUE

Group Number:________________
Participant Number:___________

The following questions pertain to your overall evaluation of the Idea Generation technique. In general, please provide your overall assessment of the utility of this technique for use in future group activities.

A. OVERALL EVALUATION

Using the Idea Generation technique in a group I'm involved in would be:

	Extremely Good	Neither	Extremely Bad
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Harmful	Neither	Extremely Beneficial
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Wise	Neither	Extremely Foolish
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Negative	Neither	Extremely Positive
(circle one)	1-----2-----3-----4-----5-----6-----7		

NI/1

B. PERCEIVED EASE OF USE NI/2

The following questions pertain to your evaluation of the use of the Idea Generation technique. In general, please provide your overall assessment of how easy you believe this technique was to learn and use.

For these questions please use the following scale:

Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

1---------2---------3---------4---------5---------6---------7

1. Learning to use the Idea Generation technique was easy for me:

Extremely Unlikely   Neither   Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

2. I found it easy to get the Idea Generation technique do what I want to do:

Extremely Unlikely   Neither   Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

3. It was easy for me to become skillful at using the Idea Generation technique:

Extremely Unlikely   Neither   Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

4. I found the Idea Generation technique easy to use:

Extremely Unlikely   Neither   Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

C. PERCEIVED USEFULNESS NI/3

The following questions pertain to your evaluation of the use of the Idea Generation technique. In general, please provide your overall assessment of how useful you believe this technique would be to support activities for a group in which you would be working.

For these questions please use the following scale:

Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

1---------2--------3--------4--------5--------6---------7

1. Using the Idea Generation technique would improve my work group performance:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

2. Using the Idea Generation technique in my work group would increase our productivity:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

3. Using the Idea Generation technique would enhance the effectiveness of my work group:

Extremely Likely — Neither — Extremely Unlikely

(circle one) 1-----2-----3-----4-----5-----6-----7

4. I would find the Idea Generation technique useful in my work group:

Extremely Unlikely — Neither — Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

TECHNIQUE EVALUATION for ELECTRONIC IDEA GENERATION

Group Number:________________
Participant Number:__________

The following questions pertain to your overall evaluation of the Electronic Idea Generation system. In general, please provide your overall assessment of the utility of this technique for use in future group activities.

A. OVERALL EVALUATION

Using the Electronic Idea Generation system in a group I'm involved in would be:

	Extremely Good	Neither	Extremely Bad
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Harmful	Neither	Extremely Beneficial
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Wise	Neither	Extremely Foolish
(circle one)	1-----2-----3-----4-----5-----6-----7		

	Extremely Negative	Neither	Extremely Positive
(circle one)	1-----2-----3-----4-----5-----6-----7		

ENI/1

B. PERCEIVED EASE OF USE ENI/2

The following questions pertain to your evaluation of the use of the Electronic Idea Generation system. In general, please provide your overall assessment of how easy you believe this technique was to learn and use.

For these questions please use the following scale:

Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

1---------2---------3---------4---------5---------6---------7

1. Learning to use the Electronic Idea Generation system was easy for me:

   Extremely Unlikely — Neither — Extremely Likely

   (circle one) 1-----2-----3-----4-----5-----6-----7

2. I found it easy to get the Electronic Idea Generation system do what I want to do:

   Extremely Unlikely — Neither — Extremely Likely

   (circle one) 1-----2-----3-----4-----5-----6-----7

3. It was easy for me to become skillful at using the Electronic Idea Generation system:

   Extremely Unlikely — Neither — Extremely Likely

   (circle one) 1-----2-----3-----4-----5-----6-----7

4. I found the Electronic Idea Generation system easy to use:

   Extremely Unlikely — Neither — Extremely Likely

   (circle one) 1-----2-----3-----4-----5-----6-----7

C. PERCEIVED USEFULNESS ENI/3

The following questions pertain to your evaluation of the use of the Electronic Idea Generation system. In general, please provide your overall assessment of how useful you believe this technique would be to support activities for a group in which you would be working.

For these questions please use the following scale:

Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

1---------2---------3---------4---------5---------6---------7

1. Using the Electronic Idea Generation system would improve my work group performance:

Extremely Unlikely   Neither   Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

2. Using the Electronic Idea Generation system in my work group would increase our productivity:

Extremely Unlikely   Neither   Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

3. Using the Electronic Idea Generation system would enhance the effectiveness of my work group:

Extremely Likely   Neither   Extremely Unlikely

(circle one) 1-----2-----3-----4-----5-----6-----7

4. I would find the Electronic Idea Generation system useful in my work group:

Extremely Unlikely   Neither   Extremely Likely

(circle one) 1-----2-----3-----4-----5-----6-----7

The following questions evaluate the features of the Electronic Idea Generation system. Please use the following scale to respond to these questions:

Strongly Disagree	Neutral/ Undecided	Strongly Agree

1-----2-----3-----4-----5-----6-----7

1. The amount of information I could enter at one time using the Electronic Idea Generation system limited my expression of ideas:

Strongly Disagree	Neutral/ Undecided	Strongly Agree

1-----2-----3-----4-----5-----6-----7

2. My typing ability greatly hampered my ability to use the Electronic Idea Generation system:

Strongly Disagree	Neutral/ Undecided	Strongly Agree

1-----2-----3-----4-----5-----6-----7

3. Not hearing others orally generate ideas hindered my ability to generate new ideas or build on the ideas of others:

Strongly Disagree	Neutral/ Undecided	Strongly Agree

1-----2-----3-----4-----5-----6-----7

4. It was difficult to read the ideas of others as they were displayed on the computer screen:

Strongly Disagree	Neutral/ Undecided	Strongly Agree

1-----2-----3-----4-----5-----6-----7

APPENDIX C.4

POST-SESSION SURVEY

* Group member **Satisfaction** with the idea generation process was calculated by first summing the responses for all group members to Question 15 from this survey. This sum was then divided by the number of members in the group to arrive at a group mean.

POST-SESSION PARTICIPANT SURVEY   Group Number:________________

Participant Number:__________

Directions: We are interested in how your group session went. Please indicate in the space provided the degree to which each statement applies to this session. Indicate your choice by circling the appropriate number. There are no right or wrong answers. Work quickly; just record your first impressions.

1. I was not very satisfied with the idea generation process in this session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

2. The instructions that were given for the idea generation technique were easy to understand:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

3. The idea generation technique was easy to use:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

4. It was fun to participate in the session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

5. It was easy to generate ideas for the task presented in this session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

6. The group concentrated exclusively on the idea generation task:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

7. Everyone had an equal opportunity to contribute ideas:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

8. I am confident that the ideas my group generated are of high quality:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

9. One or two members produced a majority of the ideas:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

10. I felt comfortable contributing my ideas:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

11. During the session, I was motivated to generate good quality ideas:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

12. I was able to get my ideas out as soon as they occurred to me:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

13. I was able to contribute all the ideas that occurred to me:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

14. I would recommend this idea generation technique to others as a means of generating ideas:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

15. Overall, I was very satisfied with this idea generation session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

16. Estimate the percentage of the group's ideas you generated:

____________ % (of the group's ideas).

APPENDIX C.5

BACKGROUND TASK INFORMATION QUESTIONNAIRE

TASK BACKGROUND QUESTIONNAIRE   Group Number:_______________

Participant Number:__________

1. Do you have a car with you here in Bloomington?   Yes   No

2. How many times have you driven on campus? (choose one)

____ Have never driven on campus
____ Have driven on campus once or twice
____ Have driven on campus less than ten times
____ Have driven on campus several times
____ Drive on campus all the time

3. How familiar are you with parking problems on the IU campus? (chose the item you feel is most appropriate)

____ Have personally experienced them as a passenger/driver
____ Have experienced them as a pedestrian/bystander
____ Have read about them in the paper/heard about them on the radio/television
____ Have not heard/seen anything about parking problems here

4. How familiar are you with the libraries on the IU campus? (choose one)

____ Have never been to an IU library
____ Have been to one IU library
____ Have been to more than one IU library

5. How often do you use the IU libraries? (choose one)

____ Not at all
____ Less than once a week
____ About once a week
____ Two to three times a week
____ More than three times a week

6. Have you ever faced the types of problems previously discussed at any of the IU libraries (e.g., materials stolen, damaged or destroyed)? (chose one)

____ Have never had any problems like that at any of the IU libraries or any other libraries
____ Have never personally experienced such problems, but have heard about such problems from friends/media
____ Have experienced such problems as a library patron on one occasion
____ Have experienced such problems as a library patron on more than one occasion
____ Have experienced such problems as a library patron on several occasions

APPENDIX C.6

FINAL SURVEY

FINAL PARTICIPANT SURVEY

Group Number:________________
Participant Number:___________

We are interested in how you feel about the two sessions in which you participated. Please indicate in the space provided the degree to which the statements apply to the two sessions. Indicate your choice by circling the appropriate number. There are no right or wrong answers. Work quickly; just record your first impressions.

1. Overall, the computer-supported session was more efficient than the noncomputer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

2. The noncomputer-supported session enabled the group to concentrate more on idea generation than the computer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

3. The noncomputer-supported session was more effective than the computer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

4. The computer-supported session was more successful, in terms of generating ideas to address the problems, than the noncomputer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

5. Overall, the computer-supported session was more satisfying than the noncomputer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

6. It was easier to access the ideas of others during the noncomputer-supported session than during the computer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

7. Overall, the computer-supported session was more fun than the noncomputer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

8. I felt more comfortable participating in the noncomputer-supported session than the computer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

9. In the computer-supported session I was less likely to evaluate ideas than in the noncomputer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

10. In the noncomputer-supported session my thought processes were more stimulated than in the computer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

11. In the computer-supported session it was easier to exchange ideas among group members than in the noncomputer-supported session:

	Strongly Disagree	Neutral/ Undecided	Strongly Agree
(circle one)	1-----2-----3-----4-----5-----6-----7		

12. In the noncomputer-supported session it was easier for group members to influence the group's direction than in the computer-supported session:

	Strongly Disagree			Neutral/ Undecided			Strongly Agree
(circle one)	1	2	3	4	5	6	7

13. In the noncomputer-supported session there was more opportunity for equal group participation among members than in the computer-supported session:

	Strongly Disagree			Neutral/ Undecided			Strongly Agree
(circle one)	1	2	3	4	5	6	7

14. In the computer-supported session it was easier to contribute my ideas than in the noncomputer-supported session:

	Strongly Disagree			Neutral/ Undecided			Strongly Agree
(circle one)	1	2	3	4	5	6	7

15. Overall, I feel that the noncomputer-supported technique was easier to use than the computer-supported technique:

	Strongly Disagree			Neutral/ Undecided			Strongly Agree
(circle one)	1	2	3	4	5	6	7

16. Overall, I feel the computer-supported session was more productive than the noncomputer-supported session:

	Strongly Disagree			Neutral/ Undecided			Strongly Agree
(circle one)	1	2	3	4	5	6	7

17. Please describe why you feel that one type of session was better than the other for generating ideas:

18. Please describe why you feel that one session was more personally satisfying for you to participate in than the other:

19. What impact did the following factors have on the productivity of the computer-supported idea generation session:

	Highly Negative			No Impact			Highly Positive
a) Anonymity	1-----2-----3-----4-----5-----6-----7						
b) Simultaneous idea generation	1-----2-----3-----4-----5-----6-----7						
c) Recording of information on computer system	1-----2-----3-----4-----5-----6-----7						
d) Rapid/Easy access to the comments of others	1-----2-----3-----4-----5-----6-----7						
e) Equal opportunity to contribute ideas	1-----2-----3-----4-----5-----6-----7						
f) other __________ ____________________	1-----2-----3-----4-----5-----6-----7						
g) other __________ ____________________	1-----2-----3-----4-----5-----6-----7						

THANK YOU FOR YOUR TIME AND COOPERATION!!!!!

APPENDIX D.1

INSTRUCTIONS FOR RATERS

Procedures for Determining Number of Ideas Generated

The following procedures will be used in order to provide values for each group for the dependent variable Number of Ideas Generated as follows:

1) Total Number of Ideas Generated
2) Number of Different Ideas Generated
3) Number of Unique Ideas Generated

Before individual group values can be determined, an evaluation must be made of all the statements generated by all the groups. Drawing on the procedures used by previous studies the following rules will be used:

1) What must be done first is to determine if a statement generated by a participant does constitute an idea. The basic rule to follow is that a statement must point to a specific, concrete alternative for the problem at hand.

2) Statements that are too general should not be counted because the intent cannot be determined.

3) If a participant included a list of suggestions or examples, then it will only count as one idea; if all suggestions or examples are explained, then each one will count individually as an idea.

4) To determine if two similar ideas are the same or different requires the determination of whether or not there is a descriminable difference between two ideas. If a second idea adds something to the first, it will be regarded as a different idea and counted as such.

5) An idea will be determined to be "unique" if it is found to occur only once in the entire set of ideas generated by all groups.

The result of these determinations will provide a list of all the different ideas that have been generated by the groups, along with an indication of which ideas were produced by only one group (unique). By comparing each group's list of statements with the overall list of ideas, the factors previously listed can be determined for each group as follows:

1) Total number of ideas generated (by eliminating all suggestions that did not meet the criteria of an idea),

2) Number of different ideas generated (by eliminating any redundant ideas - those suggested more than once by a group),

3) Number of unique ideas (the number of ideas that were generated <u>only</u> by this group).

Rating Categories for Idea Generation Tasks

PS n.n - Proposes Solution # n.n from the idea scheme. Proposed solutions not on the scheme are coded as PS X (where X is a unique, ascending number beginning after the last n.n).

NS - Non-Solution. Does not provide a specific, concrete alternative (solution) to the problem statement.

SC - Supportive Comment. e.g., "Good idea"; "I like that "proposal". Expresses evidence for a proposal without adding evidence or argument.

SA - Supportive Argument. e.g., "I like that because it will eliminate the crowding."

SCL - Supportive Clarification. e.g., "We could make the remote parking in a shopping center." Adds detail or new features favoring a proposed solution.

PCL - Problem Clarification. e.g., "The real problem is time, as well as money"; "Another thing we need to worry about is congestion on the local streets." Adds detail or new features to problem statements.

CC - Critical Comment. e.g., "I don't like that": "That's a terrible idea." Expresses opposition to a proposal without adding evidence or argument.

CA - Critical Argument. e.g., "A drawback to that scheme is..." Opposes a proposal and gives evidence or argument.

QS - Query Solution. e.g., "How would the shuttle deal with handicapped riders?" Requests clarification or a proposed solution. Responses will be coded into one of the other categories.

QP - Query Problem. e.g., "Are we trying to deal with student parking or just faculty/staff?" Requests clarification of problem specification or solution criteria. Responses will be coded as one of the other categories.

COMP, +/- Positive, negative, or neutral comment about the computer network or its operation. e.g., "This system is too slow."

GRP, +/- Positive, negative, or neutral comment about the interpersonal processes of the group. e.g., "Lets try to agree on something, anyway."

OTT - Comments that are "off the topic" and do not fit the existing categories.

UC - Uncodable text.

APPENDIX D.2

INSTRUCTIONS FOR JUDGES

Instructions to Expert Judges

Attached is a random-ordered listing of ideas that have been generated to provide solutions to the (Library Problem/Parking Problem). For your information, an additional copy of the problem statement and participant instructions are attached.

Based upon your experience, please rate each idea on the following criteria:

Effectiveness - to what extent would a proposed idea help to attain the goal stated in the problem?

Feasibility - to what extent could a proposed solution be carried out, given the constraints of reality; are unrealistic assumptions presupposed by it?

Innovativeness - to what extent does the proposed solution introduce a new idea, method or device when addressing the problem.

Please rate each idea on a scale of one (1) to ten (10), where one is highly infeasible, highly ineffective, and not innovative; and ten is highly feasible, highly effective, highly innovative (as shown below). Please rate each idea independently of the other ideas.

highly ineffective	highly effective

1----2----3----4----5----6----7----8----9----10

highly infeasible	highly feasible

1----2----3----4----5----6----7----8----9----10

not very innovative	highly innovative

1----2----3----4----5----6----7----8----9----10

Thank you for your time and effort!

APPENDIX E.1

DIAGRAMS OF CWS LAB SETTINGS:

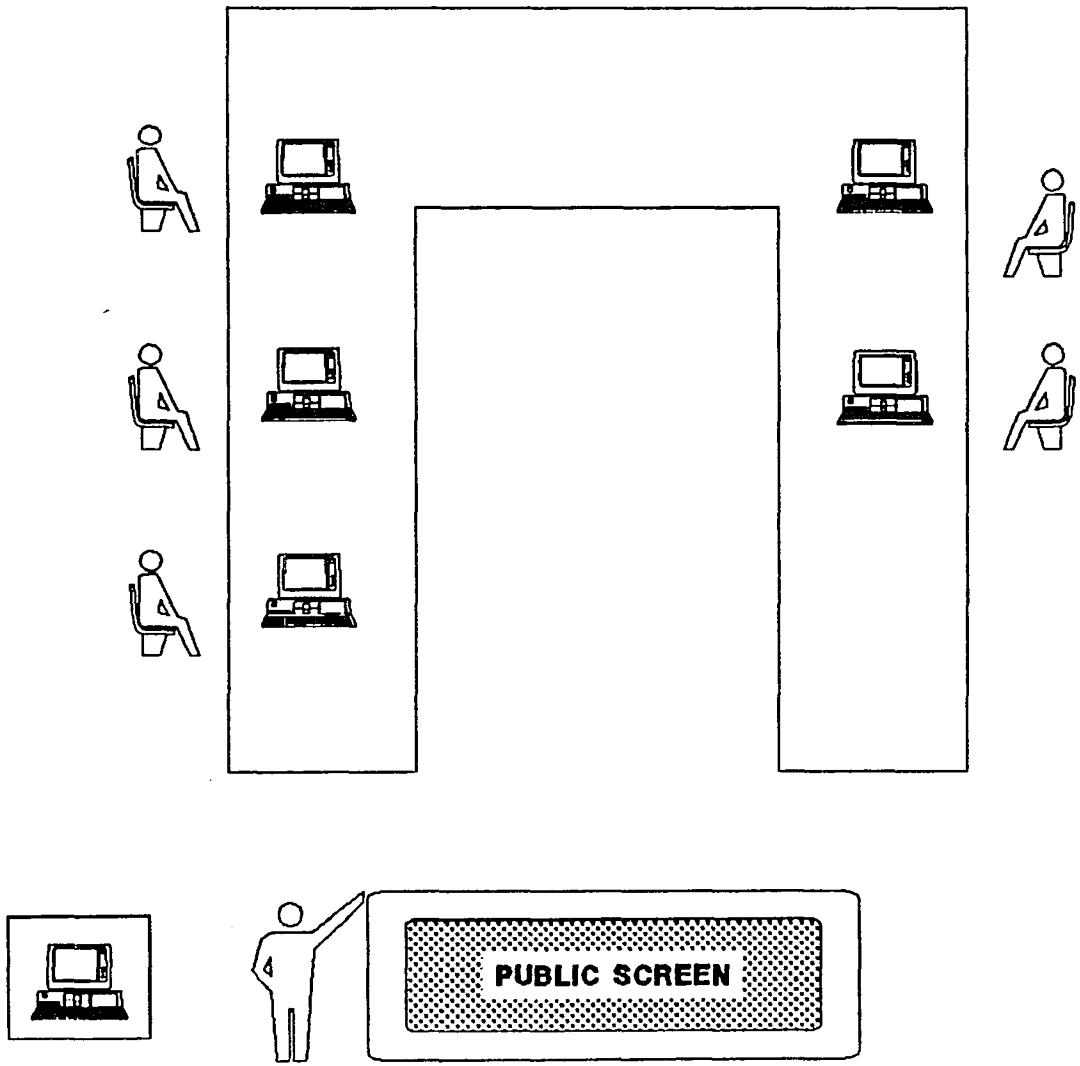
Electronic Brainstorming/Electronic
No Instructions Configuration

- Group Size = 5
- Group Size = 10

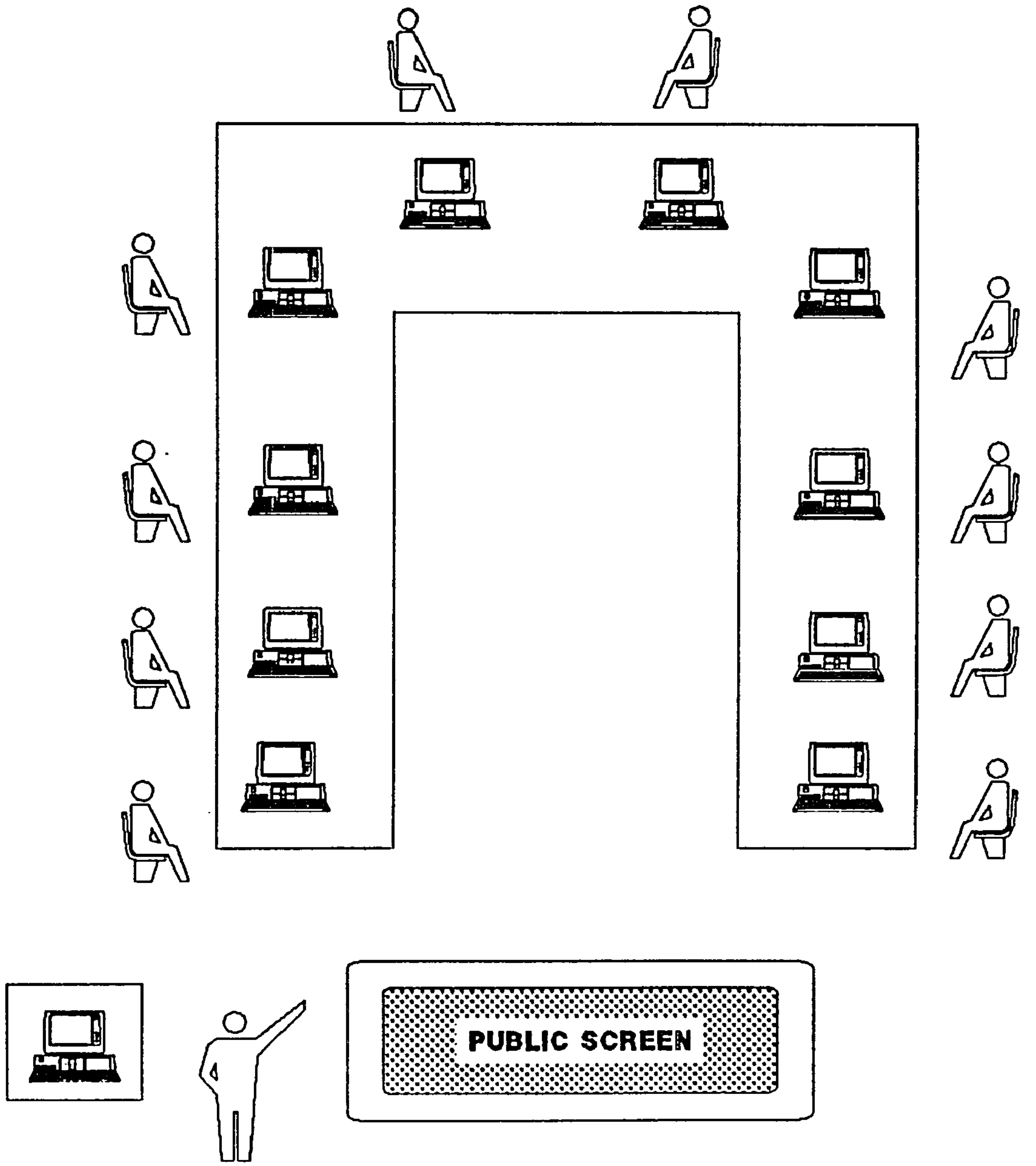
Brainstorming/No Instructions Configuration

- Group Size = 5
- Group Size = 10

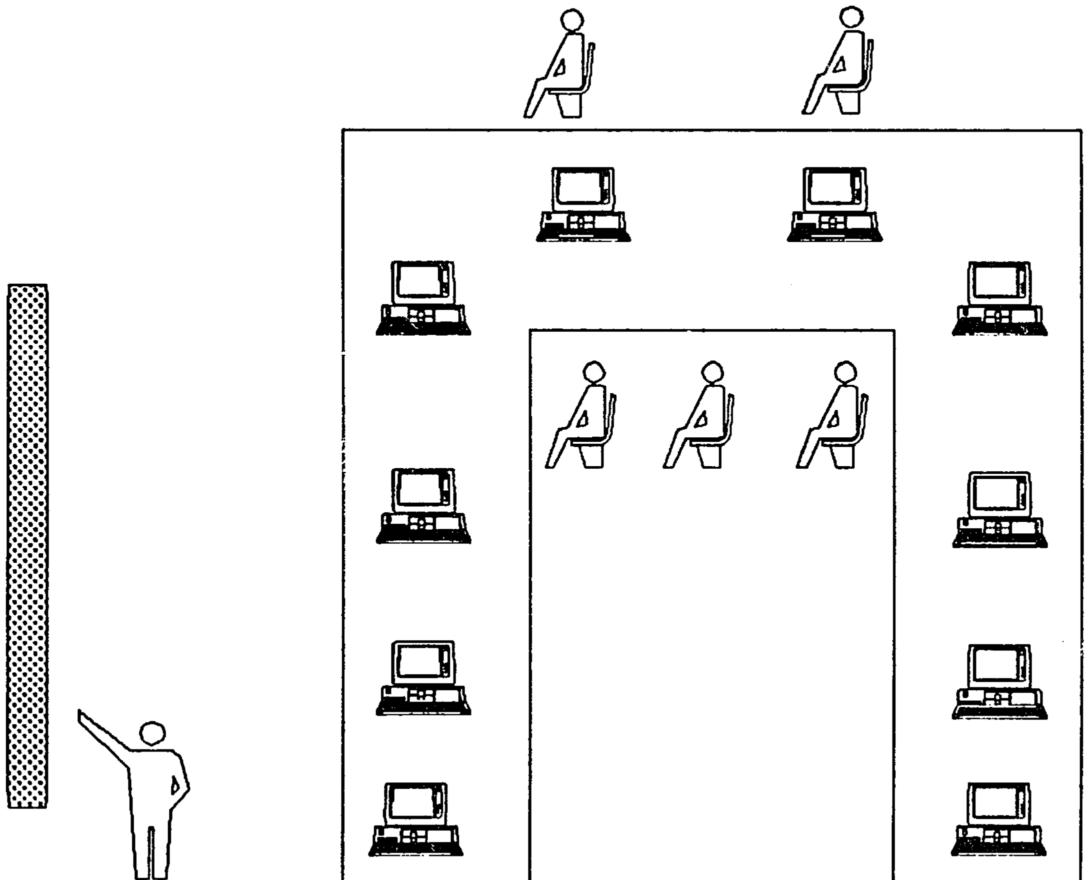
ELECTRONIC BRAINSTORMING CONFIGURATION



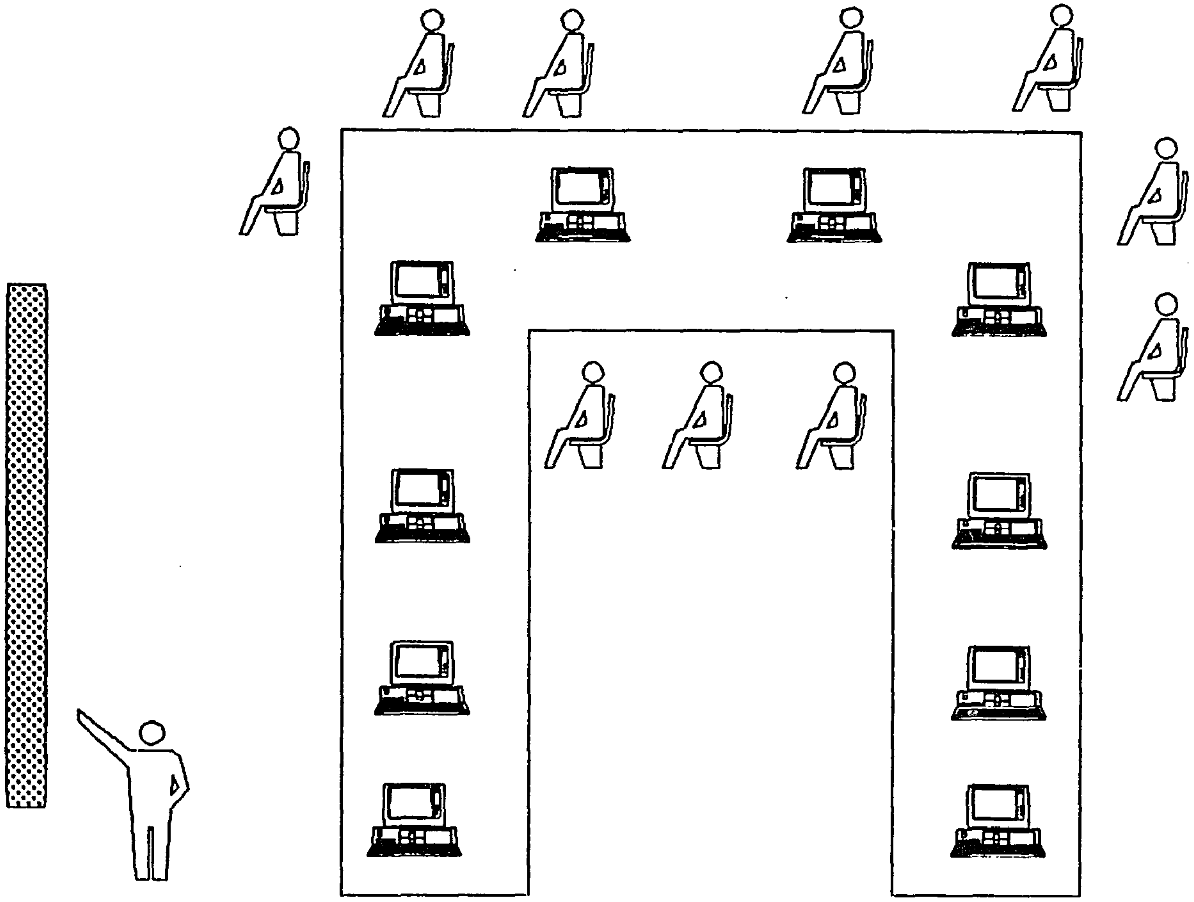
ELECTRONIC BRAINSTORMING CONFIGURATION



BRAINSTORMING CONFIGURATION



BRAINSTORMING CONFIGURATION



APPENDIX F

INFORMATION FROM THE PILOT STUDY

- Background Information
- Pilot Study Results

Background Information on the Pilot Study

The original experimental design for this study was a 2 X 3 completely randomized factorial design with two levels of computer support (GDSS or No GDSS) and three levels of idea generation techniques (brainstorming, brainwriting, and no instructions) using groups of the same size (five). It was a repeated measures design such that groups would use GDSS support for one task and no GDSS support for the other task.

Pilot testing began in August 1988 with the following intentions: to test experimental procedures, to determine task comparability, and to test instruments for question understanding and completeness. Nine groups of four subjects were run using modified procedures: Each group generated ideas on the two main tasks during one session, with 15 minutes provided for each task. From these groups it was determined that the two tasks chosen (Tea Bag (from: Gryskiewicz, 1980) and Vinyl Disk Problems) were fairly comparable (based on number of ideas generated, subject rating of task difficulty, and debriefing discussions). Experimental procedures and the experimenter script were refined based on feedback and learning. The subjects found that the task descriptions, technique instructions, and instruments used were clear and understandable. Based on interviews with the subjects, they felt that the questionnaires were complete and provided ample opportunity to provide feedback on the study.

Based on these results, a formal pilot study began in September 1988. Groups of subjects were solicited from introductory Computers in Business (K201) classes and randomly assigned to groups, and groups to treatments. Each group participated in two idea generation sessions, two days apart. Each session included a five minute warm-up idea generation session, followed by a thirty minute session for the main task. Two tasks that had been used previously in idea generation studies were added for the warm-up tasks (Library and Parking problems). After running seven groups it became apparent that the students were far more interested and motivated to perform for the two warm-up tasks (Parking and Library) than the main tasks. Discussions with the students during the debriefing sessions strongly supported this observation. Data collected during this time period further supported the task comparability of the Tea Bag and Vinyl Disk Problems, as well as providing preliminary support for comparability of the Parking and Library Problems. It was felt that a number of positive benefits could be gained by switching the tasks: providing students with a problem that they can better understand and relate to increases their motivation, as well as providing stronger face validity and external validity for the study.

It was then decided to run a set of groups with the tasks switched: the Tea Bag and Vinyl Disk Problems would become the warm-up tasks, and the Parking and Library

Problems would become the main tasks. A small number (five) of groups were then run using this task set-up. Observations and debriefings with the subjects indicated that, in fact, the students were more interested in and motivated by these tasks. It appeared that by using the less serious task for a warm-up also helped to put the students in a more creative mood. However, the total number of ideas generated for the two main tasks were not as high as with the previous tasks, given the more realistic and serious nature of the problems.

At approximately the same time the decision was made to switch tasks, an evaluation of the total number of ideas generated indicated that there was not much difference between some of the treatments. The average number of ideas generated for the four main techniques were as follows (based on total number of ideas; "n" is number of groups):

Idea Generation Technique	Total Number of Ideas
Brainstorming (n=2):	90
Electronic Brainstorming (n=2):	94
Brainwriting (n=4):	113.75
Electronic Brainwriting (n=4):	113

The main factor that seemed to be influencing these results was the group size selected for the study. Five-person groups were being used and, as previously indicated, five is the optimal size for groups in terms of group productivity. At that point it was decided to investigate some groups of larger sizes (seven and nine) to see what impact, if any, group size would have on the results.

About the same time as the decision was made to look at some groups of larger sizes, another problem was encountered: the unexpected problems and unreliability of one of the PLEXSYS system tools (topic commenter - the tool used for electronic brainstorming). Several subjects lost data during idea generation sessions. Due to the unreliability of this tool it was decided not to use it in future sessions. This forced a change in the way that the groups could be run and required the use of two non-equivalent techniques (electronic brainwriting with brainstorming). This comparison was not really valid due to the structural differences that existed between the two treatments [not the automation, but the differences in terms of the access to previously generated ideas: all ideas for brainstorming and only a subset (1 / n + 1, where n is the number of users on the system) for electronic brainwriting]. A relatively large number of the subjects commented during the debriefing sessions that they would have liked to have access to all ideas at one time (as both brainstorming and topic commenter allow). In spite of these inequalities, several larger groups were run (the numbers reported are an average of the total number of ideas generated by the groups; "p/p" - denotes number of ideas per person):

Technique (num. of groups)	Group Size	Total Num. of Ideas
Brainstorming (2)	5	28 (5 p/p)
Electronic Brainwriting (2)	5	62.5 (12 p/p)
Brainstorming (1)	7	36 (5 p/p)
Electronic Brainwriting (1)	7	140 (20 p/p)
Brainstorming (3)	9	40.67 (4 p/p)
Electronic Brainwriting (3)	9	98.33 (9 p/p)

Given the differences in the treatments, direct comparisons were not viable; however, indications from these numbers and discussions with the group members indicated that as the group size increased, the preference for the technique with GDSS support, both in terms of performance and satisfaction, also increased. Through questionnaire responses, interviews, and debriefing sessions the participants provided information about why they preferred the techniques with GDSS support and why they felt they were more productive. The key factors identified were among the main GDSS support capabilities outlined earlier: simultaneous input of ideas and anonymity. While these responses provided some preliminary evidence for these support factors, a strong temptation may have existed to further refine this study to evaluate just the specific factors that provide these advantages. But before such a study should be undertaken, it is important to determine if these advantages (techniques with GDSS support over techniques without GDSS support) actually did exist when sufficient numbers of groups were run with equivalent techniques and specific controls to ensure a complete and thorough evaluation. The impact of group size must also be evaluated in this manner. It is after these evaluations have been made that studies aimed at identifying the advantages of specific GDSS benefits can be undertaken.

Based on the observations of the sessions and discussions with the subjects, along with a further perusal of the literature and discussion with committee members, the changes that have been made are reflected in this dissertation. One other change, not yet discussed, has also been made: Instead of having the two main sessions lasting 30 minutes each and being two days apart, these sessions have been shortened to 20 minutes each and occur on the same day (students only show up for <u>one</u> session instead of two). The main reasons for this change are:

1) The problem of subject mortality, especially with larger group sizes [mortality rate in the pilot was approximately 8% - however, several groups were not run at all due to "no shows", that is, not enough subjects showed up at the time they had scheduled (even with the practice of signing-up more students than needed at each time slot, a practice that was continued)];
2) The time required to run all the necessary groups to complete the study would have taken an estimated four to six weeks. This is especially true given the evening

test schedules of (pre)Business school sophomores (Accounting, Economics, Business Law, K201 - all have evening tests) that don't allow any groups to be run the week of a test (groups would have to be run on a MW, TR basis; if there was a test Tuesday night (e.g., K201, A201) then no groups could be run on TR and not very many students wanted to participate the night before a test (Monday);

3) Along those same lines, the need for two day apart schedules restricted the available times to run groups. Groups could only be run MW and TR late afternoons and evenings, and on Friday - Sunday afternoons, due to student availability (based on experience with pilot);

4) There was potential for problems in the area of group development: The second meeting of any group is often its most nonproductive. This could impact the performance of the group, as well as the confounding the comparisons of the two techniques in the final survey. (There is also the potential for problems with recency in the comparative evaluation.);

5) The fact that many idea generation studies had subjects do two, three, or even four different idea generation tasks in one session. By having half the groups generate ideas for one task first and then the other, and vice-versa, should help to control for learning effects that may take place during the session (the only

concern is participant burnout, which might lead to the considerations for shortening the main task times to 20 minutes, a time used in some previous brainstorming studies, or re-evaluating the use of two warm-up tasks).

Pilot Study Results

Based upon changes that took place with the tasks and group size, three different sets of groups were run. The results of each set are reported as a separate "pilot study". Comparisons are based on means for all three studies, with some additional statistical analysis for the third study. Given the small sample size of the third study (n=14), and the resulting unequal cell sizes, a nonparametric statistical technique was used to perform this analysis. The Wilcoxon Signed Ranks Test is the nonparametric equivalent of the matched pairs t-test and was used to make comparisons between two treatments based on the null hypothesis that there is no difference between the treatments.

Results of this analysis provide some support for predicted outcomes as follows:

> When provided with GDSS support, groups generated more total ideas and more different ideas than when they were not provided with GDSS support;
>
> Electronic brainwriting groups more total ideas and more different ideas than brainstorming groups;
>
> Techniques with GDSS support had a higher acceptance score (perceived usefulness) than techniques without GDSS support for all comparisons (overall, vs. brainwriting, brainstorming, for small groups and for large groups);
>
> Although not significant, group satisfaction ratings favor techniques with GDSS support over techniques without GDSS support.

Given the small sample and the comparison of nonequivalent techniques (electronic brainwriting with brainstorming) these results should be viewed with caution. However, they did provide some preliminary support for the hypothesized relationships between treatments.

Task and order effects were also evaluated and found not to be significant. Results of all three studies follow.

PILOT STUDY (#1) - 9 GROUPS (GROUP SIZE = 5)

Group Number	First Task	Second Task	Third Task
8-8-1	BW-TB 46/40	EBW-VD 44/37	**
8-9-1	EBW-VD 37/32	BW-TB 41/38	**
8-9-3J	EBW-TB ***	BW-VD 64/58	**
8-9-3L	BW-VD 49/46	EBW-TB 63/59	**
8-9-7	BS-VD 75/74	EBS-TB 97/94	**
8-11-8	EBS-TB 35/33	BS-VD 29/29	**
8-12-9	EBW-TB 72/65	BW-VD 89/79	EBS-LE 68/63
8-12-11	BS-TB 27/27	EBS-LE 40/40	EBW-VD 34/32
8-12-1	ENI-TB 33/33	NI-LE 55/55	EBW/VD 39/38*

TOTAL NUMBER OF IDEAS / NUMBER OF DIFFERENT IDEAS GENERATED

KEY:
BW - BRAINWRITING
EBW - ELECTRONIC BRAINWRITING
BS - BRAINSTORMING
EBS - ELECTRONIC BRAINSTORMING
ENI - EBS WITH NO INSTRUCTIONS
NI - BS WITH NO INSTRUCTIONS

TB - TEA BAG TASK
VD - VINYL DISK TASK
LE - L'EGGS EGG TASK
* - 3 PEOPLE ONLY
** - TWO TASKS ONLY
*** - DATA LOST (OP ERROR)

COMPUTER SUPPORT	IDEA GENERATION TECHNIQUE		
	BRAINSTORMING	BRAINWRITING	NO INSTRUCTIONS
GDSS	57.5 (4)	43.8 (6)	33 (1)
NO GDSS	43.3 (3)	52.2 (5)	55 (1)

AVERAGE NUMBER OF DIFFERENT IDEAS GENERATED (Number of Groups)

TASKS: TEA BAG (n=8): 48.6
VINYL DISK (n=9): 47.2

PILOT STUDY (#2) - 7 GROUPS (GROUP SIZE = 5)

Group Number	First Tech.	Warm-up Task	First Task	Second Tech.	Warm-up Task	Second Task
9-12-1P	EBW	PP - 25	TB - 81	BW	LP - 25	VD - 109
9-12-6P	EBW	LP - 21	VD - 103	BW	PP - 23	TB - 105
9-12-8P	EBS	PP - 25	TB - 91	BS	LP - 15	VD - 99
9-13-8A	BW	PP - 20	TB - 126	EBW	LP - 28	VD - 118
9-13-4P	BW	LP - 20	VD - 115	EBW	PP - 28	TB - 150
9-16-3P	EBS*	LP - 18	VD - 115	BS	PP - 14	TB - 81
9-19-8P	ENI*	LP - 14	VD - 27	NI	PP - 8	TB - 42

TOTAL NUMBER OF IDEAS GENERATED

BW - Brainwriting
BS - Brainstorming
NI - No Instructions
TB - Tea Bag Problem
PP - Parking Problem
* - Planner problems: lost data

EBW - Electronic Brainwriting
EBS - Electronic Brainstorming
ENI - EBS with No Instructions
VD - Vinyl Disk Problem
LP - Library Problem

COMPUTER SUPPORT	IDEA GENERATION TECHNIQUE		
	BRAINSTORMING	BRAINWRITING	NO INSTRUCTIONS
GDSS	94.0 (2) * 21.5 (2)	113.00 (4) 25.5 (4)	27 (1) * 14 (1)
NO GDSS	90.0 (2) 14.5 (2)	113.75 (4) 22.0 (4)	42 (1) 8 (1)

AVERAGE TOTAL NUMBER OF DIFFERENT IDEAS GENERATED (No. of Groups)

TASKS (n=7): (Means)	TEA BAG: VINYL DISK :	96.57 95.43	LIBRARY: PARKING:	20.14 20.43

PILOT STUDY (#3) - 14 GROUPS

Group Size	First Tech.	Warm-up Task		First Task		Second Tech.	Warm-up Task		Second Task	
5	BW	VD	9/7	LP	44/38	EBW	TB	21/18	PP	64/60
4	BW	TB	16/13	PP	45/34	EBW	VD	12/11	LP	46/44
6	BW	VD	30/25	LP	98/72	EBW	TB	37/32	PP	97/82
4	EBW	TB	NA	PP	45/44	BW	VD	11/11	LP	31/25
7	BW	TB	34/33	PP	110/89	EBW	VD	38/34	LP	91/88
7	BW	VD	30/27	LP	89/74	EBW	TB	45/34	PP	91/80
7	EBW	TB	29/24	PP	112/101	BW	VD	29/29	LP	95/72
9	EBW	TB	30/26	PP	104/93	BS	VD	18/18	LP	45/44
7	BS	VD	14/14	LP	36/36	EBW	TB	53/45	PP	140/121
9	BS	TB	12/12	PP	42/41	EBW	VD	54/37	LP	96/77
5	BS	TB	14/14	PP	26/26	EBW	VD	32/30	LP	61/56
9	EBW	VD	43/38	LP	95/76	BS	TB	10/10	PP	35/35
9	EBW	VD	42/33	LP	96/80	BW	TB	31/24	PP	120/97
5	EBW	TB	23/20	PP	66/56	BS	VD	10/10	LP	30/30

TOTAL NUMBER OF IDEAS / NUMBER OF DIFFERENT IDEAS GENERATED

BW - Brainwriting
BS - Brainstorming
TB - Tea Bag Problem
PP - Parking Problem

EBW - Electronic Brainwriting
EBS - Electronic Brainstorming
VD - Vinyl Disk Problem
LP - Library Problem

TASKS: (Means)

LIBRARY (n=14): 65.5 / 55.43
PARKING (n=14): 68.3 / 59.86

VINYL DISK (n=14): 26.6 / 23.1
TEA BAG (n=13): 27.3 / 23.5

PILOT STUDY (#3) (Continued)

GROUP SIZE	IDEA GENERATION TECHNIQUE		
	ELECTRONIC BRAINWRITING	BRAINSTORMING	BRAINWRITING
SMALL (4-6)	63.3 / 57 25 / 22.2 (6)	28 / 28 12 / 12 (2)	54.5 / 42.25 16.5 / 14 (4)
LARGE (7-9)	103.13 / 89.5 42.5 / 33.88 (8)	39.5 / 39.25 13.5 / 13.5 (4)	103.5 / 83 31 / 28.25 (4)

AVERAGE TOTAL NUMBER OF IDEAS/NUMBER OF DIFFERENT IDEAS GENERATED
(Number of Groups)

DATA ANALYSIS (WILCOXON SIGNED RANKS TEST)

FOR NUMBER OF IDEAS GENERATED:

OVERALL COMPARISON: COMPUTER-SUPPORTED VS NONCOMPUTER-SUPPORTED (total number/number of different ideas):

NONCOMPUTER-SUPPORTED TECHNIQUE (-)	COMPUTER-SUPPORTED TECHNIQUE (+)	d	Rank of d
44 / 38	64 / 60	20 / 22	6 / 7
45 / 34	46 / 44	1 / 10	1.5 / 3.5
31 / 25	45 / 44	14 / 19	4 / 6
98 / 72	97 / 82	-1 / 10	-1.5 / 3.5
110 / 89	91 / 88	-19 / -1	-7 / -1
89 / 74	91 / 80	2 / 6	3 / 2
95 / 72	112 / 101	17 / 29	5 / 9
45 / 44	104 / 93	59 / 49	12 / 13
36 / 36	140 / 121	104 / 95	14 / 14
42 / 41	96 / 77	54 / 36	11 / 11
26 / 26	61 / 56	35 / 30	9 / 10
35 / 35	95 / 76	60 / 41	13 / 12
120 / 97	96 / 80	-24 / -17	-8 / -5
30 / 30	66 / 56	36 / 26	10 / 8

N = 14

T+ = 88.5 / 99

T- = 16.5 / 6

For Total Number of Ideas: p = .0234

For Number of Different Ideas: p = .0018

The null hypothesis of no difference between the two treatments (computer-supported versus noncomputer-supported) would be rejected for both total number of ideas and number of different ideas at the alpha = .05 level of significance.

For the remainder of the comparisons, only the N, T+, T- and p-values will be reported.

COMPARISONS FOR THE NUMBER OF IDEAS GENERATED:

	N	T+	T-	P	
EBW (+) VS. BW (-):					
TOTAL IDEAS:	8	28.5	7.5	.1954	
DIFFERENT IDEAS:	8	30	6	.1094	
EBW (+) VS. BS (-):					
TOTAL IDEAS:	6	21	0	.0312	*
DIFFERENT IDEAS:	6	21	0	.0312	*
EBW (+) VS. BW & BS (-):					
FOR SMALL GROUPS (4-6):					
TOTAL IDEAS:	6	19.5	1.5	.0938	
DIFFERENT IDEAS:	6	21	0	.0312	*
FOR LARGE GROUPS (7-9):					
TOTAL IDEAS:	8	29	7	.1484	
DIFFERENT IDEAS:	8	32	4	.0546	

NOTES:

EBW VS. BS & BW is a comparison of computer-supported versus noncomputer-supported techniques.

* - $p < .05$

GROUP SATISFACTION WITH THE IDEA GENERATION PROCESS:

	N	T+	T-	P
EBW (+) VS. BW & BS (-):	12	57	21	.1762
EBW (+) VS. BW (-):	7	16	12	NA (NS)
EBW (+) VS. BS (-):	5	15	0	.0626
EBW (+) VS. BW & BS (-):				
FOR SMALL GROUPS (4-6):	5	12	3	.3126
FOR LARGE GROUPS (7-9):	7	19	9	.4688

NOTES:

EBW VS. BS & BW is a comparison of computer-supported versus noncomputer-supported techniques.

Sample size of 12 is due to two ties which are dropped out.

Sample sizes of 5 and 7 also lose one value to ties.

NA - not available in table

NS - not significant

Means for each of the reported groups:

EBW (n=14) = 5.47
BS & BW (n=14) = 5.17

EBW (n=8) = 5.5
BW (n=8) = 5.22

EBW (n=6) = 5.48
BS (n=6) = 5.06

EBW (SMALL GROUPS (4-6)) = 5.59
BS & BW (SMALL GROUPS) = 5.18

EBW (LARGE GROUPS (7-9)) = 5.38
BS & BW (LARGE GROUPS) = 5.16

(Range: 1 - 7; 1 is "not at all", 7 is "to a great extent")

GROUP ACCEPTANCE OF THE IDEA GENERATION TECHNIQUE:

	N	T+	T-	P	
EBW (+) VS. BW & BS (-):	14	105	0	.0002	*
EBW (+) VS. BW (-):	8	36	0	.0078	*
EBW (+) VS. BS (-):	6	21	0	.0312	*
EBW (+) VS. BW & BS (-):					
FOR SMALL GROUPS (4-6):	6	21	0	.0312	*
FOR LARGE GROUPS (7-9):	8	36	0	.0078	*

NOTES:

EBW VS. BS & BW is a comparison of computer-supported versus noncomputer-supported techniques.

* - $p < .05$

Means for each of the reported groups:

EBW (n=14) = 2.03
BS & BW (n=14) = 2.61

EBW (n=8) = 2.07
BW (n=8) = 2.67

EBW (n=6) = 1.98
BS (n=6) = 2.53

EBW (SMALL GROUPS (4-6)) = 2.18
BS & BW (SMALL GROUPS) = 2.98

EBW (LARGE GROUPS (7-9)) = 2.19
BS & BW (LARGE GROUPS) = 2.33

(Range: 1 - 7; 1 is "extremely likely", 7 is "extremely unlikely")

APPENDIX H.1

LIST OF IDEAS AND JUDGES' RATING FOR EACH PROBLEM

- Library Problem
- Parking Problem

Responses to the Library Problem

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Require a deposit to be made before getting any material. A full refund will be given if the person returns the item in good shape.	27	6	33
Require students to leave backpacks at the entrance so that they cannot be taken into the stack areas.	20	13	33
Have more copy machines available for students to use.	21	23	44
Have more book drop-off boxes located around campus.	9	13	22
Revoke campus parking privileges for those caught damaging/stealing library materials (offenders).	13	15	28
Chain books to the shelves.	16	5	21
Shorten the library hours and limit the number of people that will be allowed in the library at any one time.	11	4	15
Put magnetic strips (such as those in books) in all library materials (e.g., magazines) so that an alarm will be set off when someone tries to leave the library with a stolen item.	19	21	40
List the names, and put the pictures, of offenders in the IDS; display them in campus cafeterias; and other such forms of public humiliation.	19	12	31
Add a library fee onto tuition (like the technology fee) that will provide each student with a limited amount of free copying (xeroxing).	22	15	37

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Have a list of library rules and fines posted so that students know what is not allowed and what the consequences will be for breaking the rules.	13	25	38
Have two copies of each item in the library: one on reserve for in-library use only and one available to be checked out.	17	7	24
Have more materials available on/backed up on microfilm.	19	8	27
Only let IU faculty, staff and students use the IU libraries (i.e., check IDs).	10	11	21
Require offenders to do community service.	10	9	19
Have an amnesty day in which people can return stolen materials without penalty.	14	16	30
Allow bound journals to be checked out.	10	10	20
Have staff make periodic checks of materials to check for damaged/stolen items so that the items can be replaced.	13	14	27
Have devices that can detect a page being torn/ripped.	18	5	23
Install video cameras throughout the library to monitor students and material usage (conspicuously so that they can easily be seen by students).	18	5	23
Require offenders to serve as tackling dummies for the football team.	19	4	23

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Let the students know that there is a problem/Increase student awareness of the problem (e.g., article in the IDS, posters around campus, etc.).	14	25	39
Hire a staff of grandmothers to make students feel guilty about damaging/stealing materials.	8	6	14
Have more materials available on audiotapes (e.g., cassettes, microcassettes).	10	9	19
Provide free copy machine access for all students.	22	5	27
Do not allow any library materials to be checked out - all materials must be used in the library.	11	4	15
Do not allow people with criminal records into the libraries.	8	3	11
Take credit/money machine cards away from offenders.	7	3	10
Require all new/transfer students to go through a library orientation session and tour of the library (as part of this tour, inform them of the problem of damaged/stolen materials).	10	19	29
Add a library fee onto each student's tuition equal to their portion of the damages (total damages in all library divided by total number of students).	15	9	24
Have more reference information available on computer systems (like INFOTRACK).	15	19	34
Have copy machines available on every floor of the library.	15	19	34

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Reduce the number of items a person may check out (both number of items at one time and overall number of items).	7	7	14
Have a library staff member stay with each and every person while they use library materials to ensure that no damage/theft takes place.	24	3	27
Enlarge the exit detection devices (that detect the magnetized strips) so that they encompass the entire doorway, not just a smaller area.	18	10	28
Have offenders pay for any damages that they do to library materials (to cover repair or replacement).	13	25	38
Have warning signs posted around the libraries warning students not to steal or damage library materials.	10	23	33
Have more material available on/backed up on microfiche.	14	15	29
Put the most frequently/commonly used materials on reserve to provide greater access to students.	19	19	38
Form a library club and kick the offenders out.	8	6	14
Bind each journal upon receipt.	5	4	9
Lengthen the amount of time an item may be checked out from the library.	14	13	27
Close the libary.	27	3	30
Have people hand in their shoes when they check out materials for in-library use - they will get their shoes back when they return the materials.	20	3	23

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Don't have individual carrels for studying - have well-supervised study areas with tables and chairs.	12	6	18
Protect the covering and each individual page by laminating them in plastic.	15	2	17
The only way in which a student may use an item is to request it from a library staff member who will take the student's request and provide them with the appropriate item(s) (no direct access to materials for students).	21	6	27
Add a library fee onto every student's tuition equal to the total of all damages in all libraries.	17	16	33
Give offenders a slap on the wrist.	8	6	14
Let people know that there is a public library in Bloomington that they can use in addition to the university libraries.	8	20	28
Have more library materials available on video tapes.	11	10	21
Have more library branches, more conveniently located around campus, with more materials available (e.g., more dorm libraries with more materials).	14	8	22
Have a library staff person inspect each item as it is returned to check for damages.	21	6	27
Have more change machines/access to change for copying.	15	15	30
Reward those who turn in offenders (e.g., prizes, copying, etc.).	12	5	17

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Have bodily punishment for offenders (e.g., cut off fingers/hands, tar and feather, beat-up, execute, etc.).	22	3	25
Charge people a fee for each book that they check out.	16	3	19
Have multiple copies (greater than or equal to two) of each item for library use and checking out.	18	5	23
Have more materials available on slides and movies.	11	9	20
Lower the price of copy machines (e.g., penny copies).	20	7	27
Only allow graduate students in the research/graduate collections.	15	6	21
When a page is torn out of a book/journal, have ink spray from the item onto the person (or some sticky substance, fumes, electrical shock, or an explosion).	20	4	24
Have library materials carved in stone to prevent damage.	24	3	27
Add a library fee onto tuition so that students will gain an appreciation of the services provided to them.	17	10	27
Do not let offenders check out library materials for a designated time period after their offense (e.g., two months).	17	9	26
Reward students for returning items undamaged.	15	8	23
Eliminate all 24 hour reserves.	7	9	16

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Launch a campaign to combat the problem (e.g., book-abusers anonymous, just say no to damaging books, etc.).	16	15	31
Provide a certain amount of free copying for each student each year (such as $10.00).	17	15	32
Place books up on high shelves.	12	4	16
Have students request journal articles and only give them the specific pages for the article they need.	21	4	25
Have much louder alarms sound when an item is taken through detection devices (to embarrass the offender).	12	13	25
Hire more library monitors/security people to provide ample supervision of students throughout the library.	16	6	22
Have offender's violations included in his/her permanent IU record.	12	16	28
Add a library fee onto tuition to pay for the damages.	14	12	26
Have more library materials available for access from campus computer system - students could access items, read, print out any pages they so desire from all over campus.	16	9	25
Have more copy machine maintenance available to keep copy machines in working order.	15	14	29
To use/get an item you must show your student/staff/faculty ID to a library staff person.	14	20	34
Increase the weight of books.	9	3	12

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec- tiveness	Feasi- bility	Quality Score
Have offenders re-shelve library books and/or do cleaning in the library for some period of time.	10	12	22
Have Bob Knight make announcements at basketball games about the problems at the libraries (e.g., "We don't damage books at IU!").	15	20	35
Provide a means whereby students can access desired library materials stored on video tapes from their home (e.g., over cable TV).	17	8	25
Allow students to use only one item at a time when in the library.	12	6	18
Give lie detector tests to students leaving the library (ask if they damaged/stole any materials).	19	5	24
Sensitize/Magnetize every page in each book/magazine so that if a page is torn out it will set off the detection alarm when the offender tries to leave the library with it.	24	4	28
Have offenders pay fines when caught.	17	19	36
Decrease library staff salaries to help pay for damaged items.	6	3	9
Give each student a roll a Silly Putty to use for copying.	4	6	10
Have multiple copies of items so there are copies available to sell to students (e.g., journals, specific articles).	16	7	23
Separate students from materials: have areas in the libraries for studying and areas for (supervised) material access.	17	8	25

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec- tiveness	Feasi- bility	Quality Score
Install mirrors (like in stores) so that students can be more closely monitored.	13	9	22
Have a machine that counts the number of pages, and checks for damage, in a book/journal when it is returned.	19	4	23
Require all offenders to do work at a computer terminal/or take the introduction to computers course/or participate in brainstorming sessions (like the one where these ideas were generated).	7	12	19
Allow library materials to be ordered by computer and sent to users (e.g., books to check out, copies of journal articles).	11	16	27
Have a "diary lock" on each book - require students to get the key from a librarian to use book.	13	4	17
Have fewer/no research papers assigned by professors - less need should result in less damage/stolen items.	16	5	21
Have students pay other people to do their copying for them.	13	7	20
Computerize the library record keeping process - make it more efficient.	7	19	26
Provide 24 hour access to the library or designated portions of the library.	10	10	20
Kick offenders out of school.	14	14	28
Reward those who bring problems to the attention of the library staff (e.g., things missing, damaged, etc.).	8	7	15

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Add a library fee onto tuition to increase the staff and improve facilities.	12	8	20
Have more library materials written on steel plates/in braille on steel.	12	5	17
To use an item in the library you must get it through, and leave your ID with, a library staff person - when you return the item it will be inspected and your ID returned (if damaged, appropriate action would be taken before the ID is returned).	20	7	27
Have multiple copies of items available to give copies to students (e.g., copies of journal articles).	16	7	23
Do not let offenders have any food for a certain period of time.	15	3	18
Any future libraries built at IU should be smaller so that students can be more closely monitored.	14	4	18
Make the copiers into slot machines - one would get a copy and maybe some cash too.	17	7	24
Auction off the references to the highest bidder.	7	5	12
Have subliminal messages all over the library walls (e.g., "you really don't want to rip out that page, do you?").	9	12	21
People must sign-up to use an item.	12	16	28

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Sensitive/Magnetize random pages in each book/magazine so that if a sensitized/magnetized page is torn out it will set off the detection alarm when the offender tries to leave the library with it.	16	12	28
Do not let offenders use the library (or even let them in the library).	13	8	21
Have an awareness campaign that points out the costs of this problem on an overall and per student basis; as well as any future/potential impacts on each student.	14	23	37
Have more library materials available on computer disks/diskettes that can be checked out.	11	12	23
Have professors provide more information for research papers rather than having the students look it up in the libraries.	11	8	19
Chain people to desks.	12	3	15
Restrict the number of people in the library, or designated areas, at any given point in time.	10	4	14
Charge offenders the cost of any item they damage, plus a fine.	14	19	33
Have rest rooms on the first floor only.	8	5	13
Have special detection devices at library exits (e.g., trap doors, drop paint on violators).	14	4	18
Ask magazine publishers to donate copies of journals to replace those damaged/stolen.	10	5	15

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Only allow people in the library who are there to use reference materials or to study (no loitering, or "hanging out").	15	9	24
Have "fake" video cameras (real cameras, but no film or monitoring taking place).	15	10	25
Have more microfilm/fiche readers/copiers/printers available.	13	10	23
Have optical scanners to scan desired materials.	11	8	19
Shorten the length of time an item may be checked out.	8	14	22
Have only donated books in the libraries.	5	5	10
Have each professor assign papers on specific topics such that there is a one-to-one correspondence between each class and topic - so if specific materials are damaged/missing the offenders should be easier to track down.	8	6	14
Have library staff make required copies for students.	12	5	17
Have undercover library monitors/cops watching students.	12	16	28
Require offenders to give up their first-born child.	13	4	17
Subsidize students who want to receive there own copy of major magazines.	10	5	15
Do not let people into the library with scissors, razors, pencils, etc. - only allow them to read and copy.	16	6	22

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Hire people or have volunteers to serve as "research buddies" to help people find information and learn how to do research - these people can also help monitor for the proper way to do research and for damage.	15	6	21
Have library materials copied onto large pieces of durable cardboard.	11	3	14
Require students to reserve items ahead of time for use (such as 24 hours in advance).	11	3	14
Stamp a person's hand when an item is checked out for in-library use - when they return the item their hand is re-stamped after the item is checked for any damage (must have re-stamp to exit library).	12	4	16
Revoke extra-curricular activity privileges for offenders (e.g., ballgames, movies, dances, etc.).	13	6	19
Have faster, more efficient check-out procedures.	9	16	25
Have high-tech robots who patrol and scan the library for violators.	13	7	20
Sell bonds to buy new library materials.	14	5	19
Have damaged materials checked for fingerprints.	9	5	14
Items must be returned directly to a librarian (no drop boxes or leaving items on tables, etc.).	16	4	20
Patrons must purchase copies of all the materials (books, journals, etc.) they use.	19	3	22
Offenders must listen to a three-hour lecture by President Ehrlich.	10	4	14

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Add a library fee onto tuition to buy new materials (books, journals) and equipment (microfilm/fiche readers, copy machines, computers).	17	10	27
Have the library open longer (longer hours).	11	10	21
Search all/suspicious looking person's (their book bags, purses, coat pockets, etc.) when they leave the library.	13	5	18
Have substantial fines for offenders (greater than $10; possibly substantially higher - e.g., $50, $100 or more).	15	15	30
Tie a student's hands so that they cannot take/damage anything.	21	5	26
Have tracking/homing devices in all materials so that if an item is taken it can be traced.	19	5	24
Have people sign into a carrel/table for the amount of time they will be using an item (book, journal) - they cannot leave early without notifying library personnel who would then check the item for any damage.	18	5	23
Have assistance available over the phone to help users locate reference items more easily.	11	13	24
Have items returned to the shelves more quickly and correctly.	11	14	25
Do not let offenders check out any library materials for a specific period of time after their offense to make them appreciate what they have.	12	14	26

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Have student hire trustworthy people to look up reference materials for them.	16	3	19
Have all books put in steel bindings.	20	5	25
Put at least the most recent or frequently used items on a computer system that students can then use to access and print out information from anywhere on campus.	20	11	31
If an item is missing, randomly check with potential borrowers (e.g., if it is a chemistry book, send out a notice to chemistry students/professors asking that the book be returned).	10	6	16
Have more (and more friendly) librarians available to help students.	13	13	26
Lower the offender's GPA.	12	4	16
Have people pay to enter the library, or parts of the library, and use the money to buy new materials.	19	12	31
Have books that "grow" new pages when one is torn out.	24	4	28
Have video surveillance cameras installed so that students cannot see that they are being monitored/watched (hidden cameras).	15	12	27
Have guard dogs that sniff out/hear pages being torn, or search out stolen items at exits.	20	5	25
Search clothes of those suspected of smuggling out items (strip search if necessary).	22	4	26

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Have a law against damaging/stealing library materials and sentence offenders to a jail term/deportation.	15	16	31
Require a "pass" to enter the research areas/stacks - this pass would come from your professor and indicate that you are doing research for the class and do need access to the reference materials.	16	8	24
Have all materials in the library on a computer system, when items are checked out this is recorded; an inventory could be done periodically to report unauthorized missing items.	9	15	24
Have a study buddy system in which a book could not be taken out of the library without someone that the person has been assigned to - one could not leave without the other (people could be rewarded for reporting theft or vandalism).	15	6	21
Have pages in books/journals made from paper that cannot be ripped/torn.	22	7	29
Have library materials recorded onto vinyl disks (albums).	18	6	24
Use the honor system.	10	21	31
Have checkpoints throughout the library - not just at exits.	11	5	16
When you check-out an item to use in the library, a magnetic bracelet is put on your wrist - the bracelet is removed when you return the item (and it is checked) - if you try to exit the library with the bracelet still on, an alarm will sound.	17	11	28

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
When an item is discovered missing, lock everyone in the library until that item is found.	19	4	23
Offenders must work as library monitors for a certain amount of time (e.g., one month).	10	7	17
Let students charge copying using their ID and have the charges added onto their (tuition) bills.	13	21	34
Engrave all article on the library walls.	18	3	21
Every time a student wants to use a magazine, they run their ID through a machine so the librarians know who is responsible for each item.	13	12	25
Have armed library guards/monitors (e.g., stun guns, real guns).	16	3	19
Create break rooms in the library that create a more positive environment - this might help change the attitude of students.	15	14	29
Have professors let students have more freedom in the topic selection for research - this would reduce the demand (and competition) for the same resources by large groups of students.	14	11	25
Have offenders put on probation or suspended from school.	16	20	36
Require each patron to have a library card to use in checking items out - this would enable better monitoring of the flow of materials from person to person and enable those who damage items to be caught more easily.	14	18	32

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Have detection devices (e.g., magnetic strip detectors) on each floor (items would have to be checked out on each floor - or used on that floor only).	16	13	29
Have students sign a sheet when they check-out materials that informs them of the problem (and the costs, fines, implications, etc.).	11	16	27
Have library materials written onto tea bags.	7	3	10
Send offenders to Bob Knight (or Dick Vitale) for lectures.	11	7	18
Have a "term paper file" for all/common research topics that includes bibliographies, pertinent information, copies of previous papers, etc..	16	12	28
Have offenders rewrite the damaged material by hand and/or write a paper on the topic of the damaged material/on damaging materials.	12	7	19
Have warning stickers (possibly bright red circles) on all books, magazines, etc., warning people about damaging/stealing items.	13	11	24
Hire very intimidating-looking individuals to work as monitors or security guards.	16	11	27

Responses to the Parking Problem

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Reduce the price of a campus bus pass.	16	11	27
Have more parking areas specifically for motorcycles and scooters.	13	18	31
Offer more classes during the evening and less during the day.	19	10	29
Limit the amount of time that any one car can be parked in a parking space.	14	8	22
Do most of the campus construction (especially on the roads) when there are less students, and therefore less traffic, around campus.	18	18	36
Add more parking lots around campus.	28	17	45
Do away with the parking stickers and let people park free on a first come, first served basis.	5	5	10
Restrict/Limit the number of cars that will be allowed on campus at any one point in time.	16	6	22
Have increased IUPD patrols and ticketing.	15	13	28
Have no "pay parking" on campus - all parking lots and garages should be sticker parking.	21	13	34
Widen streets in and around campus to allow for more on-street (parallel) parking.	16	7	23
Encourage car pooling to reduce the number of cars on campus (by students/faculty/staff).	15	9	24

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Issue parking stickers to students based on such criteria as their GPA, age, seniority (combination of age and GPA) - (e.g., either have a minimum GPA to get an "E" sticker, or let students with high GPAs get higher (e.g., "A", "B" or "C") stickers).	19	13	32
Provide for parking on the roofs of existing university buildings.	6	4	10
Have more bus shelters on the campus bus routes.	13	21	34
Promote walking (and/or jogging, running, etc.) as a healthy (for fitness) alternative to driving.	11	14	25
Allow only compact cars to drive and park on campus/Issue parking stickers to compact cars only.	15	6	21
Increase the price of hourly parking in campus pay parking lots and garages.	19	21	40
Increase the price of gas (or gas taxes) in the Bloomington area.	7	4	11
Issue a number of parking stickers equal to the number of parking places on campus (or just slightly higher).	18	15	33
Increase the amount of fines for parking violations.	15	22	37
Give students who do not have cars a free bus pass.	12	7	19
Add more levels to existing parking lots/garages (e.g., turn the Library lot into a garage; add more levels to the 10th and Fee garage).	25	16	41

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Drastically increase the price of parking stickers to drive demand down.	17	14	31
Build a monorail system to provide campus-wide transportation.	16	4	20
Have toll booths at entrances to the campus - charge a fee to let people drive on campus.	11	8	19
Have more classes taught as TV lecture classes so that students could watch from home.	18	10	28
Make sure that ticket fines are promptly paid - if they are not paid in a certain amount of time (e.g., ten days), take the student to court.	11	11	22
Do away with the stickers altogether and have all pay parking.	8	8	16
Raise the tuition of parking violators.	7	4	11
Do not let IU athletes have cars.	8	8	16
Dig canals around/Flood the campus and let people commute in boats or on surf boards.	6	5	11
Have more open/free parking areas where stickers are not required.	15	6	21
Greatly reduce the amount of campus parking that is open/available to students - so less will be tempted to drive.	11	14	25
Have alternating parking privileges (e.g., MW, TR) based on such criteria as: gender, color of the vehicle, license plate number.	12	8	20

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Get better campus bus drivers.	8	10	18
Have shuttle buses provided by (major) apartment complexes to transport their student tenants to and from campus.	18	11	29
Let people park anywhere they want on campus (e.g., in yards, on sidewalks, in front of fire hydrants, etc.).	5	4	9
Issue parking stickers based on need - to those who can provide justification for stickers (e.g., medical reasons, commuting, transportation to and from work, etc.) - in terms of both getting a sticker and the type of sticker (e.g., "A", "C", or "F") they should receive.	10	5	15
Have underground tunnels/walkways to promote walking - especially in bad weather.	9	4	13
Tow, and do not return, illegally parked cars (once the car is towed - it is gone).	12	7	19
Have an equal number of spaces around campus for each sticker - the number of "A" spaces = the number of "B" spaces = the number of "C" spaces = the number of "D" spaces = the number of "E" spaces.	12	9	21
Have more one way streets in order to provide more on-street parking.	12	7	19
Have campus buses go further out from campus.	13	12	25
Have a one-time student fee allocation (e.g., $10.00) and use that money to help fund additional campus parking structures.	20	13	33

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Issue stickers to only those with red and/or white cars.	6	4	10
Have students swing to class on vines (like Tarzan).	3	3	6
Let university roads fall into disrepair such that when people drive on the roads their cars will be destroyed.	7	6	13
Have free parking (no sticker/charge) in current pay parking lots and garages.	6	7	13
Provide rewards to those who turn in violators.	9	8	17
Have less "R" (reserved) parking places on campus.	7	8	15
Do away with stickers altogether and have metered parking all around campus.	10	9	19
Have levitation beams that support cars off the ground.	3	3	6
Have better sidewalks (repaired/improved) so that more people would be encouraged to walk.	7	13	20
Have less 24 hour tow zones.	7	12	19
Have the university provide more information to students about parking alternatives, both on- and off-campus, to make them aware of all the alternatives.	18	18	36
Teach classes only in good weather - cancel them during bad weather when more people are likely to drive.	7	5	12
Provide free valet parking for students.	9	5	14

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Require violators to take a driving course.	10	7	17
Issue only one type of parking sticker, that will let you park anywhere on campus, and then let people park on a first come, first served basis.	7	5	12
Have "car pool" only lots - in order to park in these prime location lots cars must have a minimum number of passengers (stickers for these lots are issued to people who have agreed to car pool and can be issued at discounts).	19	13	32
Provide free campus busing to all students.	15	9	24
Limit campus sporting events to students only.	7	5	12
Have parking attendants at the entrances to parking lots who will let potential parkers know if there are available spaces in the lot (or if it is full).	10	7	17
Have a commuter train that goes between the Bloomington and Indianapolis campuses.	7	6	13
Issue jet packs to students to commute around campus - they will take less space to store than cars.	6	4	10
Issue parking stickers to only those with American-made cars.	10	5	15
Add more parking garages around campus.	27	20	47
Require that all students must go on parking patrol for a week - they may be less likely to park illegally after that experience.	10	6	16

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Have more temporary parking zones around campus buildings (e.g., 5 minute zones - especially around dorms).	9	11	20
Issue parking stickers that will let people park in either the morning (AM) or the afternoon (PM) (everyone could park at night).	10	13	23
Set up student car pools based on class schedule - either as a part of the registration process, or during the first week of classes when students can see who is in their classes.	13	10	23
Promote bicycling as an alternative to cars (can be quicker, less congested, better for health/fitness).	11	15	26
Have more classes taught off-campus (at apartments, public schools, etc.).	9	7	16
Have more pay parking and less sticker parking on campus.	12	11	23
Provide free bikes/mopeds for those who do not have a car.	6	5	11
Have more metered parking around campus.	9	11	20
Restrict which students can get parking stickers based upon their class (e.g., seniors only, no freshman, etc.).	16	15	31
Have stacked or elevator parking (like in big cities), where multiple cars can occupy the same space (at different levels).	22	9	31
Add more buses to the campus bus fleet.	15	13	28

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Increase towing of illegally parked cars and increase the towing fee.	12	14	26
Re-allocated spaces in existing parking lots/garages (e.g., have more "compact car only" areas, reduce lane space and create more parking places, etc.).	13	13	26
Give students the option of getting a parking sticker or a half-price discount card to local bars.	5	5	10
Instead of sticker/pay parking, have specific spots assigned or sold to individuals.	15	12	27
Have gondolas (ski lifts) around campus as an alternative form of transportation.	5	4	9
Add underground parking garages around campus.	15	6	21
Don't have stickers, let people fight for parking places.	6	6	12
Spread out the times that classes are taught and for the activities that occur on campus.	12	9	21
Don't let faculty park on campus.	10	4	14
Reduce the number of parking tickets that are given.	6	7	13
Improve the lighting on campus to increase the safety level for those walking to classes (to help promote walking).	13	15	28
Have more bicycle parking available around campus - to help encourage people to bike instead of driving.	12	20	32

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Have better posting of bus schedules so that students know when and where they can take the bus.	13	25	38
Have pay parking by the day, instead of by the hour.	9	14	23
Issue parking stickers to students based on their place of residence (e.g., commuting or off-campus students would have a higher priority for stickers than those living in dorms; while those living in dorms (on the north side of campus) may have to park at the stadium).	15	13	28
Decentralize classes - spread them out all over campus rather than concentrating them in a few clusters/locations.	8	5	13
Have all parking lots be open 24 hours a day.	7	14	21
Encourage students to transact as much business over the phone as possible (e.g., have students order and buy books over the phone).	9	18	27
As an alternative form of transportation have trams/cable cars/rollercoasters/trains installed on campus.	8	5	13
Do away with the campus bus system and use bus lanes and bus parking for automobile parking.	5	6	11
Have more 24 hour tow zones.	7	9	16
Take GPA points away from parking violators.	8	5	13
Reopen any parking areas that may currently be closed.	8	7	15

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Have heated sidewalks/walkways on campus (like Miami U. in Ohio) to provide safer walking in winter (when sidewalks may be icy).	8	10	18
Have golf carts/riding lawn mowers/go-carts for students to get around campus.	6	5	11
Auction parking stickers at high prices - should both drive down demand and increase revenues.	9	8	17
Include the price of a campus bus pass in tuition and issue one to each student.	15	16	31
Have more day classes and less classes offered at night.	7	7	14
Don't let university staff park on campus.	8	5	13
Use the park lots of businesses that are adjacent to the campus during non-business hours (e.g., have parking in a restaurant's parking lot when it is not open).	6	6	12
Use molecular transport (from Star Trek - "beam me to class, Scotty!").	6	4	10
Don't allow the sale of gasoline in the Bloomington area.	8	4	12
Have stricter enforcement of who can and cannot get parking stickers and which stickers they can get.	10	13	23
Have long-term, off-campus vehicle storage for students who only use their cars occasionally - such as an on-campus student who only uses their car to drive home once a month - this way their car would not occupy a campus parking spot all the time.	12	15	27

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Offer amenities/entertainment on the campus buses to encourage people to use them (e.g., music, food, coupons, giveaways, etc.).	7	11	18
Take away parking privileges from parking offenders (e.g., if a person gets a certain number of tickets, they lose their campus parking privileges).	14	14	28
Have more rides provided to students through such means as Women's Wheels and other non-profit organizations.	9	9	18
Have more concentrated class schedules for each major (e.g., for Business students, all classes would be taught in the Business building, not all over campus).	6	8	14
Do not let any cars on campus, or a central portion of the campus - all parking would be off-campus.	8	6	14
Have more bicycle lanes/jogging paths to encourage alternative forms of transportation.	10	12	22
Have less yellow curbing and no parking zones around campus.	8	6	14
Have Bob Knight threaten people not to park illegally.	10	5	15
Fines for illegal parking should be based on how far a car is from its "designated" parking sticker (e.g., if a person has an "E" sticker and they park in an "A" lot the fine should be higher than if that same person with an "E" sticker parks in a "C" lot, etc.).	8	7	15

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Have a system of underground roads around campus in addition to the existing roads.	7	4	11
Issue parking stickers to faculty only.	10	6	16
Let the Bloomington city buses come onto the central portion of campus where they currently are not allowed to go.	13	15	28
Decrease the price of hourly parking in the pay parking lots and garages.	6	8	14
Decrease the overall size of the campus, so buildings (and therefore classes) are not so spread out.	8	5	13
Have the university provide free taxi/limousine service.	11	5	16
Issue an equal number of each type/class of sticker (same number of "A", "B", "C", "D" and "E").	8	8	16
Offer discounts to students for the price of a bus ride/pass.	9	10	19
Damage/Destroy illegally parked cars (e.g., car bomb, park on top of it, slash the tires, steal the keys, steal the car, etc.).	8	4	12
Have a free shuttle bus for those who have registered cars (e.g., for the stadium lots directly to central campus).	17	15	32
Have special designated "prime time" areas for high traffic events where anyone with a university sticker can park in these areas (e.g., around the HPER during evening intramurals).	9	9	18

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Build a subway system around campus.	11	4	15
Have more on-campus activities so that students will stay on campus all day instead of going back and forth between home and classes (e.g., shopping, entertainment, etc.).	8	7	15
Have "parking passes" that will let you park in a particular parking lot or garage for a certain period of time (e.g., a month) for a set fee.	13	18	31
Issue parking stickers to students based on their major so it will be easier for them to park in the area where their classes will be held.	7	8	15
Improve the efficiency of the bus system to encourage more people to use it - (e.g., have buses be more dependable and more on-schedule).	15	20	35
Have routine car safety inspections on campus to reduce the number of people driving through campus.	6	7	13
Decrease the number of students attending the university.	20	5	25
Have helicopters/balloons so that students can skydive/be airlifted to class.	6	5	11
Reallocate parking stickers so that students have more alternatives (e.g., decrease the number of "A" stickers, but let students buy "A", "B" and "C" stickers).	9	11	20
Reduce IUPD patrolling.	6	8	14
Have special/designated parking areas for faculty/staff only.	19	22	41

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effec-tiveness	Feasi-bility	Quality Score
Reduce tuition or give tuition credits to students who do not have a car on campus.	7	7	14
Make it harder to get Visitor parking stickers.	6	20	26
Have bus-only lanes.	6	7	13
Encourage students to use motorcycles/scooters instead of driving cars.	9	9	18
Restrict where university-owned vehicles can park.	6	20	26
Allow only men to drive on campus.	4	4	8
Have free/open parking in all lots and garages after 5:00 PM (or starting later).	11	17	28
Set up hitching posts and have students ride horses/camels to get around campus.	6	6	12
Distribute parking stickers to students such that an equal (set) number are issued to each dorm, fraternity, sorority, apartment complex, etc..	7	7	14
Have the university actively solicit funds from outside sources - both public and private - for building additional parking structures (e.g., alumni, corporation, grant agencies, etc.).	20	12	32
Arrest drivers who park illegally.	9	7	16
Do not allow people who smoke to drive/park on campus.	6	5	11
Encourage students to ice skate/roller skate/skate board to class - depending on the season - as an alternative to driving a car.	6	7	13

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Simplify things by having a limited sticker set - such as just "A" and "E".	11	18	29
Add more bus routes on campus.	11	15	26
Do not let businesses, apartments, other organizations build near campus - they would be taking up potential parking places.	8	5	13
Have "car-eating" parking places that will randomly eat/engulf cars.	8	4	12
Have a lottery for students wanting parking stickers - in doing so make more types of stickers available to students.	7	6	13
Have university-provided shuttle buses go to all (major) apartment complexes.	13	8	21
Have for-profit ride services available to students (like "Women's Wheels" - but run for a profit - could be run by students or student organizations).	12	11	23
Only let those wearing red and white on campus.	11	4	15
Have designated parking areas where visitors can park (e.g., family, for ballgames, etc.).	8	9	17
Only let cars with greater than a minimum number of passengers on campus.	13	8	21
Have the entire campus be "A" parking during the day and open/free parking at night.	12	7	19
Have moving sidewalks/walkways that are enclosed and heated to encourage people not to drive.	10	4	14

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Tear down the entire campus and rebuild it with parking in mind.	20	4	24
Make it harder to get the higher stickers - "A", "B" and "C".	22	21	43
Try to catch all the people that lied to get stickers.	10	9	19
Have parking lots and garages designated as "long-term" or "short-term" to be used based on need (e.g., a staff person who parks from 8:00 AM - 5:00 PM would use a long-term lot, while a student who is going to class for an hour would use a short-term lot).	11	12	23
Have less metered parking.	6	13	19
Get some new/more efficient/better campus buses.	11	14	25
Don't let student drive/park on campus at all.	21	8	29
Have more business located close to campus so students will not need cars - these businesses would be within walking distance (e.g., grocery store, drug store, photo developing, laundry, etc.).	8	7	15
Do not let non-US citizens drive/park on campus.	6	5	11
To encourage alternative forms of transportation, have the university rent/distribute/giveaway scooters.	8	5	13
Issue parking stickers to students only.	7	7	14
Allow only women to drive on campus.	7	5	12

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Limit parking for students to a certain number of times per semester or to a certain number of semester.	8	8	16
Have students set up car pools from their residences (e.g., fraternities, sororities, apartment complexes, etc.).	15	14	29
Have shuttle buses running to and from the Assembly Hall/Stadium parking lots that run directly to the central part of campus.	18	14	32
Have Jetson-type cars (that fold up into a brief case); or at least extremely small cars.	8	5	13
Improve IUPD ticketing procedures in order to catch more violators.	9	14	23
Offer incentives to those who do not own cars (e.g., free vacations, trips, beer, etc.).	6	6	12
Have less one way streets and more on-street parking.	6	7	13
Have more bus stops on campus.	9	18	27
Allow people to park only in the lots for the type of sticker they have (if you have an "A" sticker - you can only park in "A" lots - not in any other (such as "B" or "E"); if you have an "D" sticker, you could only park in "D" lots, etc.).	8	10	18
Have a transport helicopter take every 20th car from parking lots and then bring it back at a designated time.	8	5	13
Have physical harm done to those who park illegally.	7	5	12

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Have less/no parking for university-owned vehicles.	7	5	12
Have parking lots and garages assigned to students based on major.	7	5	12
Have classes/services closer to students/faculty residences (e.g., over telephone, fax, bank machines, etc.).	9	9	18
Widen the streets to allow for angle parking.	9	5	14
Have elevated walkways/skywalks for getting around campus.	9	5	14
Have less free parking hours on campus.	9	11	20
Only let students/faculty/staff on campus - no outsiders.	8	6	14
Have express (non-stop) bus routes.	8	10	18
Either allow cars on campus - or alcohol on campus.	6	5	11
Have incentives/awards/prizes for those who walk/bike/etc. (alternative forms of transportation from driving; e.g., have gifts along the walking paths, or for those who walk the most miles, etc.).	8	9	17
Have special permits that can be issued to students to allow them to park in designated places for special events (e.g., ballgames, musical events, etc.).	7	17	24
Have movable parking (e.g., on semi trucks).	8	5	13
Encourage out-of-town weekend trips for families, students.	6	7	13

Please rate each response on a scale of 1 (lowest) to 10 (highest) for each criteria: Effectiveness and Feasibility. Please use only whole numbers.

	Effectiveness	Feasibility	Quality Score
Have general university announcements that discourage driving on campus and encourage alternative forms of transportation.	17	9	26
Give students piggyback rides to class.	8	5	13
Build a wall around Bloomington/Put a bubble over the campus - decrease the number of cars that are allowed in.	18	4	22
Have an equal number of parking stickers issued to each dorm, fraternity, sorority, etc. - when a car from one of those organizations is illegally parked, the organization gets the fine - not the individual.	10	8	18
Have electronic sensors under the front end of each car that will be over a sensor in the parking space - if the car is illegally parked, then warning light goes off on an indicator board at IUPD so the car could then be ticketed/towed.	12	6	18
Encourage/Require that more students live on-campus (in dorms).	13	14	27

APPENDIX H

SPSS-X MANOVA OUTPUT

SPSS-X RELEASE 3.1 FOR VAX/VMS

* * * * * * A N A L Y S I S   O F   V A R I A N C E -- DESIGN   1 * * * * * *

EFFECT .. SIZE BY STRUCT
Multivariate Tests of Significance (S = 1, M = 3 , N = 9 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.21983	.73966	8.00	21.00	.657
Hotellings	.28178	.73966	8.00	21.00	.657
Wilks	.78017	.73966	8.00	21.00	.657
Roys	.21983				

Note.. F statistics are exact.

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EFFECT .. SIZE BY STRUCT (Cont.)
Univariate F-tests with (1,28) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
T1	3.19516	274.31188	3.19516	9.79685	.32614	.572
T3	.07562	66.51250	.07562	2.37545	.03184	.860
T5	.01562	1.14250	.01562	.04080	.38293	.541
T7	108.42016	38366.6369	108.42016	1370.23703	.07913	.781
T9	.26304	3.18395	.26304	.11371	2.31321	.139
T11	.12250	4.39875	.12250	.15710	.77977	.385
T13	6.06391	145.15688	6.06391	5.18417	1.16970	.289
T15	.09000	14.40500	.09000	.51446	.17494	.679

SPSS-X RELEASE 3.1 FOR VAX/VMS

* * * * * * A N A L Y S I S   O F   V A R I A N C E -- DESIGN   1 * * * * * *

EFFECT .. STRUCT
Multivariate Tests of Significance (S = 1, M = 3 , N = 9 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.32370	1.25644	8.00	21.00	.317
Hotellings	.47864	1.25644	8.00	21.00	.317
Wilks	.67630	1.25644	8.00	21.00	.317
Roys	.32370				

Note.. F statistics are exact.

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EFFECT .. STRUCT (Cont.)
Univariate F-tests with (1,28) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
T1	3.01891	274.31188	3.01891	9.79685	.30815	.583
T3	3.15063	66.51250	3.15063	2.37545	1.32633	.259
T5	.39063	1.14250	.39063	.04080	9.57330	.004
T7	1134.84766	38366.6369	1134.84766	1370.23703	.82821	.371
T9	.05284	3.18395	.05284	.11371	.46470	.501
T11	.00250	4.39875	.00250	.15710	.01591	.901
T13	12.87016	145.15688	12.87016	5.18417	2.48259	.126
T15	1.00000	14.40500	1.00000	.51446	1.94377	.174

SPSS-X RELEASE 3.1 FOR VAX/VMS

* * * * * * A N A L Y S I S   O F   V A R I A N C E -- DESIGN 1 * * * * * *

EFFECT .. SIZE
Multivariate Tests of Significance (S = 1, M = 3 , N = 9 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.99455	479.36341	8.00	21.00	.000
Hotellings	182.61463	479.36341	8.00	21.00	.000
Wilks	.00545	479.36341	8.00	21.00	.000
Roys	.99455				

Note.. F statistics are exact.

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EFFECT .. SIZE (Cont.)
Univariate F-tests with (1,28) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
T1	.37516	274.31188	.37516	9.79685	.03829	.846
T3	16.60563	66.51250	16.60563	2.37545	6.99053	.013
T5	.10563	1.14250	.10563	.04080	2.58862	.119
T7	17825.5877	38366.6369	17825.5877	1370.23703	13.00913	.001
T9	116.15720	3.18395	116.15720	.11371	1021.49882	.000
T11	3.15062	4.39875	3.15062	.15710	20.05513	.000
T13	.83266	145.15688	.83266	5.18417	.16062	.692
T15	.20250	14.40500	.20250	.51446	.39361	.535

SPSS-X RELEASE 3.1 FOR VAX/VMS

* * * * * * A N A L Y S I S   O F   V A R I A N C E -- DESIGN 1 * * * * * *

EFFECT .. SIZE BY STRUCT BY GDSS
Multivariate Tests of Significance (S = 1, M = 3 , N = 9 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.25369	.89231	8.00	21.00	.540
Hotellings	.33993	.89231	8.00	21.00	.540
Wilks	.74631	.89231	8.00	21.00	.540
Roys	.25369				

Note.. F statistics are exact.

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EFFECT .. SIZE BY STRUCT BY GDSS (Cont.)
Univariate F-tests with (1,28) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
T2	3.19516	157.13937	3.19516	5.61212	.56933	.457
T4	.01000	37.08000	.01000	1.32429	.00755	.931
T6	.01000	.66000	.01000	.02357	.42424	.520
T8	89.53891	18424.3019	89.53891	658.01078	.13608	.715
T10	.09249	2.08278	.09249	.07438	1.24342	.274
T12	.27562	4.42375	.27562	.15799	1.74456	.197
T14	.66016	89.14687	.66016	3.18382	.20735	.652
T16	.85563	7.98750	.85563	.28527	2.99937	.094

SPSS-X RELEASE 3.1 FOR VAX/VMS

* * * * * * A N A L Y S I S   O F   V A R I A N C E -- DESIGN   1 * * * * * *

EFFECT .. STRUCT BY GDSS
Multivariate Tests of Significance (S = 1, M = 3 , N = 9 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.25069	.87823	8.00	21.00	.550
Hotellings	.33456	.87823	8.00	21.00	.550
Wilks	.74931	.87823	8.00	21.00	.550
Roys	.25069				

Note.. F statistics are exact.

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EFFECT .. STRUCT BY GDSS (Cont.)
Univariate F-tests with (1,28) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
T2	.54391	157.13937	.54391	5.61212	.09692	.758
T4	.81000	37.08000	.81000	1.32429	.61165	.441
T6	.04000	.66000	.04000	.02357	1.69697	.203
T8	318.17641	18424.3019	318.17641	658.01078	.48354	.493
T10	.02307	2.08278	.02307	.07438	.31009	.582
T12	.07562	4.42375	.07562	.15799	.47867	.495
T14	.00391	89.14687	.00391	3.18382	.00123	.972
T16	.33062	7.98750	.33062	.28527	1.15900	.291

SPSS-X RELEASE 3.1 FOR VAX/VMS

* * * * * * A N A L Y S I S   O F   V A R I A N C E -- DESIGN   1 * * * * * *

EFFECT .. SIZE BY GDSS
Multivariate Tests of Significance (S = 1, M = 3 , N = 9 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.52129	2.85844	8.00	21.00	.026
Hotellings	1.08893	2.85844	8.00	21.00	.026
Wilks	.47871	2.85844	8.00	21.00	.026
Roys	.52129				

Note.. F statistics are exact.

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EFFECT .. SIZE BY GDSS (Cont.)
Univariate F-tests with (1,28) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
T2	49.87891	157.13937	49.87891	5.61212	8.88771	.006
T4	1.44000	37.08000	1.44000	1.32429	1.08738	.306
T6	.25000	.66000	.25000	.02357	10.60606	.003
T8	159.70641	18424.3019	159.70641	658.01078	.24271	.626
T10	.00630	2.08278	.00630	.07438	.08470	.773
T12	.00250	4.42375	.00250	.15799	.01582	.901
T14	.92641	89.14687	.92641	3.18382	.29097	.594
T16	.18062	7.98750	.18062	.28527	.63318	.433

SPSS-X RELEASE 3.1 FOR VAX/VMS

* * * * * * A N A L Y S I S   O F   V A R I A N C E -- DESIGN 1 * * * * * *

EFFECT .. GDSS
Multivariate Tests of Significance (S = 1, M = 3 , N = 9 1/2)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.89120	21.50114	8.00	21.00	.000
Hotellings	8.19091	21.50114	8.00	21.00	.000
Wilks	.10880	21.50114	8.00	21.00	.000
Roys	.89120				

Note.. F statistics are exact.

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EFFECT .. GDSS (Cont.)
Univariate F-tests with (1,28) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
T2	967.98766	157.13937	967.98766	5.61212	172.48162	.000
T4	146.41000	37.08000	146.41000	1.32429	110.55771	.000
T6	.25000	.66000	.25000	.02357	10.60606	.003
T8	74877.4814	18424.3019	74877.4814	658.01078	113.79370	.000
T10	.38487	2.08278	.38487	.07438	5.17397	.031
T12	3.42250	4.42375	3.42250	.15799	21.66262	.000
T14	26.13766	89.14687	26.13766	3.18382	8.20953	.008
T16	12.42563	7.98750	12.42563	.28527	43.55775	.000

VITA

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