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GDSS환경하에서 집단상호작용이 집단의사 결정의 성과에 미치는 영향

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The Effects of Group Interaction on The Performance of Group Decision Making in A GDSS Environment

Most of the research on a group decision support system [GDSS] has focused on directly examining its effect on the decision outcomes. Under this research framework, however, the role of group interaction process is largely ignored. This study focuses on the effect of the group interaction process on decision–making performance when a GDSS is used as the only medium for group interaction. Specifically, this study sought to determine whether significant relationships exist between the quality of the decision and the decision functions, contingent phases, and different decision paths. Natural interaction processes of decision–making groups was simulated in an experimental setting in which volunteer subjects from several business classes were assigned to dispersed three–person groups undertook the experimental task via a decision network. A baseline GDSS was developed for this setting. The results of this study confirmed earlier studies in a non–GDSS setting to suggest significant effects of decision functions and contingent phases on the quality of decision but no significant relationship between decision path and the quality of group decision.

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I . INTRODUCTION

Recently, the development of a group decision support system (GDSS) in computer information systems research has made a significant contribution to the organization of the future. GDSS combines communication, computer, and decision technologies to facilitate the solution of less-structured tasks by a group with joint responsibility. GDSS also enhances communication among group members [Bui & Jarke, 1986 ; DeSanctis & Gallupe, 1987 ; Huber, 1984b].

There has been remarkable growth in GDSS research throughout the past decade. The research findings as well as the developments in technology in this area are well-documented in several recent studies [Dennis, George, Jessup, Nunamaker, & Vogel, 1988 ; Kraemer & King, 1988 ; Pinsonneault & Kraemer, 1989]. This emerging body of research in GDSS provides evidence that computer technology can and does affect the quality of group decision making. With few exceptions, most GDSS research has been oriented toward investigating the effects of GDSS and other situation variables on group outcomes such as quality of decisions or group consensus. Very few studies have focused on the group process. Those that have are far from an in-depth analysis of the process itself. Of the few exceptions is the Adaptive Structurational Theory [DeSanctis and Poole, 1994 ; Poole, Siebold, and McPhee, 1985] is an encompassing theory which focuses on the interaction process as the primary consituent of group decision making using a GDSS.

While GDSS research has largely ignored the process of group interaction, many small group scholars have long been interested in the role that the process in face-to-face settings may play in determining whether a group will arrive at a low- or high-quality decision [Collins & Guetzkow, 1964;Hackman & Morris, 1975;Hirokawa, 1982;Janis, 1983;McGrath, 1984]. Many of the efforts have led to the general conclusion that is clearly reflected in Huber's [1984b] often cited equation :

Actual Decision-making Effectiveness
=Potential Decision
-making Effectiveness
-Process Losses+Process Gainss

However, few have actually measured the "process variables" of group decision making. Despite the efforts of a number of researchers, it has yet to be demonstrated with any degree of certainty, what is going on when a group is interacting and what kind of relationship exists between group interaction processes and group decision-making outcomes [Hewes, 1986].

Research on group decision processes encompasses an array of theories which serve as models for observing group interaction. A series of recent essays [Gouran & Hirokawa, 1983, 1986; Hirokawa, 1982, 1988] explain the functional perspective which contends that the quality of outcome of group decision process is closely related to effective performance of certain decision functions by a decision group. The decision functions include : ① define and analyze the problem, ② establish criteria for evaluation, ③ generate alternative solutions, ④ evaluate the positive consequences of the alternatives, ⑤ evaluate the negative consequences of the alternatives, ⑥ choose from the alternatives, and ⑦ establish operational procedures.

In addition to the task dimension [decision functions], the group interaction process has a relational dimension [working relationships] [Fisher & Ellis, 1990]. Poole and Roth [1989] identified four classes of working relationships : ① focused work, ② critical work, ③ conflict, and ④ integration. According to the contingency model of group decision process, a contingent phase can be categorized as a combination of both categories of decision functions and working relationships [Poole, 1983]; for example, the contingent phase of problem analysis in a focused working relationship. Despite the efforts of the researchers mentioned above, it has yet to be established with any degree of certainty that significant relationships exist between time spent for certain types of interaction behaviors and group decision-making performance.

There is very little doubt that empirical efforts need to be directed toward determining whether a systematic relationship exists between group decision-making outcomes and the micro- and macro-level patterns of interaction. The main objective of this study is to addresses the following research questions :

(1) Is there any significant relationship between the quality of decision and the decision functions?
(2) Is there any significant relationship between contingent phases on decision performance?
(3) Is there any significant relationship between the quality of decision and different decision paths?

The ensuing discussion of group decision making requires a full understanding of several key terms that specifies a rather precise meaning, probably narrower than the meaning used in everyday conversation. Shaw [1976, p.11] defined a *group* as "two or more persons who are interacting with one another in such a manner that each person influences and is influenced by each other person." This definition perceives the central element of a group to be interaction among its members so that the members are interdependent among themselves. *Group interaction* refers to the dynamic interplay of individual and collective behavior of group members, acting in a complex environment. In this study, the terms interaction and *communication* are used interchangeably. A *group decision* is an ultimate outcome of group interaction. It is inevitably a choice made by group members from among alternative proposals available to them.

II. HYPOTHESES

There is a number of possible variables for the group decision. A list of the variables includes the decision quality, the consistency of group performance, the breadth of the decision, the acceptance of the decision by the members, and so on. Of these possible variables, however, "quality of decision" is chosen as the only variable for decision outcome in this study. This is not only because it has been a consistent outcome variable in the previous research but also because it allows this study to be compared directly with those conducted in a non-GDSS environments. The quality of a group's decision has been linked to the group interaction process by a number of small group researchers [Collins & Guetzkow, 1964;Gouran, 1973;Hackman & Morris, 1975;Hirokawa, 1982;Steiner, 1972].

The conceptual model, which indicates the variables of most relevance and importance to this study, provides a basis for the elaboration of the hypotheses that are tested in the research. Figure 1 presents the conceptual model of the research.

Most research questions and hypotheses are drawn from the previous research on "natural group process," that is, non-GDSS research. These prior research findings, however, represent a baseline on which the hypotheses for many GDSS research is based. Whether the same patterns of group interaction observed in non-GDSS decision processes were also observed in the groups using GDSS was carefully examined.

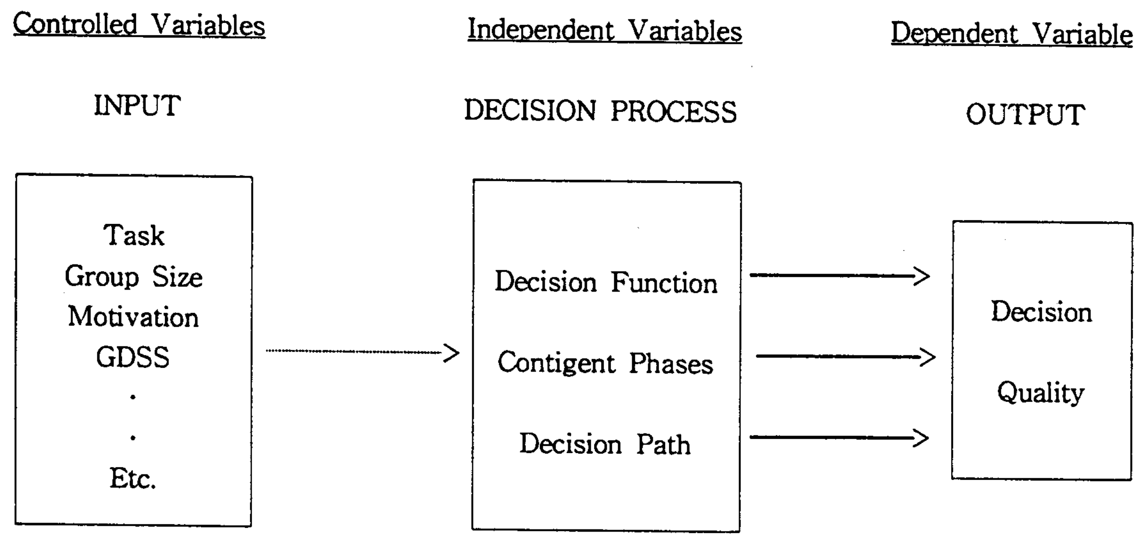

Figure 1. A conceptual model

Despite the efforts of the researchers mentioned above, it has yet to be established with any degree of certainty that systematic relationships exist between the frequency of certain types of interaction behaviors and group decision making. The functional perspective described above suggests the effects of decision functions and the decision performance. It leads to the statement of the first research question.

Research Question I :

Is there any significant relationship between the quality of decision and the decision functions?

This question can be rephrased as "Which decision functions account for more variance of the outcome variables?" As a result, finding a significant relationship between the decision phases and the quality of decision virtually means the testing of the "functional perspective". There is some evidence that three critical task requirements out of the four mentioned above had positive relationships with the decision quality [Hirokawa, 1983a, 1983bb]. From this, three hypotheses are stated :

H1a : The quality of the decision is significantly related to time spent analyzing the problem in a decision group using a GDSS.

H1b : The quality of the decision is significantly related to time spent establishing criteria for evaluating alternatives in a decision group using a GDSS.

H1c : The quality of the decision is significantly related to time spent assessing negative qualities of alternatives in a decision group using a GDSS.

The contingency model of group decision process describes the development of a decision as a series of intertwining threads of activity that evolve simultaneously and interlock in different patterns over time. These threads are none the less the two aspects of behavior that reflect both task and relational dimensions. The categories of behaviors in the task dimension are summarized as the task functions mentioned in the previous section. For the relational dimension mentioned above, the working relationships among group members are of particular interest in this research of decision making. Poole and Roth [1989] identified four classes of such working relationships : ① focused work, ② critical work, ③ conflict, and ④ integration. A contingent phase can be categorized as a combination of both categories of task and working relationships ; for example, the contingent phase of problem analysis in a focused working relationship.

As in the case of decision functions, it also can be implied that there may be some relationship between these contingent phases and the quality of the decision. As a corollary of Research Question I, the second research question is stated.

Research Question II :

Is there any significant relationship between contingent phases and decision performance?

No hypotheses are stated for this research question because there has been no evidence reported on the effect of any specific phases in the previous research. Consequently, by answering this research question, the contingency theory of decision process can possibly be tested.

There are some prescriptive models of group decision process that would support "ideal" processes or "best" ways to make decisions. One of the most popular models of decision process is the rational reflection model, drawn from Dewey's [1910] *How We Think*. This model relies on careful exploration of symptoms, causes, and generation of criteria for an effective solution before a conclusion is reached. Based on this model, various descriptions about the process have emerged ; all of which are summarized in Figure 2.

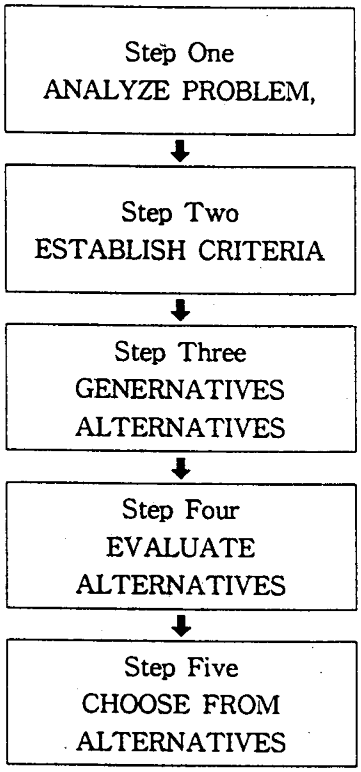

Figure 2. A normative model of group decision making

The rational reflection model has had its critics. Siebold [1988] argued that the procedure is too complex, it is costly in time, and it views problems in a closed rather than open systems framework. Furthermore, people using the procedure find it difficult to agree on values or to gather enough information to do the job properly. These criticisms, however, have not prevented communication scholars from recommending its use in group discussions. Research Question Ⅲ is stated to address this issue.

Research Question Ⅲ :

Is there any significant relationship between the quality of decision and different decision paths?

This also can be restated as "Does an effective decision path exist?" or "What sequence is the most closely related to better performance?" As a result of answering this research question, the effectiveness of the rational reflection model will be tested. Hirokawa [1982] implied that the rational reflection model is related to effective group performance because solutions are generated after the problem is analyzed. A later study by Hirokawa [1983b] suggested that the middle phases of solution generation also have significant positive relationships with the quality of the decision. Two hypotheses are stated based on these findings :

H3a : Groups performing "problem analysis" in the first stage of their decision path are more likely to come up with a higher−quality decision in the decision making using a GDSS.

H3b : Groups performing "alternative generation" in the middle stage of their decision path are more likely to come up with a higher−quality decision in their decision making using a GDSS.

III. Measures

Modeling Group Interaction

The interaction is typically represented by the conditional probability of moving from one category to another in a specified unit of time regardless of who makes the remark :

$$\text{Prob}(X_b \text{ at } t \mid Y_a \text{ at } t-n) \neq \text{Prob}(X_b \text{ at } t)$$

That is, the odds (Probability) of a behavior X being performed by a person B at some time t, given that person A performed behavior Y at some earlier time, t −n, does not equal the odds that B would perform X regardless of A's earlier behavior. Hewes [1986] argued that this equation offers the most precise definition of communication yet available.

Based on this conceptual isomorphism as well as its potential predictive power, Hawes and Foley [1976] chose to model group interaction with a Markov chain which is a discrete state stochastic process. The advantage of knowing that a process closely resembles a discrete Markov chain is the resulting ability to predict the distribution of coded utterances at any point in the future.

The ensuing analyses focus not upon the individual or paired codes of talk but upon transitions between coded utterances. More specifically, the procedures focus on the relative frequencies of transitions between utterances rather than on the relative frequencies of the utterances themselves.

Coding Systems

Two coding systems were used to identify two aspects of group communication, task process behavior, and behavior reflecting working relationships in the groups. A coding system that will index task process behavior is displayed in Figure 3. It is a modified version of Poole's Decision Functions Coding System (DFCS) [Poole & Roth, 1989]. It is specifically set up to distinguish among statements focused on the problem, on the evaluation criteria, on solution design, on evaluation/choice, and on operating procedures.

Analyze Problem (P): includes the statements that identify and clarify the nature of the problem, its symptoms and seriousness, or its causes [problem analysis]; and evaluates for or against a problem analysis statements [problem analysis evaluation].

Build Evaluation Criteria (C): includes the critical requirements for a choice ; that is, the specific objectives that need to be achieved in order to remedy the problem, or the specific standards that choice must satisfy in order to be judged as acceptable.

Generate Alternative Solutions (A): includes statements of the principles that should guide group actions or decisions [solution guidelines]; any concrete, particular, specific proposal for action [solution proposal]; and any statement that modifies, elaborates, qualifies, or provides details on solution proposals or bargains [solution elaboration].

Evaluate Alternatives (E): includes the following subcategories.
Confirm Evaluation (ECON): includes arguments for or aganst a solution guideline, proposal, or elaboration statements.

Evaluate Positive Consequences (EPOS): includes any statement or question which helps the group identify positive and desirable implications and consequences of an alternative when it is accepted.

Evaluate Negative Consequences (ENEG): includes any statement and question which helps the group identify negative and undesirable implications and consequences of an alternative when it is accepted.

Establish Operating Procedures (O): includes the statements that orient the group to its work and specify the process the group will follow in working on its task [orientation], and statements that reflect on or evaluate ongoing group process [reflection].

Figure 3. Categories of Task Activities

For the classification of working relationships, Poole and Roth's Working Relationships Coding System (WRCS) was used. The atmosphere of each statement was categorized using WRCS. This coding system is summarized in Figure 4.

Focused Work (FW): includes the atmosphere in which members are working with a concentrated focus on the task at hand. There is a high degree of idea development and the socioemotional tenor of the interaction is positive. Common statements in this category include adding to and clarification of ideas, building on member contributions, dividing labor on the task, and sharing thoughts and opinions on issues.

Critical Work (CW): includes the atmosphere in which the group concentrates on the task at hand and there is a high degree of idea development. However, unlike focused work, in critical work members critically examine each others' contributions. There are disagreements but no sense of opposition. Criticism is incorporated into the stream of ideas and is directed toward the proposal on the floor. Common statements include criticism about other's ideas and positions, building on member contributions, and clarification of ideas.

Conflict (CO): includes the atmosphere in which members form sides and take opposing positions [opposition]; one side gives in to the other [win-lose]; members drop the subject or postpone considerations until later [tabling]; and parties try to discuss the conflict in a way that can lead to a mutually acceptable resolution [open discussion].

Integration (IN): includes the atmosphere in which the group is not "on topic". There is little or no idea development. Common statements include joking, non-task discussions and personal discussions.

Figure 4. Categories of Relational Activities

Measures for Independent Variables

There are three independent variables involved in the research model : decision functions, contingent phases, and decision path. The measures of each variable are described.

Measures for Decision Functions. Decision functions are identical with the six categories of the Decision Function Coding Systems(DFCS) : analyze problem (P), build evaluation criteria (C), generate alternative solutions (A), evaluate positive consequences (EPOS), evaluate negative consequences (ENEG), and establish operating procedures (O).

After coding every message exchanged in an experimental group discussion, a profile of codes in some order of interdependence is obtained. For example, if a message for evaluating positive consequence of an alternative [coded as "EPOS"] was answered by a message to modify the original alternative [coded as "A"], then there is an interdependence between the two messages or functions : "EPOS" is followed by "A". If we assume a Markov process for the exchange of messages, this interdependent order of functions implies a transition of states from "EPOS" to "A".

Suppose the stationary transition probability matrix of the Markov chain be P. Then,

$$\lim_{n\to\infty} p^{(n)} = \lim_{n\to\infty} p^{(0)}P^{(n)}$$
$$= p^{(0)}V = v = [v_1, v_2, \dots, v_m]$$

where m=1, 2, ... , m[김재전, 1991]. The qualities v_j are referred to as steady−state probabilities or limiting probabilities decision functions. They do not depend on the initial state $p^{(0)}$. Since they describe the long−run behavior of the process and can be interpreted as the long−run proportion of time the group spends in state j or decision function j; the v_j are taken to be measures for decision function variables.

There are well−established methods to check the validity of this instrument [Billingsley, 1961 : Anderson and Goodman, 1957].

Measures for Contingent Phases. Each contingent phase is defined when a message is coded as a combination of task and relational categories of the coding systems described above. The Decision Function Coding Systems (DFCS) includes five task categories : P, C, A, EPOS, ENEG, and O. The Work Relational Coding System (WRCS) includes four categories : FW, CW, CO, and IN.

Since each message is coded by these two coding systems(DFCS and WRCS), twenty−four possible combinations of the two categories are independent variables : problem analysis in focused work (PFW), problem analysis in critical work (PCW), ... through operating procedure in integration (OIN). These 24 contingent phases comprise the state space of a Markov process:S ⊇ s = {1, 2, ... , m}, where m is 24 for the same number of contingent phases. Through the same procedure described in the previous section, the long−run proportion of time the group spends in state j or contingent phase j are calculated to be measures for contingent phase variables.

Measures for Decision Paths. There is another operationalization of this independent variable to answer the third research question_decision path. Decision path is a "logical" sequence of the decision phases through which a group is followed. As depicted earlier in Figure 2, the decision phases include "Analyze Problem," "Establish Criteria," "Generate Alternatives," "Evaluate Alternatives," and "Choose from Alternatives." The sequence is not streamlined along the passage of time during the decision−making session. Rather it is a precedence relationship of the five phases a particular group would have followed. This "logical" sequence is determined by manipulating the transition probability matrices as described below.

In order to determine the sequence of phases, a method is employed, which uses

Pelz's statistic Gamma [1985]. As a measure of ordinal relationship, the Gamma is computed :

$$\Gamma=(P-Q)/(P+Q)$$

where

Γ=measure of ordinal relationship [precedence and separation],

P=frequencies that phase i precedes phase j,

Q=frequencies that phase i follows phase j.

A positive Gamma would indicate that phase i precedes phase j, while a negative Gamma would indicate that j precedes i. The value of Gamma, which ranges from +1.0 to −1.0, indicates the proportion of one phase that precedes or follows another. Gamma can also be used to establish the degree of separation of phases. An examples of calculating gamma and interpreting the result is included elsewhere [김재전, 1992].

Measure for Dependent Variable

The only dependent variable is the quality of decision. Determining the quality of a group's final product has always been problematic in discussion tasks when answers are not clear−cut. The developers of the "Bonanza" case, however, have already worked out the correct answer which has been verified by experts [Jarvenpaa & Dickson, 1986]. The quality of decision was measured as "1" if a group came up with the correct answer and as "0" otherwise. This binary measure helps simplify the analysis. This kind of measure also helps exclude raters' arbitrariness when they evaluate each group's performance based on the raters' own judgement.

Ⅳ. METHOD

An experimental simulation[McGrath, 1984] was conducted for this study. It was a laboratory study in which leaderless group discussions were created. These discussions were expected to simulate naturally interacting groups but they were artificial in that they were created by the researcher and the people performed for research purposes rather than for personal reasons.

Pilot Study

There was a series of pilot studies before this study. Those studies were conducted to check the functions and reliability of the system, MACCOLS. During that period, the task and the coding system were also tested and the procedure of the experiment was finally set up.

Experimental Task

The task used for this study is the "Bonanza Business Case" [Jarvenpaa & Dickson, 1988]. This task has been extensively tested at the University of Minnesota and seems to meet the requirements of face, content, and external validity [Gallupe, 1986].

The case describes the Bonanza Business Forms Company, a firm that sells continuous paper forms for businesses in three markets [the small business market, the hospital market, and the financial institution market]. During the previous three quarters the profits of the company were steadily declining while total sales dollars were increasing. As described in the case, Bonanza's management could not determine the cause of the declining profits and consequently asked for help. The group's task was to find the cause of the company's problem using a series of business reports, and to correctly identify why the problem was occurring.

Essentially all the data were available to make the decision, and there was one "best" solution. It does not necessarily mean that this problem can be "solved" using algorithmic procedures. That kind of problem can probably be better solved by individual experts than by groups. The levels of difficulty of the task were not manipulated in this experimental simulation. The "moderately difficult" version of the "Bonanza Business Case" was used for all participating groups.

Subjects

Two hundred and thirty-six senior undergraduate and graduate business administration students participated in the study. These subjects were enrolled in at least one course of strategic management, strategic marketing, or computer information systems at the Arizona State University in the 1989-1990 academic year. The subjects were randomly assigned to groups of three. Random assignment such as this closely simulated a practical situation where some members had worked together before but some had not in organizational groups. It increased the likelihood that unknown individual difference factors such as decision-making ability were spread among the groups. Three-person groups are very small in size. The impacts of a GDSS may be more dramatic in large size groups, but the average number of people attending an organizational meeting is reported to be five or less [Datamation, 1986].

Seventy—one groups produced final decisions as end results of the experiment. This yielded sufficient degrees of freedom for a statistical analysis of the data. In order to prepare subjects for the experiment, all subjects were given an overview of the experimental task, and all groups were given training at the beginning of the experimental session on the use of the GDSS so that any unanticipated effects due to training would be constant across treatment conditions.

GDSS Setting

The setting for this experiment was a local area decision network [LADN] [Dennis et al., 1988]. A Macintosh network with twenty—seven workstations at Arizona State University was used for this research. It accommodates up to nine groups of three at one time. A dispersed group was simulated by assigning the machine as far away as possible from other members of the group and prohibiting them from talking to each other during the session.

The system developed for use in this experiment can be labeled as a baseline level 1 GDSS [DeSanctis & Gallupe, 1987]. This system, MACCOLS (MACintosh COLlaboration System), was developed by the researcher using HyperCard and a software called HyperAppleTalk. The system allows each decision maker to type/edit, send/receive , store/retrieve, and link to/browse through the messages. The main screen of the system is shown in Figure 5.

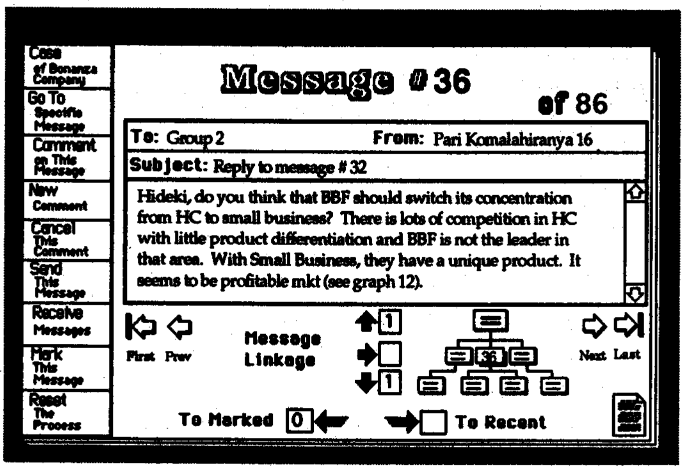

Figure 5. A Sample Screen of The MACCOLS

The 'Case' button allows users to refer to the experimental task case which provides textual and graphics information as often as necessary. Both 'Comment' and 'New' buttons will have a new blank message card popped up. Typed text may be either "Canceled" or sent. Upon clicking the 'Send' button, the typed message is sent to other group members. Users can also receive messages at any time using the 'Receive' button. When a message is sent or received, new hierarchical links among messages is established automatically based on their interdependence. Black arrows will allow users to navigate through the messages in parent, children, or the same level order. It is also possible to navigate according to temporal order of messages as they are stored using normal arrows [prev, next, first, last]. The 'Recent' arrow keeps track of the recently received messages for quick reference.

Procedure

Experimental groups met at the Macintosh site for a 75 minute experimental session. The experiment consisted of the following steps :

(1) The description of the "Bonanza" case was distributed in a class a week before the experiment was conducted. It did not include any specific information that would lead to a possible solution of the case. Subjects were asked to read the case to become familiar with the task but not to discuss any of it with their classmates.

(2) A week later, at the experimental session, subjects were randomly assigned to a group and a preassigned seat. They were provided with Mac workstations and a diskette with MACCOLS software. They were asked not to talk with any other participant. The researcher and an assistant were available for questions from participants.

(3) The first 25 minutes were spent in a hands—on practice of how to use MACCOLS. They initialized the connection by entering group number and participant's name. Once the connection was established successfully, they were instructed on the functions of each buttons, how to edit/type the messages, how to refer to online information regarding the description and data of the "Bonanza" case, and most importantly, how to navigate across the stored messages. In this period, they

had a chance to examine the full description of the experimental task along with the business reports attached to it. Then they were allowed to exchange any messages for the remaining time to gain more familiarity with the various functions of MACCOLS.

(4) The remaining 50 minutes were devoted to the MACCOLS–enabled discussion to determine the cause of the Bonanza's problem. At the end of the discussion each group was asked to type one major cause of the problem in the case as a consensus solution of that group. As an alternative to a single consensus solution, groups were allowed to type three alternative causes, one from each member, and rank them.

(5) After the experimental session ended, diskettes were collected with all the messages the subjects had exchanged.

The properties of these experimental groups coincide with those of the leaderless group discussion (LGD). The groups were given a time limit for completing the task. Most of the group discussions ended with a decision within the time limit. The data for the groups that did not produce a result were excluded from the rest of the study.

V. ANALYSIS AND DISCUSSION

For each research question, an analysis and discussion for specific hypotheses are presented first, followed by more general research questions.

Descriptive Statistics

Data were collected for 80 experimental groups. All the data collected, however, were not usable. Data for nine groups were eliminated.

Consequently, data for the remaining 71 groups were used for analysis. Twenty–eight groups or about 40 percent of the total groups ended up with the correct decision. This is consistent with the classification of moderate to difficult task level according to the developers of this task [Jarvenpaa & Dickson, 1986]. The average number of messages exchanged during an experimental session was fifty–four with a standard deviation of twenty–one messages. The highest number of messages was 138 and the lowest was 29. The number of messages was considered smaller than expected. However, it is consistent with Hiltz and Turoff's [1985] finding that the written and communication mode in an electronic communication channel generates rather smaller numbers of remarks during discussion. Since a message was allowed to be coded with multiple codes, data points were more than the number of messages. For example, if a five-line message can contain multiple sentences and they have two distinctive decision functions, the same message is assigned two codes instead of one.

Statistical Methods

To test the relationships between decision efficacy and decision functions or contingent phases, data were analyzed using the logistic regression procedure. Since the dependent variable (the quality of decision) is a binary measure (i.e., 0 and 1), the logit link function was used to transform the dependent variable[2]. The linear logistic model has the form :

$$\text{logit}(p)=\log(p(1-p))=\alpha+\beta x$$

where α is the intercept parameter, and β is the vector of slope parameters. The response, Y, of an experimental unit or a decision group can take on one of two possible values, denoted by 0 and 1 (e.g., Y=1 if a group decision is correct; otherwise Y=0).

The relationship between decision quality and decision path was investigated using the contingency table procedure. The FREQ procedure of the SAS package was used to compute the contingency table model. The statistical procedures developed by Anderson and Goodman [1957] were used to test the assumptions of a Markov chain. Hawes and Foley [1976] discussed the detailed procedures to the Anderson and Goodman test. The procedures were programmed by the researcher using SAS/IML, a programming language to manipulate matrices.

Research Questions I and II : The Effect of Decision Functions and Contingent Phases

This section reports the results of the experiment and discusses the findings regarding Research Question I and its corollary, Research Question II. It is followed by a discussion of the results.

2) The logit link function, $g(p)=\log(p/(1-p)$, is the inverse of the cumulative logistic distribution function, which is $F(x)=1/(1+\exp(-x))$.

Results

The primary purpose of the first analysis is to determine whether the six decision functions (problem analysis through operating procedure) and contingent phases (working relationship nested within each decision function) exert main effects on group performance. In order to identify this relationship, logistic regression analysis was used. First, the following hypotheses regarding the effects of the decision functions are addressed. In essence, this test seeks to establish that each of the six functions represent a unique decisional activity important for group decision–making efficacy.

- H1a : The quality of the decision is significantly related to time spent analyzing the problem in a decision group using a GDSS.
- H1b : The quality of the decision is significantly related to time spent establishing criteria for evaluating alternatives in a decision group using a GDSS.
- H1c : The quality of the decision is significantly related to time spent assessing negative qualities of alternatives in a decision group using a GDSS.

The decision quality score (dependent variable) was regressed onto the six decision functions (independent variables), that is, problem analysis (P), evaluation criteria (C), alternative generation (A), assessment of positive qualities of alter-natives (EPOS), assessment of negative qualities of alternatives (ENEG), and operating procedures (O). The dependent variable was measured as "1" if a group arrived at the correct decision and as "0" otherwise. The independent variables were times spent for each decision function measured in terms of state probabilities of these functions. When all six functional categories were taken into the model simultaneously, the logistic regression analysis revealed significant main effects for the four decision functions (problem analysis, criteria for evaluating alternatives, generating alternatives, and assessing positive qualities of alternatives). Model fitting was sound (Chi–square=22.392; p=0.001) and predictability of the model also seemed strong (Gamma=.642). Thus this result indicates that variations in group decision quality were strongly related to the time spent for each of the four functional categories during the decision–making session.

The negative sign of coefficients should not be directly interpreted as a negative effect of the particular function to the quality decision. It should rather be interpreted like partial derivatives in differential equations; that is, given all other functions held constant, the particular function has the negative effect of the magnitude on the decision quality. In other words, the magnitude of the effect of the particular decision function may change depending on the behavior of other decision functions. Therefore, it is safer to simply state the existence of a significant relationship regardless of the negative or positive direction of the effect. Table 1 summarizes the results of this logistic regression analysis.

Table 1. Logistic Regression Analysis for Decision Functions

Analysis of Maximum Likelihood Estimates

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr> Chi-Square
P	11.3770	5.3649	4.4971	0.0340*
C	−15.4536	7.7252	4.0017	0.0455*
A	6.0976	2.2552	7.3104	0.0069*
EPOS	−16.9891	5.6511	9.0380	0.0026*
ENEG	3.7693	4.8699	0.5991	0.4389
O	−2.2965	1.8280	1.5783	0.2090

Note : * $p<.05$
Note : Response Levels : 2 (1, 0)
Number of Observations : 71(1 : 28, 0 : 43)
Link Function : Logit

Criteria for Assessing Model Fit

Criterion	Chi-Square for Covariates	df	p
−2 LOG L	26.626	6	0.0002
Score	22.392	6	0.0010

Note : Association of Predicted Probabilities and Observed Responses :
Somers' D=0.636, Gamma=0.642.

Having found significant main effects for the four functional categories, the dependent variable (decision quality score) was then regressed onto the working relationship categories nested within each of the six decision functions. Since there are four categories for working relationship, that is, focused work (FW), critical work (CW), conflict (CO), and integration (IN), there can possibly be 24 decision phases or combinations of the two categories, such as problem analysis in focused work (PFW), problem analysis in critical work (PCW), evaluation criteria in focused work (CFW), and operating procedure in integration (OIN), to name a few. With the exception of OIN, however, no functional categories combined with "conflict" and "integration" working relationships collected any frequencies at all. Thus, thirteen decision phases were taken into the model after eliminating phases with no collected frequencies in order to test the main effects for the decision phases. The independent variables were measured in terms of the state probabilities of each decision phase.

When all thirteen contingent phases were taken into the model simultaneously, the logistic regression analysis revealed significant main effects for the six contingent phases (problem analysis in focused work, problem analysis in critical work, criteria for evaluating alternatives in focused work, generating alternatives in focused work, assessing positive qualities of alternatives in critical work, and operating procedures in critical work). Model fitting was sound (chi−square=33.596;p=0.0014) and predictability of the model also seemed strong(Gamma=.812). Thus, this result indicates that variations in group decision quality were strongly related to the time spent for each of the six contingent phases during the decision−making sessions. Table 2 summarizes the results of this logistic regression analysis.

Discussion

This analysis found that variations in group decision quality are closely related to the efforts directed toward the performance of decision functions. More precisely, the results indicate that the first two hypotheses can not be rejected and the decision function of "evaluating positive qualities of alternatives" also has a main effect on the quality of decision. On the contrary, the third hypothesis could not hold according to the results of this analysis. For the most part, the findings of this study are fairly consistent with the findings of the previous research by Hirokawa [1985], and appear to offer additional support for the functional perspective in the GDSS setting. In short, the results of this analysis suggest that the time spent performing various decision functions is an important factor in predicting group decision performance.

Table 2. Logistic Regression Analysis for Contingent Phases

Analysis of Maximum Likelihood Estimates

Variable	Parameter Estimate	Standard Error	Wald Chi-Square	Pr> Chi-Square
PFW	18.9630	8.2183	5.3241	0.0210 *
PCW	172.4000	72.2424	5.6925	0.0170 *
CFW	−43.2902	16.0216	7.3007	0.0069 *
CCW	50.8209	43.8653	1.3423	0.2466
AFW	9.4142	3.7248	6.3881	0.0115 *
ACW	−21.7809	14.7670	2.1755	0.1402
EPOFW	−22.7642	10.5354	4.6688	0.0307 *
EPOCW	−2.5464	28.5467	0.0080	0.9289
ENEFW	18.9624	10.3413	3.3623	0.0667
ENECW	3.1273	17.2082	0.0330	0.8558
OFW	1.3764	5.7277	0.0577	0.8101
OCW	−261.1000	119.6000	4.7642	0.0291 *
OIN	−9.1460	5.2836	2.9964	0.0834

Note : * $p<.05$
Note : Response Levels : 2 (1, 0)
Number of Observations : 71('1' : 28, '0' : 43)
Link Function : Logit

Criteria for Assessing Model Fit

Criterion	Chi-Square for Covariates	df	p
−2 LOG L	48.412	13	0.0001
Score	33.596	13	0.0014

Note : Association of predicted probabilities and observed responses :
Somers' D=0.806, Gamma=0.812.

Nevertheless, one notable difference needs to be acknowledged regarding the third hypothesis. Whereas previous research found no significant relationship between group decision performance and the "assessment of positive qualities of alternative choices," this study discovered a significant relationship between decision performance and the time spent to assess the positive qualities of alternatives.

The findings of the present analysis may simply reflect the manner in which the groups in this study approached the evaluation of alternative choices. The discovery of a significant main effect for "assessment of positive qualities" may be a consequence of the fact that groups tend to employ a "positive" (as opposed to a "negative") approach in evaluating alternatives. In other words, rather than eliminating competing choices on the basis of their perceived negative qualities, they arrive at decisions by basing their choice on the positive qualities of alternative options.

It is also noticeable that time spent for "generation of alternative solutions" was found to have a significant relationship with the quality of decision($p=0.0069$). This result is contradictory with previous research findings (Hirokawa, 1988). It is not surprising, however, since it is rather logical that the effort to develop ideas on possible solutions is essential for any decision—making processes.

The relationships between contingent phases and the quality of decision are reported in Table 2. It was interesting that "operating procedure in critical work relationship" (OCW) shows a significant relationship with the quality of decision ($p=0.0291$) and "evaluating negative qualities of alternatives" (ENECW) shows a near by significant level ($p=0.0667$). However, it does not seem adequate to attempt to directly interpret this difference because it may have a lot to do with other controlled variables such as task, group composition, and technical environment (i.e., types of GDSS used in the experiment). Instead of this static analysis, it is more meaningful to observe the dynamic pattern of communication behavior as discussed in the last analysis.

Research Question Ⅲ :
The Effect of Decision Path

The primary purpose of this analysis was to determine whether the different decision paths (sequence of decision functions or contingent phases) exert main effects on group performance.

Results

First, the following hypotheses on the effects of the sequence of certain decision functions are addressed. In essence, this test seeks to establish that a better group decision-making efficacy will be the result of a certain sequence of decision functions.

H3a : Groups performing "problem analysis" in the first stage of their decision path are more likely to propose a higher quality decision in their decision-making using a GDSS.

H3b : Groups performing "alternative generation" in the middle stage of their decision path are more likely to propose a higher quality decision in their decision-making using a GDSS.

A decision path for a decision group was identified using Pelz's Gamma as described earlier. SAS/IML was used to compute the Gamma values. In this analysis, a decision path is a sequence of four decision functions : problem analysis (P), criteria evaluation (C), alternative generation (A), and alternative evaluation (E) The last function, E, is an aggregate of evaluation confirmation (ECON), positive assessment (EPOS), and negative assessment (ENEG). Twenty different paths were observed out of 24 possible combinations of the four functions. In order to determine whether the special types of sequence described in the hypotheses have a significant relationship with better quality of decision, frequency analysis was used.

For the first hypothesis, a new variable P1 was created with the value "Y" when a group performed "problem analysis" (P) in its first stage and the value "N" otherwise. A frequency analysis with row variable of P1 and column variable of Score was performed. Column variable, Score, is the measure of group performance in terms of the quality of decision. General association between the two variables was 4.673, suggesting that the null hypothesis of independence between the variables can be rejected ($p=0.031$) at an established level of significance. This means that with $alpha=0.05$, there was significant association detected between the two variables. The column 1 risk suggests that the groups starting with "problem analysis" are 1.88 times more likely to come up with the correct decision than the groups starting with other decision functions. The corresponding 95 percent interval was 1.06 to

3.33 times. Table 3 summarizes the results of this frequency analysis.

Table 3. Frequency Analysis for Decision Path P1

Table of P1 by Score

P1	Score: 1	Score: 0	Total	Legend
Y	15	12	27	Frequency
	21.13	16.90	38.03	Percent
	55.56	44.44		Row Pct
	53.57	27.91		Col Pct
N	13	31	44	
	18.31	43.66	61.97	
	29.55	70.45		
	46.43	72.09		
Total	28	43	71	
	39.44	60.56	100.00	

Cochran–Mantel–Haenszel Statistics [Based on Table Scores]

Statistic	Alternative hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	4.673	0.031
2	General Association	1	4.673	0.031

Estimates of the Common Relative Risk [Rowl/Row2]

Type of Study	Method	Value	95% Confidence Bonnds	
Cohort	Mantel–Haenszel	1.880	1.061	3.333
(Coll Risk)	Logit	1.880	1.066	3.317

Note : Total Sample Size=71

For the second hypothesis, a new variable P23 was created with the value "Y" when a group has "alternative" (A) in the second or third stage in its decision path and value "N" otherwise. Frequency analysis with variables P23 and score of decision quality was performed. With alpha= 0.05, the null hypothesis of independence between the two variables should not be rejected (general association=4.673; p= 0.764). That is, no significant association between the two variables was detected. It follows that no significant difference can be claimed between the groups generating alternatives in their middle stages of a decision path and the groups doing otherwise. Table 4 summarizes the results of this frequency analysis.

Table 4. Contingency Table Analysis for Decision Path P23

Table of P23 by Score

P23	Score 1	Score 0	Total	Legend
N	16	23	39	Frequency
	22.54	32.39	54.93	Percent
	41.03	58.97		Row Pct
	57.14	53.49		Col Pct
Y	12	20	32	
	16.90	28.17	45.07	
	37.50	62.50		
	42.86	46.51		
Total	28	43	71	
	39.44	60.56	100.00	

Cochran–Mantel–Haenszel Statistics [Based on Table Scores]

Statistic	Alternative hypothesis	DF	Value	Prob
1	Nonzero Correlation	1	0.090	0.764
2	General Association	1	0.090	0.764

Estimates of the Common Relative Risk [Rowl/Row2]

Type of Study	Method	Value	95% Confidence Bounds	
Cohort	Mantel–Haenszel	1.094	0.609	1.967
(Coll Risk)	Logit	1.094	0.610	1.963

Total Sample Size=71

Table 5. Comparison of Means between Different Decision Paths

General Linear Models Procedure

Class Level Information
Class Levels Values

PATH 20 P1234 P1243 P1324 P1342 P1423 P1432 P2143 P2314 P2341 P3124 P3142 P3214 P3241 P3412 P3421 P4123 P4132 P4231 P4312 P4321

Number of observations in data set=71

Tukey's Studentized Range [HSD] Test for variable : SCORE
Alpha=0.05 df=51 MSE=0.170868
Critical Value of Studentized Range=5.282
Minimum Significant Difference=1.449
Harmonic Mean of cell sizes=2.270782

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	PATH
A	1.0000	2	P3421
A	1.0000	1	P4123
A	0.7500	8	P1243
A	0.6667	9	P1234
A	0.6429	14	P2143
A	0.5000	2	P1342
A	0.5000	4	P1423
A	0.5000	2	P4321
A	0.0000	2	P2341
A	0.0000	2	P1432
A	0.0000	2	P1324
A	0.0000	4	P3124
A	0.0000	2	P3241
A	0.0000	2	P3412
A	0.0000	2	P3142
A	0.0000	4	P2314
A	0.0000	4	P4132
A	0.0000	1	P4231
A	0.0000	2	P4312
A	0.0000	2	P3214

In an extended analysis, the general linear model procedure was used to determine whether a unique decision path is significantly related to better quality of decisions. However, any pairwise comparison of means among different paths did not secure high enough F value to indicate the significant difference.

Another problem with this analysis is found when the mean values are compared to each other. The magnitude of means in this analysis does not indicate the magnitude of the efficacy of corresponding decision paths. For example, a mean value of 1.0 for decision path P3421 does not mean that it is twice as good as decision path P1423 with mean value of 0.5. Neither is it clear that decision paths with higher mean values are more desirable than those with lower mean values.

Table 5 summarizes the results of the general linear model procedure.

Discussion

The present analysis sought to determine whether the normative decision process is supported empirically. In other words, do the results of the present analysis suggest that there is a significant relationship between the manner in which a group discussion develops over time and the quality of the group solution [or decision] that results from that discussion? The answer is no according to the results of this study. However, it was found that groups starting with "problem analysis" are 1.88 times more likely to come up with better decisions. Thus first hypothesis is supported.

This observed difference between the sequences of interaction displayed by the groups in this study appears to provide partial evidence that the manner in which a group approaches its problem may have important implications for that group's ability to come up with a viable solution. In the context of this study, it can be argued that when groups are presented with an unfamiliar problem and are required to produce a solution within a limited amount of time (e.g., 50 minutes), "successful" decision making requires that the group make the most of the time available to them. This effective and efficient use of time necessitates that group members possess a clear understanding of the problem before attempting to solve it. Quite simply, if a group does not fully understand the problem before attempting to solve it, group members may waste valuable time discussing possible solutions which, given a better understanding of the problem, should have been quickly dismissed. Under limited time constraints, such wasted effort is likely to result in an insufficient amount of time for the group to develop a viable solution. Thus, it is possible that the "successful" groups arrived at a higher-quality solution than their unsuccessful counterparts because they possessed a better understanding of the problem before attempting to solve it.

The present analysis suggests that there is no significant difference in terms of the quality of decision between the groups on the basis of whether they "generate alternatives" in their middle periods or not. Thus the second hypotheses was not supported with the data collected from this experiment.

Although no significant difference was found among all the different decision paths in Table 5, it can be noted that the three paths with the greatest frequencies (P1243, P1234, and P2143) allows us to speculate that "problem analysis" and "evaluation criteria" performed in the first half of the decision process and "alter-native generation" and "evaluation of those alternatives" performed in the second half are more desirable timing for a group decision-making session.

P1243 and P2143 of the three paths have "evaluation" ahead of "alternative generation". It is not awkward, however, if considering the situation where the "evaluation" function is an aggregation of "evaluation confirmation", "evaluating both positive and negative qualities of alternatives." For example, there could possibly be more "evaluating qualities" preceding "generating alternatives" to reinforce the alternative which had been initially proposed. A sample of six consecutive messages [msg1 through msg6] with corresponding categories are listed in order to illustrate this situation :

msg1 : alternative 1 (A)
msg2 : evaluating positive qualities (EPOS)
msg3 : modification of alternative 1 (A)
msg4 : criteria in critical work (C)
msg6 : evaluating positive qualities (EPOS)
msg5 : modification of alternative 2 (A)

In this particular sequence of messages, "evaluating" preceded "alternative" twice while "alternative" preceded "evaluation" just once. Again, this suggests a need for an analysis of the dynamic communication behavior in which direct observation of the transition of those functions or phases is involved. Insofar as the study found no sequence (or sequences) of phases that was uniquely associated with higher quality of decision, it seems safe to conclude that the performance of the groups cannot be easily distinguished solely on the basis of the sequence of decision phases that characterized their problem—solving discussion.

The results of the present analysis become more meaningful when viewed in the context of recent findings by several researchers [Hirokawa, 1983b ; Mintzberg et al., 1976 ; Poole & Doelger, 1988]. That is to say, each of those studies, like the present investigation, discovered that there is no single "path" [or sequence of interaction phases] that necessarily leads to "successful" or "unsuccessful" group decision making. On the contrary, there appears to be a number of different "paths" that a group could take that might lead them to either a "high" or "low" quality group decision. No one "path" is necessarily superior or inferior to any other in terms of its ability to facilitate [or impede] successful group decision making.

The notion of normative process implies a trade—off, that is, the avoidance of delay and redundancy at the expense of creativity and group cohesiveness. Fisher and Ellis [1990, p. 142] offered a caveat, saying "All groups should examine their composition, resources, time, energy, commitment, goals, and problems before deciding on a particular approach."

In this regard, it would appear necessary to alter the direction of research attempting to understand the relationship between group discussion development and group decision—making performance. This means that researchers need to redirect their efforts to examine how groups "adjust" their discussion to overcome certain barriers and constraints they may encounter during the decision—making process. This is consistent with the position that the comprehensive Input—Process—Output research model takes.

The next analysis approaches the problem in a slightly different way. It focuses on the micro—level pattern of interaction which is regarded as relatively free from a pre—imposed macro—level structure like the notion of normative decision process just mentioned.

Ⅵ. CONCLUSION

The present study partly replicates the previous studies conducted in a face—to—face setting to determine the relationship between interaction process and the outcome of group decision making. Specifically, the first and second research questions fall into this category. This is the first study in which a GDSS was used as a communication channel to confirm the previous research findings. Therefore, implications must be drawn cautiously, and it is only with an accumulation of knowledge in this area that any degree of firmness can be applied to the implications.

There are some more limitations that also bound the interpretation of the results of this study. These include a set of assumptions that this study is based on, theoretical rationale for the research framework, and the experimental settings to obtain empirical data.

Given these limitations, conclusions of this study are stated as follows :

The process—output relationship of a comprehensive input—process—output research model was investigated. The results of an experimental situation reveal that there exists significant relationships between the process and output variables. More specifically, statistically significant relationships were detected between the quality of group decision and the process variables such as decision function and contingent phase. It thus confirms the functional perspective that contends that the quality of decision is closely related to performance of certain decision functions by a decision group.

However, the results of the simulation do not reveal any significant relationship between the quality of decision and the decision paths. Thus, the normative theories of group decision making do not hold for this study.

As the first experimental study of process—output model in GDSS settings, this study provides some ideas for future study rather than concrete proposals for the practical application of the results. In future studies, it is recommended that some causal models be developed and tested in an input—process—output research framework. The methodology of interaction analysis employed in this study turned out to be rigorous enough to be used in follow—up studies.

The final recommendation relates to the use of an ontological approach to GDSS design. Conventional approaches under the prevailing cognitive paradigm sould attempt to devise artificial and prescriptive structures and impose them on the human interaction process. Consequently, it might well hinder the natural and creative flow of human exchange in group decision making. Instead, it is recommended that future GDSS designers pay attention to the distinct patterns of group interaction such as those identified in this study. These distinctions can be incorporated into GDSS to "facilitate" human interaction process.

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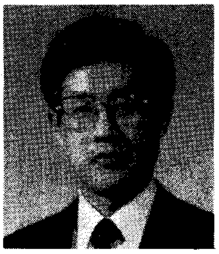
◇ 저자소개 ◇



저자 김재전은 현재 전남대학교 경영학과 부교수로 재직중이다. 그는 고려대학교 경영학과를 졸업하고 Arizona State University에서 경영정보시스템 전공으로 경영학 박사학위를 받았다. 한국 IBM에서 영업대표로 근무한 적이 있다. 주요 관심분야는 의사결정지원시스템, 그룹웨어, 정보기술을 기반으로 한 경영혁신, 초고속 정보망 응용서비스, 지역정보화 추진전략 등이다.