Available online at www.sciencedirect.com
SCIENCE DIRECT®
Decision Support Systems 37 (2004) 239–263
Decision Support Systems
www.elsevier.com/locate/dsw

An analysis of communication mode in group support systems research

Jerry Fjermestad*

Information Systems Department, School of Management, New Jersey Institute of Technology, Newark, NJ 01702, USA

Received 1 August 2000; accepted 1 January 2003

Available online 6 March 2003

Abstract

Group support systems (GSS) have been the subject of many investigations and meta-analyses over the past decade. This study presents, summarizes, and analyzes the results of 145 experiments that used communication mode as an independent variable. The results show that the modal outcome for GSSs compared to Face-to-Face (FtF) methods is "no difference," while the overall percentage of positive effects for results that compare GSS to FtF is 29.2%. The results suggest that the use of a GSS improves decision quality, depth of analysis, equality of participation, and satisfaction over manual methods. Additionally, more detailed analysis suggests that task type, GSS type and the interaction of both have a moderating effect on adaptation and outcome factors. Specifically, groups working on idea generation tasks using GSS decision room technology improve to 39.6% (GSS>FtF) effect. Conversely, asynchronous computer-mediated communication (CMC) groups working on decision making tasks improved to 46.4% (GSS>FtF) effect. FtF groups show higher levels of consensus and perceived quality, communicate more, and are more efficient (requiring less time to complete the tasks). No differences are observed between FtF and GSS groups on satisfaction and usability.

Keywords: Group decision support systems; Categorical assessment; Experimental analysis

1. Introduction

Group support systems (GSS) have been studied for over a quarter century via case studies, surveys, and experiments. More than 90% of the experimental studies have been conducted since 1990. There have been several assessments of the empirical results. What have we learned from these studies? What variables are important in determining whether GSS improves or harms the process and outcomes of group decision making?

In a previous paper, Fjermestad and Hiltz [7] presented a description and an analysis of all the independent variables in 200 experiments on GSS, published in journal articles or conference proceedings to that date. This study is a subset and more detailed analysis of the data collected and stored in the data bases described in that paper, as it were a "drill down" through the data and focuses on only one independent variable—communication mode. Since the Fjermestad and Hiltz [7] study was published, 38 additional papers have identified and

* Tel.: +1-973-596-3255; fax: +1-973-596-3074.
E-mail address: fjermestad@adm.njit.edu (J. Fjermestad).

0167-9236/$ - see front matter © 2003 Elsevier B.V. All rights reserved.
doi:10.1016/S0167-9236(03)00021-6

coded, thus bringing the total to 238 experiments. Thus, the objective of this paper is to provide the group support system researcher and manager with an updated assessment of empirical results for communication mode. To do this, the results of 238 published GSS experiments have been reviewed and 145 experiments from 137 published papers listed in Appendix A (there were eight papers with multiple experiments), which compared Face-to-Face (FtF) communication mode to a mode employing a GSS, are being reported on. (The remaining experiments compared different modes or conditions of use of GSS to one another, e.g., varying the presence or absence of various tools or procedures, or varying group size or composition.) There were then a total of 705 measures (results) of effects of the independent variable (communications mode: GSS vs. Face-to-Face communication) on various dependent variables.

This paper is not a meta-analysis. A meta-analysis works with percent of variance explained. Unfortunately this statistic is not reported in a large number of published studies. For this assessment, we strove to include all experimental results, even those that employed non-parametric tests. It is a categorical assessment of the variables (independent, dependent, control, and intervening). As such, the analysis shows the interrelationships between the variables and this is the paper's major contribution.

In this paper, we will first briefly describe the methods of classification of communication modes that have been contrasted in laboratory studies of group support systems, and the classification of outcomes. Next, we will look at whether the type of GSS seems to make any difference on outcomes, and also at the distributions of results for all GSS modes combined, compared to the non-supported FtF mode, for the major categories of dependent variables that have been studied. Then, we will drill down one more level and determine if task type has any moderating effects on outcomes. It has been hypothesized that information technology (IT) before the digital economy era and IT after the digital economy era is significantly different. In order to test this hypothesis, we will analyze the journal and conference proceedings by publication year. Finally, we will make recommendations for future research.

1.1. The framework—categorizing the variables

In order to assess the effects of the independent variable, communication mode, outcomes of group interaction were categorized following the framework developed by Fjermestad [6]. Briefly, the complete framework (Table 1) consists of four categories of variables: contextual or independent variables; intervening variables; group adaptation process; and outcomes. Independent variables include characteristics of the particular technology (GSS) being used, of the group, and the task, environmental and organizational contexts. Intervening variables refer to meeting characteristics such as session length, number of sessions, and presence and role of a facilitator, which can change from session to session. The adaptation (adaptive structuration) or interaction process of the group includes such things as their level of effort, their attitude toward the GSS, and participation patterns. They are the variables that are controlled by the group on an individual or collective basis.

Outcomes are the result of the interplay of the intervening factors and adaptation of the group with the contextual factors. These results or dependent variables include efficiency measures (e.g., calendar time to decision), effectiveness measures (e.g., decision quality), usability of the system and methods used, and subjective satisfaction measures.

1.2. Defining communication mode

Communication mode is defined as the medium or media of communication used by the group. The various levels of these independent variables used by the authors of the studies, and counts of each instance which, were used in the 145 experiments, are shown in Table 2. From inspection of this table, it is possible to see that there have been many different forms of the independent variable communication mode used in GSS research. The two most frequent modes were GSS vs. FtF and CMC vs. FtF representing 32.2% and 24.3% of the instances, respectively.

Table 3 shows a re-coding of these 49 independent variables into eight categories of communication modes. The most frequently employed mode in GSS experiments is synchronous (decision room) studies, or group decision support systems (GDSS), in which group members are gathered at the same time and

Table 1
Theoretical framework for analyzing group support systems

INPUT	PROCESS		OUTPUT
CONTEXTUAL FACTORS	INTERVENING FACTORS	ADAPTATION FACTORS	OUTCOME FACTORS
TECHNOLOGY: . Task Support (Tools): Agenda, electronic brain storming, voting, cognitive feedback, etc. . Process Structures: Anonymity, time, proximity, settings, procedures, control & structure; e.g. sequential Vs parallel process; levels 1, 2, and or 3, structural features-restrictiveness, comprehensiveness, agenda setting NGT, DI, DA, facilitator, chauffeur, moderator. . Communications Mode: FtF, CMC, GSS, DSS, text, graphics, voice, image, sound, and video. . Design: Room configuration, interface, embeddability, extensibility, flexibility, functionality & usability. GROUP: . Group characteristics: Size and salience, ad-hoc, established. . Composition: Heterogeneity, organizational & job tenure, shared norms, member status, history & experience, subject type (student, MBA, professional, etc.). . Leadership: Formal leadership, style, attitude, skills, power, and organizational position. . Member characteristics: Attitudes, values, power, personal beliefs, age, sex, preferences, self confidence, skills demographics, personality traits, initial quality, & experience (systems & tasks). . Meeting structure: Clarity of objective, specific work norms. . Initial levels: Cohesiveness, task understanding, consensus, and agreement. . Group Structures: Styles of interacting, knowledge & experience with structures, perceptions of others knowledge. TASK: . Type: Generate, choose, negotiate, and execute; gain/loss . Characteristics: . Structure: Structured to unstructured . Equivocality: High to low . Analyzability: High to low . Complexity: High to low . Importance: High to low . Enjoy ability: High to low . Predictability: High to low . Source: Internal to external . Degree of task knowledge . Degree of agreement on values CONTEXT: . Environment: Competition, uncertainty, time pressure, evaluative tone. . Organizational: Information system, age, goals, reward structure, organizational size, etc. . Cultural: American, British, Chinese, Hawaiian, Singaporian, etc.	METHODS: . Experimental design . Task implementation . Session length . Number of sessions . Order (order of treatment or task) . Training: technology, group process and task SUMMARY VARIABLES RESULTANT COMMUNICATION DIMENSIONS: . Bandwidth . Media richness . Social presence GROUP MEMBER PERCEPTION & PROBLEM SOLVING: . Nature and utilization of task performance strategies . Level and utilization of member knowledge & skill . Level & coordination of member effort . Task: importance,visibility, understanding, & commitment . Individual: values, personal needs, level of interest, and degree of frustration . Psychological differences . Biases ORGANIZING CONCEPTS: . Information processing systems . Consensus generating systems . Behavior motivation & regulation OPERATING CONDITIONS . Modalities available . Changes in task, rewards, norms & division of labor Shaded Areas are the areas presented in this paper. Adapted from Fjermestad, 1998 and Fjermestad and Hiltz, 1997	GROUP ADAPTATION PROCESS: Structuration . Social technology . Structural features . General spirit . Faithful/Ironic . Rules, resources- use, attitude, control, and consensus . Comfort, respect Process Variables . Participation . Consensus generating . Normative regulation . Effectiveness . Level of effort Process Issues . Diffusion of responsibility . Deindividuation . Pressure to consensus . Coordination PROCESS GAINS/LOSSES: Process Gains . Synergy, learning . Clarity, Choice shift Process Losses . Free riding . Evaluation apprehension . Attenuation blocking . Information overload . Flaming . Dominance INTERMEDIATE ROLE OUTCOMES . Role assumption by technology . Actual roles of participants Task-related & group-building: recorder, gatekeeper, follower, information/opinion seeker, information/opinion giver, proceduralist, motivator, explainer, evaluator . Values	CONSENSUS: . Decision agreement . Commitment EFFICIENCY MEASURES: . Decision time . Number of decision cycles . Time spent in activities . Time spent waiting for responses . Time to consensus EFFECTIVENESS MEASURES: . Communication . Number of comments . Idea Quality . Decision quality . Decision confidence . Process quality . Creativity/Innovation . Level of understanding . Task Focus . Depth of Evaluation . Commitment to results SATISFACTION MEASURES: . Participation . Cohesiveness . Conflict management . Influence . Confidence . Attitude . General satisfaction . Decision Satisfaction USABILITY MEASURES: . Learning time . Willingness to work together again . System utilization . Number of errors . Design Preference

Table 2
Author-defined independent variables—levels

Independent variable—levels	Count	Independent variable—levels	Count
Anonymous-GSS, GSS, FtF, Nominal	8	FtF, GSS-Level 1, GSS-Level 2	9
Anonymous-GSS, Identified-GSS	8	FtF, GSS-Decision Room, GSS-Distributed	3
Anonymous-GSS, Identified-GSS, FtF	6	FtF, GSS-Synch, GSS-Staggered Synch	2
CMC, Audio/Video	6	FtF, Synch-CMC, Asynch-CMC, Combined	4
CMC, Telephone, CMC-signals	4	FtF, Telephone, CMC	3
EBS, Nominal	7	FtF, Telephone, Videophone, CMC	12
EMS, Manual, Baseline	4	FtF, Web-Asynchronous	5
FtF, CMC	171	FtF, Web-Asynch, Combined (FtF and Web-Asynch)	2
FtF, CMC, Anonymous-CMC	6	FtF-F, GSS-F; F-Facilitation	3
FtF, CMC, Audio, Video	6	FtF-GSS, Distributed-GSS	21
FtF, CMC, CMC + Phone	5	FtF-GSS, Dist-GSS, Asynch-GSS	9
FtF, CMC, CMC-PenNames	4	FtF-US, FtF-S, CMC, Email	2
FtF, CMC, Teleconferencing	10	FtF, Anonymous-CMC, Identified-CMC	16
FtF, CMC-I, CMC-A, CMC-M	5	GSS, CMC	4
FtF, CMC/FtF, FtF/CMC, CMC	3	GSS, FtF with Moderator	13
FtF, DSS	14	GSS, FtF; Co-variates—List: Used, Unused, Shared, Unshared	1
FtF, E-Nominal, A-GSS, I-GSS	2	GSS, Manual (FtF-P), Baseline (FtF)	18
FtF, EBB Level 1, EWS Level 2	5	GSS, Manual, Baseline	11
FtF, EBS	23	GSS, Nominal	5
FtF, EBS, Delayed-EBS	2	GSS, Structured-FtF (FtF-P), FtF	3
FtF, Electronic Blackboard (EBB) Level 1, Electronic Workstation (EWS) Level 2	4	GSS-FtF, GSS-Synch, GSS-semi-Asynch	4
FtF, FtF-NGT, CC-Asynch, CC-NGT	4	GSS-Voting, FtF-voting	3
FtF, GSS	227	ShrEdit + Audio, ShrEdit + Video	2
FtF, GSS, Dist-GSS	9	Video-Conferencing, Audio-Conferencing	3
FtF, GSS, Individually	5		
Total count	**705**		

Asynch: Asynchronous
Baseline:
CC: Computer Conferencing
CMC: Computer-mediated communication
CMC-I: Computer-mediated Identified
CMC-A: Computer-mediated Anonymous
CMC-M: Computer-mediated Mislabeled
Dist: Distributed
EBS: Electronic Brainstorming
EMS: Electronic Meeting System
EWS: Electronic Work Station
FtF: Face-to-Face
FtF-P: Face-to-Face with process
NGT: Nominal Group Technique
Nominal:
ShrEdit:
Synch:Synchronous

place (generally, each with their own computer, though a few studies employed a decision support system (DSS) at a single computer, with group members gathered around it). In the decision room GSS mode, group members are able to combine communication via the computer system, and "face-to-face" mode, including non-verbal communication. 49.2% (347/705) of all the results compared GSS to FtF modes, contrasted the decision room GSS with face-to-face mode without computer support.

A second, "distributed" mode of GSS (the next two rows in Table 3) is same time/different place mode in which audio and/or video links may be used in addition to the GSS to tie together participants distributed in two or more locations. 10.9% of the results have contrasted distributed GSS, alone or in combination with GSS in a single decision room, with FtF modes.

All of these systems labeled "GSS," which account for 62% (437/705) of the results, are primarily decision support rather than communication support systems; they have features such as voting and statistical displays, and presume that at least some of the communication will be conducted via other media. Distinctions have been made in the literature about the

Table 3
Categorized independent variables

GSS communication mode	Count	CMC communication mode	Count
GSS Decision Room	347	CMC Synchronous—Level 0	10
GSS Distributed	14	CMC Synchronous	32
GSS Synchronous DR/Dist	63	CMC Asynchronous	47
GSS Synchronous/Asynchronous	13	CMC Distributed	179
Total GSS	**437**	**Total CMC**	**268**
Total Count	**705**		

Communication mode from Table 2
GSS Decision Room = same place, same time; synchronous
GSS Distributed = different places, same time; synchronous
GSS Synch DR/Dist = studies comparing decision room vs. distributed; synchronous
GSS Synch/Asynch = studies comparing synchronous/asynchronous decision room and distributed
GSS Combined = GSS Decision room, GSS Distributed, and GSS Synch/Asynch categories
CMC synch level 0 = very small scrolling window; synchronous
CMC synch = computer-mediated communication, same time, same place; synchronous
CMC asynch = computer-mediated communication, different places, different times; asynchronous
CMC Distributed = computer-mediated communication studies comparing either decision room to distributed or face-to-face to distributed, same time, different place
CMC Combined = CMC Synchronous, Asynchronous, and CMC Distributed categories

degree of sophistication of the decision support features, e.g., "level 1" vs. "level 2" systems [3], but since many publications lack sufficient detail about system characteristics to reliably make this distinction, all GSS type systems have been put in the same categories.

A different type of GSS that has been used in many studies is computer-mediated communication (CMC) systems, sometimes called "GCSS," or group communication support systems [16,17]. CMC systems, which include computer conferencing, email, and "chat" systems, are primarily oriented towards text-based communication, though some also include decision support tools and/or digitized graphics. These systems may be used synchronously (same time, generally different place) or asynchronously (anytime/anyplace). They restrict the participants to communication via computer only. In looking at the synchronous CMC systems, they differ greatly in features and screen layout. The CMC systems account for 38% (268/705) of the results. Despite the explosive growth of asynchronous CMC for group communication using the Internet, only 6.7% (47/705) of all the experimental results have focused on comparing this type of communication to traditional FtF group interaction.

2. Method

Based upon Fjermestad and Hiltz's [7] GSS assessment and the recent additions, there were 238 candidate experiments. The results of some studies were presented in more than one paper or conference proceeding and a paper; if the design of the study and description of the methodology, subjects and task were the same, the different papers were determined to be on the same study. In other words, the results from a study are only counted once no matter how many publications were derived from the same experiment.

All the experiments were categorized according to Fjermestad's [6] framework (Table 1) and then entered into a database as follows [9]:

- Experiments by author: a super key consisting of an author number and experiment number.
- Design: experimental design type (i.e., 2×1).
- Independent Category: independent variables grouped into seven categories (context; group; method; process structure; task; task support; and technology).
- Independent variables: using the name employed by different authors yields 38 independent variables.
- Dependent Category: represents 12 categories of dependent variables (consensus; effectiveness; efficiency; process gain, loss, and variables; roles; satisfaction; structuration; and usability).
- Dependent variables: representing 295 dependent variables, before combining similar variables into categories.
- Effect: four categories of results (0—no effects; 1—GSS>FtF; 2—FtF>GSS; 3—no main effects (no results were collected for a particular independent variable); 4—other effects and interaction effects.
- Outcome: represents 141 different outcomes from the experiments.

For the purposes of this paper, the databases were joined to form one database consisting of 1891 independent–dependent variable pairings. Then, a query was created to select only those parings, which had the independent variable "communication mode." The results yielded 705 pairings representing 145 experiments from 137 papers.

3. Results

Following from the basic framework developed by Fjermestad and Hiltz [7], we have organized the dependent variables categories as shown in Tables 4 and 5. Table 6 summarizes the results by dependent variable category and shows the percentages of results by effect (no effect—GSS = FtF, GSS>FtF, and FtF>GSS).

The unit of analysis is the results, as follows (these are also the column headings for Tables 6–10):

- Total: the total count of the results;
- GSS = FtF: the number instances where there were no significant differences between the treatment conditions;
- GSS>FtF: the number of instances where the GSS results were significantly better than FtF results, at the 0.05 level or better;
- FtF>GSS: the number of instances where the FtF results were significantly better than GSS at the 0.05, or better;
- No main effects: the number of instances where no main effects were measured or reported;
- Other effects and interactions: the number of instances for which relationships other than contrasts between FtF and GSS groups were tested;
- % GSS = FtF: Ratio: GSS = FtF/(Total − (No main effects + Other effects and interactions));
- % GSS>FtF: Ratio: GSS>FtF/(Total − (No main effects + Other effects and interactions));
- % FtF>GSS: Ratio: FtF>GSS/(Total − (No main effects + Other effects and interactions)).

3.1. Adaptation factors: counts of measures

Table 4 shows the total number of results in all GSS experiments that examined each of the types of variables classified as "adaptation factors." According to the Adaptive Structuration Theory [4,5,18–20], group outcomes are not determined by the effects of single elements (such as technology and task characteristics), but by a complex and continuous process in which those elements are appropriated by the group. These factors have been relatively ignored in GSS experiments; only recently have they been treated in a number of studies. The four dimensions of the construct have to do with how the system is transformed into rules of interaction and resources that are actually used: level of use, attitudes toward the GSS, level of consensus, and level of control. Structuration variables have been studied in only 21 instances; attitude toward the system and degree of comfort with it, account for eight of these results, with the other dimensions looked at very infrequently. The process variables have been examined 80 times. The most frequently studied ones are effects on participation equality and general influence (20 and 23 times, respectively). Process issues have only been studied 24 times.

Experimenters have been relatively optimistic about how GSS would affect process: they have studied process gains more frequently (58 instances) than process losses (34). Within the category of process gains, the most frequently studied phenomena have been effects on choice shifts (also called "risky shift" studies, because of the generally observed tendency for groups to make more risky decisions than individuals), with 10 instances. The results for tendency of GSS to increase the number of critical comments made by group members has been tested in only five occasions. The most frequently studied process losses are evaluation apprehension, flaming, and production blocking, with 10, 5, and 7 instances reported, respectively.

Intermediate role outcomes is a relatively new category set of dependent measures [23] and has been studied in 14 instances. Leadership and leadership issues have been studied surprisingly in only seven occurrences.

3.2. Outcome factors: counts of measures

Table 5 shows the total number of results reported in all the GSS experiments that examined each of the types of variables classified as "outcome factors." Of all the dependent variables studied, it is

Table 4
Factors model: adaptation factors (counts of the dependent variable)

Group Adaptation Process Measures- 125		
Structuration- 21	**Process Variables- 80**	**Process Issues- 24**
Attitude……..…3 Challenge.....……1 Comfort.....…8 Control.....……2 Other……..6 Decision-Phases.....……1	Composing & Editing.....1 Task Behaviors.……3 Influence (General).....23 Group Behaviors.……7 Influence Equality.....4 Level of Effort.....……6 Influence Peer Related…2 Social-Emotional……3 Influence Self Rated.....2 Perceived……6 Participation Equality...20 Influence-First Advocacy...3	Avoidance.....…….....2 Coordination.....……1 Deindividuation.....……..2 Social Preference.....……1 Social Information.....……..5 Social Pressure.....2 Constructive/Destructive…..1 Social Presence.....6 Cooperative……4
Process Gains/Losses Measures- 92		**Intermediate Role Outcomes- 14**
Process Gains- 58	**Process Losses- 34**	**Roles- 14**
Communication .General……9 Critical Comments.....……5 Synergy.....……1 Change in Understanding……..……3 Choice Shift.....……..……..……10 Information Exchange..……5 Information Credibility…….……2 Information Sharing..……..……..……5 Information Learned.....……..……9 Common Information.....……..……4 Idea Sharing……2 Information Other……..……3	Production Blocking.....…….……7 Disinhibition.....……..2 Dominance.....……..3 Evaluation Apprehension.....……10 Flaming.....……..……5 Free Riding.....……..4 Other……3	Leadership.....……..7 Status Influence.....……3 Task Orientation.....……..3 Idea Giving……1

Table 5
Factors model: outcome factors (counts of the dependent variable)

CONSENSUS Measures-29	**EFFICIENCY Measures-49**	**USABILITY Measures- 8**	**SATISFACTION Measures- 126**
Consensus.....10 Consensus Change.....7 Post-Meeting Consensus.....5 Pre-Meeting Consensus.....3 Residual Disagreement.....2 Perceived Consensus.....1 Polarization.....1	Consensus Time..... 2 Decision Cycles..... 5 Decision Time..... 40 Perceived Time..... 1 Perceived Efficiency..... 1	Design Preference.....1 Ease of Use.....2 Interface.....3 System Satisfaction.....2	**Satisfaction- 96** General Satisfaction..... 24 Satisfaction Other..... 12 Decision Satisfaction..... 20 Decision Scheme.....2 Process Satisfaction..... 37 Design Satisfaction..... 1
EFFECTIVENESS Measures- 259			
Decision quality- 105 Decision Quality.....47 Idea Quality.....5 Deviation.....2 Quality.....13 Discussion.....3 Design Quality....3 Effectiveness.....3 Meeting Quality..1 Other.....11 Creativity.....4 Judgment Accuracy.....1 Performance.....10 Comprehensiveness....2	**Communication- 67** Communication.....13 Number Comments.....20 Arguments.....6 Percent.....2 Question.....3 Supportive .....2 Unique.....2 Other.....5 **Productivity- 64** Number-Alternatives. .....11 Number Unique Ideas.....15 Depth of Evaluation.....2 Number Ideas .....23 Other .....6 Productivity.....5 Number Errors.....2	**Perceived- 23** Decision Confidence.....12 Task Focus.....5 Perceived Quality.....3 Perceived Effectiveness.....1 Perceived Performance.....2	**Conflict Management- 23** Cohesiveness..... 12 Commitment.....2 Conflict Management.....5 Conflict Other.....4 **Participation -7** Perceived Participation.....6 Perceived Preference..... 1

natural that various aspects of group effectiveness have received the most attention (55% of 471 total outcome factor measures). Aspects of decision quality, such as overall quality, idea quality, etc., have most frequently been measured (105 times). Surprisingly, creativity (creativity is measured differently in contrast to counting the number of ideas generated (see Ref. [15]) as an aspect of the quality of the group product has been studied very little, with only two instances. Productivity (64 measures) has often been measured in terms of the numbers of ideas, alternatives, or unique ideas. Communication measures have been studied in 67 instances, of which the number of comments has been investigated the most with 20 instances. Various dimensions of subjective satisfaction are next most studied after effectiveness (126 times, or 26.8% of the results), including process satisfaction, decision satisfaction, general satisfaction, etc. Of the remaining outcome variables, efficiency (49 instances) is most often measured in terms of decision time, which accounts for 40 results, alone. Consensus has been studied much less frequently (29 times) than effectiveness or satisfaction. Finally, system usability (8 occurrences) as an outcome has been measured in a variety of ways.

3.3. Results of results comparing communication modes on dependent variables

Table 6 shows the FtF vs. GSS assessment results (GSS = FtF or GSS>FtF or FtF>GSS or No main effects or Other effects and interactions) for the independent variable communication mode on the dependent variables grouped by category. Aggregating all of the dependent variables yields 39.4% of results with no effects (239 out of 705). This represents the modal effect of "no significant differences" between GSS technology and Face-to-Face (shown in the totals section). The "% GSS>FtF " effects are slightly lower than the "% FtF>GSS" effects, 29.2% vs. 31.5%, respectively.

Table 6
FtF vs. GSS assessment results: counts for all experiments on dependent variables

Dependent variables outcomes	Total	GSS>FtF	GSS = FtF	FtF>GSS	No main effects	Other effects and interactions	% GSS = FtF	% GSS>FtF	% FtF>GSS
Adaptation factors									
Structuration	21	7	4	4		6			
Process variables	80	20	31	25	3	1	40.8	26.3	32.9
Process issues	24	4	8	9		3			
Process gain	58	19	19	17	1	2	34.6	34.6	30.9
Process loss	34	13	12	9			35.2	38.4	26.4
Role outcomes	14	3	2	5	1	3			
Summary variables	3			2		1			
Total adaptation factors	234	66	76	71	5	16	35.7	31.0	33.3
Outcome factors									
Consensus	29	3	11	8	2	5			
Efficiency	49	11	4	29	2	3	8.9	24.4	64.4
Effectiveness									
Communication	67	16	17	24	3	7	29.8	28.1	42.1
Decision quality	105	28	46	17	3	11	50.5	30.8	18.7
Productivity	64	26	15	9	4	10	30.0	52.0	18.0
Perceived quality	23	2	11	7	1	2			
Effectiveness total	259	72	89	57	11	30	40.8	33.0	26.1
Satisfaction	126	24	54	25	7	16	52.4	23.3	24.2
Usability	8	1	5	1		1			
Total outcome factors	471	111	163	120	22	55	41.4	28.2	30.5
Grand totals	705	177	239	191	27	71	39.4	29.2	31.5

Percentages exclude no main effects and other effects and interactions (unit of measurement is a reported result).

3.3.1. Adaptation factors: counts of results (Table 6)

According to Nunamaker et al. [14], GSSs are generally intended specifically to increase process gains and decrease process losses. The results suggest GSS technology tends to have higher process gains than FtF methods, 34.6% vs. 30.9%, respectively. In addition, GSS technology tends to reduce process losses slightly better than FtF methods do 38.4% vs. 26.4%. Process variables and process issues were less likely with GSS, while structuration was more likely to occur in GSS than in FtF conditions (46.7% vs. 26.7%). The process variables account for the largest share (34.2% or 80/234) of the results concerning the adaptation factors and one third of the "GSS>FtF" results (20/66). From Table 4, it can be seen that participation equality accounts for 25.0% (20/80) of the process variable results and account for 40% of the "GSS>FtF" results (8/20). These results support the contention that use of a GSS improves equality of participation.

3.3.2. Outcome factors: counts of results (Table 6)

As with the adaptation factors, "no effect," which represents 41.4% of the outcomes, is the modal result for the outcome factors. The "GSS>FtF" results (111) is slightly less than the "FtF>GSS" effects (120). The overall percentages of results are 28.2% and 30.5%, respectively.

3.3.2.1. Consensus. For consensus, face-to-face groups typically outperformed GSS groups. The results yield 36.4%, compared to only 13.6% "GSS>FtF" results. It is obvious that the relative lack of ability to reach consensus is a problem for groups using GSS.

3.3.2.2. Efficiency. 24.4% of the efficiency measures yielded "GSS>FtF" results while 64.4% was "FtF>GSS" Use of GSS technology takes more time in comparison to face-to-face methods.

Table 7
Communication modes used in GSS experiments: counts of results comparing GSS to face-to-face. Percentages exclude no main effects and other effects and interactions (unit of measurement is a reported result)

Communication mode (GSS Type)	Total	GSS>FtF	GSS = FtF	FtF>GSS	No main effects	Other effects and interactions	% GSS = FtF	% GSS>FtF	% FtF>GSS
GSS Decision Room	347	105	130	61	22	29	43.9	35.5	20.6
GSS Distributed	14	3	1	10					
GSS Synch DR/Dist	63	8	22	15		18	48.9	17.8	33.3
GSS Synch/Asynch	13		7	2		4			
CMC Synch—Level 0	10	6		4					
CMC Synch	32	10	10	9		3	34.5	34.5	31.0
CMC Asynch	47	13	17	15	1	1	37.8	28.9	33.3
CMC Distributed	179	32	52	75	4	16	32.7	20.1	47.2
GSS Combined	437	116	160	88	22	51	44.0	31.9	24.2
CMC Combined	268	61	79	103	5	20	32.5	25.1	42.4
Totals	705	177	239	191	27	71	39.4	29.2	31.5

GSS Decision Room = same place, same time; synchronous
GSS Distributed = different places, same time; synchronous
GSS Synch DR/Dist = studies comparing decision room vs. distributed; synchronous
GSS Synch/Asynch = studies comparing synchronous/asynchronous decision room and distributed
GSS Combined = GSS Decision room, GSS Distributed, and GSS Synch/Asynch categories
CMC synch level 0 = very small scrolling window; synchronous
CMC synch = computer-mediated communication, same time, same place; synchronous
CMC asynch = computer-mediated communication, different places, different times; asynchronous
CMC Distributed = computer-mediated communication studies comparing either decision room to distributed or face-to-face to distributed, same time, different place
CMC Combined = CMC Synchronous, Asynchronous, and CMC Distributed categories

3.3.2.3. Effectiveness. Effectiveness measures account for 55% (259/471) of the outcome factors and has the highest "GSS>FtF" results at 33.0%. The effectiveness category consists of four sub-categories (communication, decision quality, productivity, and perceived quality), which are analyzed further.

Communication. Communication represents 14.2% of the effectiveness measures and accounts

Table 8
Counts of results comparing GSS type by task type. Percentages exclude no main effects and other effects and interactions (unit of measurement is a reported result)

GSS type	Task type	Total	GSS> FtF	GSS = FtF	FtF> GSS	No main effects	Other effects and interactions	% GSS = FtF	% GSS> FtF	% FtF> GSS
GSS Decision Room	Planning	7	2	1			4			
GSS Decision Room	Idea generation	127	44	51	16	5	11	45.9	39.6	14.4
GSS Decision Room	Intellective	69	18	25	26			36.2	24.6	39.1
GSS Decision Room	Decision making	135	34	52	18	17	14	50.0	32.7	17.3
GSS Decision Room	Cognitive	9	7	1	1					
GSS Distributed	Intellective	9	1	1	7					
GSS Distributed	Decision making	4	2		2					
GSS Distributed	Cognitive	1			1					
GSS Synch DR/Dist	Idea generation	15	4	8			3			
GSS Synch DR/Dist	Intellective	4	1		2		1			
GSS Synch DR/Dist	Decision making	30	3	11	13		3	40.7	11.1	48.1
GSS Synch DR/Dist	Cognitive	14		3			11			
GSS Synch/Asynch	Idea generation	13		7	2		4			
GSS Totals		437	116	160	88	22	51	44.0	31.9	24.2
CMC Synch Level 0	Decision making	10	6		4					
CMC Synch	Planning	3		1			2			
CMC Synch	Idea generation	5	3	2						
CMC Synch	Intellective	1					1			
CMC Synch	Decision making	23	7	7	9					
CMC Asynch	Intellective	12		5	7					
CMC Asynch	Decision making	30	13	11	4	1	1	39.3	46.4	14.3
CMC Asynch	Mixed task	5		1	4					
CMC Distributed	No task	4		4						
CMC Distributed	Idea generation	3	2				1			
CMC Distributed	Intellective	102	18	25	55	2	2	25.5	18.4	56.1
CMC Distributed	Decision making	39	8	11	7	2	11	42.3	30.8	7.7
CMC Distributed	Cognitive	24	2	11	9		2			
CMC Distributed	Mixed task	7	2	1	4					
CMC Totals		268	61	79	103	5	20	32.5	25.1	42.4
Totals		705	177	239	191	27	71	39.4	29.2	31.5

GSS Decision Room = same place, same time; synchronous
GSS Distributed = different places, same time; synchronous
GSS Synch DR/Dist = studies comparing decision room vs. distributed; synchronous
GSS Synch/Asynch = studies comparing synchronous/asynchronous decision room and distributed
GSS Combined = GSS Decision room, GSS Distributed, and GSS Synch/Asynch categories
CMC synch level 0 = very small scrolling window; synchronous
CMC synch = computer-mediated communication, same time, same place; synchronous
CMC asynch = computer-mediated communication, different places, different times; asynchronous
CMC Distributed = computer-mediated communication studies comparing either decision room to distributed or face-to-face to distributed, same time, different place
CMC Combined = CMC Synchronous, Asynchronous, and CMC Distributed categories

for more ''FtF>GSS'' results (42.1%) than "GSS>FtF" results (28.1%). This is somewhat surprising since communication is a necessary component for any improvements in effectiveness. However, since most of these studies were in a GSS decision room, the results suggest that it is still easier to communicate verbally than through the computer.

Decision quality. From Table 6, it is apparent that decision quality is the largest sub-category with a count of 105 instances. 30.8% instances had "GSS>FtF" results compared to 18.7% "FtF>GSS" results.

Productivity. "GSS>FtF" results occur in 52.0% of the productivity measures. Drilling further into the data (not shown), the dependent measures number of ideas and number of unique ideas account for 21 of the 26 "GSS>FtF" results. These results clearly show that the use of a GSS can improve the productivity of a group in comparison to face-to-face techniques.

Perceived quality. The perceived quality measures include decision confidence (12 measures), perceived quality and perceived task focus. 55% of the results were "no effects"; there were 10% "GSS>FtF" and 35% "FtF>GSS" effects.

3.3.2.4. Satisfaction. 52.4% of the satisfaction results were no effect (GSS = FtF) and the percentages were fairly equal for both GSS>FtF and FtF>GSS, at 23.3% and 24.2%, respectively. Further analysis (not shown in any table) reveals that both process satisfaction and general participant satisfaction had 26.7% (16) "GSS>FtF" effects. Decision satisfaction, on the other hand, accounted for only 23.5% (4) "GSS>FtF" results.

Table 9
Counts of results comparing GSS combined and CMC combined by task type

GSS type	Task type	Total	GSS> FtF	GSS = FtF	FtF> GSS	No main effects	Other effects and interactions	% GSS = FtF	% GSS> FtF	% FtF> GSS
GSS Combined	Planning	7	2	1			4			
GSS Combined	Idea generation	155	48	66	18	5	18	50.0	36.4	13.6
GSS Combined	Intellective	82	20	26	35		1	32.1	24.6	43.2
GSS Combined	Decision making	169	39	63	33	17	17	46.7	28.9	24.4
GSS Combined	cognitive	24	7	4	2		11			
GSS Combined total		437	112	160	92	22	51	44.0	30.8	25.3
CMC Combined	No task	4		4						
CMC Combined	Planning	3		1			2			
CMC Combined	Idea generation	8	5	2			1			
CMC Combined	Intellective	115	18	30	62	2	3	27.2	16.4	56.4
CMC Combined	Decision making	102	34	29	24	3	12	23.0	39.1	27.6
CMC Combined	Cognitive	24	2	11	9		2			
CMC Combined	Mixed task	12	2	2	8					
CMC Combined total		268	61	79	103	5	20	32.5	25.1	42.4
Totals		705	177	239	191	27	71	39.4	29.2	31.5

Percentages exclude no main effects and other effects and interactions (unit of measurement is a reported result).
GSS Decision Room = same place, same time; synchronous
GSS Distributed = different places, same time; synchronous
GSS Synch DR/Dist = studies comparing decision room vs. distributed; synchronous
GSS Synch/Asynch = studies comparing synchronous/asynchronous decision room and distributed
GSS Combined = GSS Decision room, GSS Distributed, and GSS Synch/Asynch categories
CMC synch level 0 = very small scrolling window; synchronous
CMC synch = computer-mediated communication, same time, same place; synchronous
CMC asynch = computer-mediated communication, different places, different times; asynchronous
CMC Distributed = computer-mediated communication studies comparing either decision room to distributed or face-to-face to distributed, same time, different place
CMC Combined = CMC Synchronous, Asynchronous, and CMC Distributed categories

3.3.2.5. Usability. It is too early to any meaningful analysis on usability measures in GSS research since it has only been used as a dependent measure in eight instances.

3.4. Comparisons among GSS communication modes (Table 7)

The results clearly show that positive results for GSS vs. FtF have occurred in only 29.2% of the instances (177 out of 705, not counting no measures and other effects). Table 7 shows the results by the specific type of GSS communication mode, using all dependent variables. The results, in general, show that there no real difference between GSS (GSS Combined) and CMC systems (CMC Combined), they have the same "GSS>FtF" effects at 31.9% and 25.1%, respectively. Also, there appears to be no substantial differences among the GSS decision room systems, the synchronous CMC systems, or the asynchronous CMC systems.

Surprisingly, the relatively "poverty stricken" CMC systems [12,21] that we have labeled as "level 0," (level 0 added to DeSanctis and Gallupe's [3] model) because they are restricted to the synchronous exchange of only a line or a few lines of communication, can be relatively effective for preference tasks in which the objective is to reach consensus. Though there are only a few studies on which the data in Table 8 are based, this result has been confirmed in a recent dissertation by Whitworth et al. [22], who restricted his groups to the exchange of numbers related to voting, without any text communication. If a group is motivated to reach consensus, perhaps a "rich" communication medium merely distracts them from this objective. If there is normative pressure to reach agreement, mere awareness of the positions of others is sufficient to generate agreement, without any discussion or any form of social–emotional interaction. These and some of the other results of this summary of findings cry out for a theory of GSS robust enough to explain why some of these results are occurring. Future research should not treat media as "black boxes," but needs to be designed to test alternative explanations of why observed differences (or non-differences) are occurring.

Table 10
Counts of results of journal and conference proceedings by publication year

Year	Total	GSS>FtF	GSS = FtF	FtF>GSS	No main effect	Other effects and interactions	% GSS = FtF	% GSS>FtF	% FtF>GSS
1970	2		1	1					
1981	9	7	1	1					
1982	1			1					
1986	13	5	2	6					
1987	4	4	4	2					
1988	29	9	9	7	1	3	34.6	34.6	26.9
1989	12		11	1					
1990	41	4	23	9		5	67.8	11.1	25.0
1991	47	7	26	10		4	60.5	16.3	23.2
1992	46	18	18	9		1	40.0	40.0	20.0
1993	45	13	12	11	4	5	37.3	36.1	30.6
1994	106	25	35	25	7	14	41.1	29.1	29.4
1995	57	19	26	11		1	46.4	33.9	19.6
1996	67	13	20	32	2		30.8	20.0	49.2
1997	79	16	18	25	12	6	29.5	26.2	41.0
1998	65	20	15	17	1	12	28.8	38.4	32.7
1999	79	16	22	21		20	37.2	27.1	35.6
2000	3	1		2					
1970–1995	412	111	164	94	12	33	44.7	30.2	25.6
1996–2000	293	66	75	97	15	38	31.3	27.5	40.4
TOTALS	705	177	239	191	27	71	39.4	29.2	31.5

Percentages exclude no measures and other effects (unit of measurement is a reported result).

3.5. Comparisons among GSS types and task types (Table 8)

Both Hollingshead and McGrath [10,11] and Dennis and Wixom [2] suggest that task type can moderate the effect of a GSS. Table 8 also reflects those observations. GSS groups aggregated together have "GSS>FtF" effects in 31.9% of the results. When organized by GSS type and task type, the percentage increases to 39.6% for decision room-based GSS and task type 2 (idea generation) and increases to 32.7% for task type 4 (decision making or preference).

An unexpected result is also observable for CMC systems and decision-making tasks. By looking at Table 8, it is obvious that asynchronous CMC and distributed CMC systems are fairly effective when used with tasks requiring decision-making (46.4% and 30.8%, respectively).

Table 9 aggregates GSS and CMC types by task type. The results reveal that, for GSSs, there are higher results than FtF when groups work on idea generation task in comparison to decision-making tasks (36.41% vs. 28.9%). CMC systems, on the other hand, are best when used on decision-making tasks and have a "GSS>FtF" effect of 39.1%). Thus, the results suggest that GSSs are highly effective on idea generation tasks while CMC systems are highly effective when used in decision-making situations.

4. Journal and conference proceedings by year (Table 10)

Table 10 shows the total number of results reported by journal and conference proceedings year. If a paper was first published in a conference and then in a journal only the journal year is counted, thus there is no double counting. The results suggest that 1992 had the highest "GSS>FtF" effect followed by 1998, at 40.0% and 38.4%, respectively, where there were at least 20 instances.

Are there any effects to do the digital economy? This is very difficult to ascertain. Table 10 also shows a break down of the results prior to 1995 and after 1996. The obvious difference is in the "FtF>GSS" effects where 1996–2000 has 40.4% vs. 25.6% for 1970–1995. Many of the more recent experiments were using the same configurations as the earlier experiments but were testing different types of hypotheses and measuring different outcomes (i.e., process structure, culture, time and pressure). This may account for the higher "FtF>GSS" effects.

5. Conclusions

Our objective was to present a detailed assessment of the empirical results for the effects of the independent variable communication mode, on the major dependent variables studied in group support system research. Overall, the results suggest that the research shows an overwhelming tendency to find "no significant differences" between unsupported face-to-face modes and the types of group support systems that have been studied thus far.

Less than one-third of the findings, overall, support the fact that GSS use is better than face-to-face methods (GSS>FtF). Slightly higher (GSS>FtF) results are observable when CMC systems are used for decision-making tasks (39.1%) and GSSs for idea generation tasks (36.4%). One possible explanation is that many experiments have used too few groups to achieve sufficient statistical power to discern if any significant effects occur. Out of the 145 experiments in this study, 29.2% have less than seven groups per treatment condition. However, a detailed analysis (not shown) shows no discernable differences in the "GSS>FtF" effects among three categories (less than 7 groups, 7–10 groups per cell, and 11 groups and up, at 29.9%, 32.9%, and 23.7%, respectively).

The other explanation is that there is really is no overall discernible impact of communication mode on group process and outcomes. If this is the case, it has different implications for decision room vs. distributed GSSs. There would be no reason to expend the money and effort to add GSS to face-to-face meetings, whereas "no difference" between FtF and distributed asynchronous CMC would mean that considerable time and money might be saved by avoiding the need for participants to travel long distances to meet, without sacrificing quality of the group's work.

Similar to the observations made by Hollingshead and McGrath [10,11] and the results reported by Dennis and Wixom [2], task type moderates GSS use. The results reported here suggest that GSS

decision room technology has the highest probability of aiding groups that perform idea generation tasks in comparison to other task types. This may be because idea generation benefits from independent cogitation, and does not require a great deal of agreement, or other forms of social–emotional interaction.

CMC systems provide a less "rich" environment than do decision room GSS. Perhaps, the group members can have time to reflect and digest the decision alternatives before deciding on a final decision. This might help explain why CMC groups working on a decision task have higher results.

Based on 145 experiments which span 20 years of research, we observe a 29.2% "GSS>FtF" effect (see Table 6) of GSS use over face-to-face methods. Let this limit be set as our benchmark for interpreting the detailed results on the dependent category variables. Then, the overall results on the categories of dependent variables (Table 6) suggest that the use of a GSS has relatively greater impacts on effectiveness (33.0%) and especially on productivity (52.0%), process variables (26.3%), process gains (34.6%), role outcomes (30.0%), structuration (46.7%) and preventing process losses (38.4%). Relatively negative impacts are associated with efficiency (64.4%), which is mostly decision time. GSS groups clearly tend to take longer to complete their tasks than do FtF groups. Furthermore, FtF groups appear to have an easier time gaining consensus from the group and communicate more than GSS groups. No differences are observed between FtF and GSS groups on satisfaction or usability.

Using these results as the starting point for future research, our objective is to find ways to improve the design and use of GSS. Field studies tend to show that the use of GSS actually reduces meeting time, thus efficiency is improved [8].

5.1. What needs to be studied?

Interacting social groups cannot function if they focus only on "goal" or "task" oriented activities; they must also devote time and interactions to the social–emotional interactions which build cohesion and trust and thus provide the group with the resources that enable it to succeed. As Bales put it ([1], p. 8), "The idealized interaction process would then be described as one of alternating emphasis on the two types of problems. When attention is give to the task, strains are created in the social and emotional relations of the members of the group, and attention then turns to the solution of these problems. So long as the group devotes its activity simply to social–emotional activity, however, the task is not getting done, and attention would be expected to turn again to the task area." Group support systems are built explicitly to provide task support. Text-based computer-mediated communication is not as "rich" as face-to-face or multimedia interactions for social–emotional communication (e.g., positive, such as joking and showing satisfaction or rewarding others with attention and approval; or negative, such as showing tension or hostility). Thus, it may be that, overall, we have "no difference" as the average group result in comparing face-to-face and GSS text-based media because the tools help in the task oriented interactions, but groups have difficulty in CMC with the relative lack of social presence, particularly if they have little prior experience with the system and no history as a group [13].

Many recent studies are examining the effects of different GSS structures and tools, which is beyond the scope of this paper. But, clearly, those issues need to be addressed. Of particular interest is the open question of whether new GSSs integrating the ease of use of the "point and click" web-based interfaces and multi-media features will improve the functionality and usability of GSSs, and thus increase the likelihood of improved outcomes in comparison to unsupported face to face groups. Based upon the results reported in this paper, it would make sense to investigate combined modes of communication and decision making. For example, on a more complex task that requires both idea generation and decision making, groups might be started in a decision room using face to face interaction to "get to know" one another. They might then use a decision room GSS to generate ideas. Then, using CMC, the groups could gather more information in order to assess different options and reach a solution to the problem. Several experiments like this work are in progress (e.g., Ref. [15]). The results do tend to support a combined mode approach.

Acknowledgements

Partial funding for this research was provided by the National Science Foundation (9015236) and by

the New Jersey Institute of Technology under SBR Grant number 421090. Additional support was provided by the New Jersey Center for Multimedia Research and the New Jersey Center for Pervasive Information Technology. This is a revised and expanded version of a paper presented at the Thirty-first Annual Hawaii International Conference on System Sciences. A special thank you is extended to S. Roxanne Hiltz, Robert Briggs, Alan Dennis, Ron Rice and Nicholas Romano for all of their help. In addition, a thank you is extended to two anonymous reviewers who made invaluable comments.

Appendix A. Studies Included in the Analysis

1. L. Adrianson and E. Hjelmquist, Group processes in solving two problems: face-to-face and computer-mediated communication, *Behaviour and Information Technology*, 18(3) (1999) 179–198.
2. L. Adrianson and E. Hjelmquist, Group processes in face-to-face and computer-mediated communication, *Behavior and Information Technology*, 10(4) (1991) 281–296.
3. M. Aiken, J. Krosp, A. Shirani and J. Martin, J. Electronic brainstorming in small and large groups, *Information and Management*, 27 (1994) 141–148.
4. M. Aiken and M. Vanjani, A comparison of synchronous and virtual legislative session groups faced with an idea generation task, *Information and Management*, 33 (1997) 25–31.
5. M. Alavi, Computer-mediated collaborative learning: an empirical evaluation, *MIS Quarterly*, 18(2) (1994) 159–174.
6. R. Anson, R. Bostrom and B. Wynne, An experiment assessing group support systems and facilitator effects on meeting outcomes, *Management Science*, 41(2) (1995) 189–208.
7. N.P. Archer, A comparison of computer conferences with face-to-face meetings for small group business decisions, *Behaviour and Information Technology*, 9(4) (1990) 307–317.
8. V. Arnold, S.C. Hayne, C.A.P. Smith and S.G. Sutton, Group decision making: the impact of opportunity—cost, time pressure, and group support systems, *Behavioral Research in Accounting*, 12 (2000) 69–96.
9. R. Barkhi, V.S. Jacob and H. Pirkal, An experimental analysis of face-to-face versus computer mediated communication channels, *Group Decision and Negotiation*, 8(4) (1999) 325–347.
10. R. Barkhi, V.S. Jacob, L. Pipino and H. Pirkul, A study of the effect of communication channel and authority on group decision processes and outcomes, *Decision Support Systems*, 23 (1998) 205–226.
11. R.A. Beauclair, An experimental study of GDSS support application effectiveness, *Journal of Information Science*, 15 (1989) 321–332.
12. R. Benunan-Fich and S.R. Hiltz, Impacts of asynchronous learning networks on individual and group problem solving: a field experiment, *Group Decision and Negotiation*, 8(5) (1999) 409–426. R. Benbunan-Fich and S.R. Hiltz, Learning effects of asynchronous learning networks: a comparison of groups and individuals solving ethical case scenarios, *Proceedings of the Thirty-First Hawaii International Conference on Systems Sciences*, 1 (1998) 340–347.
13. J.L. Berdahl and K.M. Craig, Equality of participation and influences in groups: the effects of communication medium and sex composition, *Computer Supported Cooperative Work*, 4(2) (1996) 179–201. K. Bouas and H. Arrow, The development of group identity in computer and face-to-face groups with membership change, *Computer Supported Cooperative Work*, 4 (1996) 153–178. A. Cummings, A. Schlosser and H. Arrow, Developing complex group products: idea combination in computer-mediated and face-to-face groups, *Computer Supported Cooperative Work*, 4(2) (1996) 229–251. L. Lebie, J.A. Rhoades and J.E. McGrath, Interaction process in computer-mediated and face-to-face groups, *Computer Supported Cooperative Work*, 4(2) (1996) 127–152. J.E. McGrath and H. Arrow, Introduction: the JEMCO-2 study of time, technology, and groups, *Computer Supported Cooperative Work*, 4(2) (1996) 107–126.
14. U. Bose and D.B. Paradice, The effects of integrating cognitive feedback and multi-attribute utility-based multicriteria decision-making

methods in GDSS, *Group Decision and Negotiation*, 8 (1999) 157–182.
15. T. Bui and T.R. Sivasankaran, Relation between GDSS use and group task complexity: an experimental study, *Proceedings of the Twenty-Third Hawaii International Conference on System Sciences*, 3 (1990) 69–78.
16. K. Burk and K. Aytes, A longitudinal analysis of the effects of media richness on cohesion development and process satisfaction in computer-supported workgroups, *Proceedings of the Thirty-First Hawaii International Conference on Systems Sciences*, 1 (1998) 135–144.
17. K. Burke, K. Aytes, L. Chidambaram and J.J. Johnson, A study of partially distributed work groups: the impact of media, location, and time on perception and performance, *Small Group Research*, 30(4) (1999) 453–490.
18. K. Burke and L. Chidambaram, Developmental differences between distributed and face-to-face groups in electronically supported meeting environments: an exploratory investigation, *Group Decision and Negotiation*, 4(3) (1995) 213–234. K. Burke and L. Chidambaram, Development in electronically supported groups: a preliminary longitudinal study of distributed and face-to-face meetings, *Proceedings of the Twenty-Seventh Hawaii International Conference on System Sciences*, 4 (1994) 104–113.
19. K. Burke, L. Chidambaram and J. Lock, Evolution of relational factors over time: a study of distributed and non-distributed meetings, *Proceedings of the Twenty-Eighth Hawaii International Conference on System Sciences*, 4 (1995) 14–23.
20. K. Burke and L. Chidambaram, Do mediated contexts differ in information richness? a comparison of collocated and dispersed meetings, *Proceedings of the Twenty-Ninth Annual Hawaii International Conference on System Sciences*, 3 (1996) 92–101.
21. J. Carey and C.J. Kacmar, The impact of communication mode and task complexity on small group performance and member satisfaction, *Computers in Human Behavior*, 13(1) (1997) 23–49.
22. K. Cass, T.J. Heintz and K.M. Kaiser, An investigation of satisfaction when using a voice-synchronous GDSS in dispersed meetings, *Information and Management*, 23 (1992) 173–182.K. Cass, T.J. Heintz and K.M. Kaiser, Using a voice-synchronous GDSS in dispersed locations: a preliminary analysis of participant satisfaction, *Proceedings of the Twenty-Fourth Hawaii International Conference on System Sciences*, 4 (1991) 554–563.
23. L. Chidambaram and R.P. Bostrom, Evolution of group performance of over time: a repeated measures study of GDSS effects, *Journal of Organizational Computing*, 3(4) (1993) 443–469. L. Chidambaram, R.P. Bostrom and B.E. Wynne, A longitudinal study of the impact of group decision support systems on group development, *Journal of Management Information Systems*, 7(3) (1990) 7–25. L. Chidambaram, R.P. Bostrom and B.E. Wynne, An empirical investigation of the impact of computer support on group performance, *Proceedings of the Twenty-Third Annual Hawaii International Conference on System Sciences*, 4 (1990) 3–12.
24. L. Chidambaram and B. Jones, Impact on communication medium and computer support on group perceptions and performance: a comparison of face-o-face and dispersed meetings, *MIS Quarterly*, 17(4) (1993) 465–491.
25. L. Chidambaram and J.A. Kautz, Defining common ground: managing diversity through electronic meeting systems, *Proceedings of the Fourteenth International Conference on Information Systems* (1993) 1–11.
26. D.L. Clapper, E.R. McLean and R.T. Watson, Mediating group influence with a group support system: an experimental investigation, *Journal of Organizational Computing and Electronic Commerce*, 8(2) (1998) 109–126.
27. L.H. Coleman, C.E. Paternite and R.C. Sherman, A reexamination of deindividuation in synchronous computer-mediated communication, *Computers in Human Behavior*, 15 (1999) 51–65.
28. W.H. Cooper, R.B. Gallupe, S. Pollard and J. Cadsby, Some liberating effects of anonymous electronic brainstorming, *Small Group Research*, 29(2) (1998) 147–178.
29. B.F. Daly, The influence of face-to-face versus computer-mediated communication channels on

collective induction, *Accounting Management and Information Technology*, 3(1) (1993) 1–22.
30. B.F. Daily and R.L. Steiner, The influence of GDSS on contribution and commitment levels in multicultural and culturally homogeneous decision making groups, *Computers in Human Behavior*, 14(1) (1998) 147–162.
31. B. Daily, A. Whatley, A.S.R. Ash and R.L. Steiner, The effects of a group decision support system on culturally diverse and culturally homogeneous group decision making, *Information and Management*, 30 (1996) 281–289.
32. A.R. Dennis, Information exchange and use in group decision making: you can lead a group to information but you can't make it think, *MIS Quarterly*, 20(4) (1996) 433–455. A.R. Dennis, Information exchange group decision making: you can lead a group to information, but you can't make it think, *Proceedings of the Academy of Management* (1993) 283–287.
33. A.R. Dennis, Information exchange and use in small group decision making, *Small Group Research*, 27(4) (1996) 532–550.
34. A.R. Dennis, K.M. Hilmer and N.J. Taylor, Information exchange and use in GSS and verbal group decision making: effects of minority influence, *Journal of Management Information Systems*, 14(3) (1998) 61–88. A.R. Dennis, K. Hilmer, N.J. Taylor and A. Polito, Information exchange and use in GSS and verbal group decision making: effects of minority influence, *Proceedings of the Thirtieth Hawaii International Conference on Systems Sciences*, 2 (1997) 84–93.
35. A.R. Dennis, J.S. Valacich, Computer brainstorms: more heads are better than one, *Journal of Applied Psychology*, 78(4) (1993) 531–537.
36. A.R. Dennis, S.T. Kinney and Y.C. Hung, Gender differences in the effects of media richness, *Small Group Research*, 30(4) (1999) 405–437.
37. V.J. Dubrovsky, S. Kiesler and B.N. Sethna, The equalization phenomenon: status effects in computer-mediated and face-to-face decision making groups, *Human Computer Interaction*, 6 (1991) 119–146.
38. F.T. Durso, C.A. Hackworth, A.L. Barile, M.R.P. Dougherty and D.D. Ohrt, Source monitoring in face-to-face and computer-mediated environments, *Cognitive Technology*, 3(1) (1998) 32–38.
39. M. El-Shinnawy and A.S. Vinze, Technology, culture and persuasiveness: a study of choice-shifts in group settings, *International Journal of Human–Computer Studies*, 47(3) (1997) 473–496.
40. M. El-Shinnawy and A.S. Vinze, Polarization and persuasive argumentation: a study of decision making in group settings, *MIS Quarterly*, 22(2) (1998) 165–198.
41. C.A. Ellis, G.L. Rein and S.L. Jarvenpaa, Nick experimentation: selected results concerning effectiveness of meeting support technology. *Journal of Management Information Systems*, 6(3) (1990) 7–24. C.A. Ellis, G.L. Rein and S.L. Jarvenpaa, Nick experimentation: some selected results. *Proceedings of the Twenty-Second Hawaii International Conference on System Sciences*, 4 (1989) 359–369.
42. J.D. Eveland and T.K. Bikson, Work group structures and computer support: a field experiment, *ACM Transactions on Office Information Systems*, 6(4) (1988) 354–379.
43. J. Galegher and R.E. Kraut, Computer-mediated communication for intellectual teamwork: an experiment in group writing, *Information Systems Research*, 5(2) (1994) 110–138. J. Galegher and R.E. Kraut, Computer-mediated communication for intellectual teamwork: a field experiment in group writing, *Proceedings of the Conference on Computer-Supported Cooperative Work*, October (1990) 95–78.
44. R.B. Gallupe, Suppressing the contributions of the group's best member: is GDSS use appropriate for all group tasks, *Proceedings of the Twenty-Third Annual Hawaii International Conference on System Sciences*, 4 (1990) 13–22.
45. R.B. Gallupe, L.M. Bastianutti and W.H. Cooper, Unlocking brainstorms, *Journal of Applied Psychology*, 76(1) (1991) 137–142.
46. R.B. Gallup, W.H. Cooper, L.M. Grise and L.M. Bastianutti, Blocking electronic brainstorms, *Journal of Applied Psychology*, 79(1) (1994) 77–86.
47. R.B. Gallupe, A.R. Dennis, W.H. Cooper, J.S. Valacich, L.M. Bastianutti and J.F. Nunamaker,

Electronic brainstorming and group size, *Academy of Management Journal*, 35(2) (1992) 350–369.
48. R.B. Gallupe, G. DeSanctis and G.W. Dickson, Computer-based support for group problem-finding: an experimental investigation, *MIS Quarterly*, 12(2) (1988) 277–296.
49. R.B. Gallupe and J.D. McKeen, Enhancing computer-mediated communications: an experimental investigation into the use of a group decision support system for face-to-face versus remote meetings, *Information and Management*, 18 (1990) 1–13.
50. J.F. George, G.K. Easton, J.F. Nunamaker and G.B. Northcraft, A study of collaborative group work with and without computer-based support, *Information Systems Research*, 1(4) (1990) 394–415.
51. J.A. Ghani, R. Supnick and P. Rooney, The experiences of flow in computer-mediated and face-to-face groups, *Proceedings of the Twelfth International Conference on Information Systems* (1991) 229–237.
52. B. Glasson, D. Atkinson, V. Chang, and A. Whiteley, Empowering systems developers through alternate methods and technologies: testing the efficacy of GDSS (group decision support systems), *Proceedings of the Twenty-Third Annual Hawaii International Conference on System Sciences*, 3 (1994) 224–233.
53. K.A. Graetz, E.S. Boyle, C.E. Kimble, P, Thompson and J.E. Garloch, Information sharing in face-to-face, teleconferencing, and electronic groups, *Small Group Research*, 29(6) (1998) 714–743.
54. T.L. Griffth and G.B. Northcraft, Distinguish between the forest and trees: media, features, and methodology in electronic communication research, *Organizational Science*, 5(2) (1994) 272–285.
55. D.E. Gundersen, D.L. Davis and D.F. Davis, Can DSS technology improve group decision performance for end users? An experimental study, *Journal of End User Computing*, 7(2) (1995) 3–10.
56. J. Hedlund, D.R. Iigen and J.R. Hollenbeck, Decision accuracy in computer-mediated versus face-to-face decision making teams, *Organizational Behavior and Human Decision Processes*, 76(1) (1998) 30–47.
57. R. Hightower and L. Sayeed, The impact of computer-mediated communication systems on biased group discussion, *Computers in Human Behavior*, 11(1) (1995) 33–44.
58. R. Hightower and L. Sayeed, Effects of communication mode and prediscussion information distribution characteristics on information exchange in groups, *Information Systems Research*, 7(4) (1996) 451–465.
59. S.R. Hiltz, K. Johnson and M. Turoff, Experiments in group decision making: communication process and outcome in face-to-face versus computerized conferences, *Human Communications Research*, 13(2) (1986) 225–252.
60. S.R. Hiltz and M. Turoff, K. Johnson, Experiments in group decision making: 3. Disinhibition, deindividuation, and group process in pen name and real name computer conferences, *Decision Support Systems*, 5 (1989) 217–232. M. Turoff, S.R. Hiltz, Computer support for groups versus individual decisions, *IEEE Transactions on Communication*, 30(1) (1982) 82–90.
61. J.L.Y. Ho, Technology and group decision process in going concern judgments, *Group Decision and Negotiation*, 8(1) (1999) 33–49.
62. T.H. Ho and K.S. Raman, The effect of GDSS and elected leadership on small group meetings, *Journal of Management Information Systems*, 8(2) (1991) 109–133.
63. T.H. Ho, K.S. Raman and R.T. Watson, Group decision support systems: the cultural factor, *Proceedings of the Tenth International Conference on Information Systems* (1989) 119–129.
64. A.B. Hollingshead, The rank-order effect in group decision making, *Organizational Behavior and Human Decision Processes*, 68(3) (1996) 181–193.
65. A.B. Hollingshead, Information suppression and status persistence in group decision making: the effects of communication media, *Human Communication Research*, 23(2) (1996) 193–219.
66. W. Huang, K.S. Raman and K.K. Wei, A process study of effects of GSS and task type on informational and normative influence in small

groups, *Proceedings of the Fourteenth International Conference on Information Systems* (1993) 91–101.
67. W. Huang, K.K. Wei, C.Y. Tan and K.S. Raman, Why does a GSS fail to enhance group consensus and satisfaction? An investigation from an influence process perspective, *Proceedings of the Thirtieth Hawaii International Conference on Systems Sciences*, 2 (1997) 104–113.
68. W. Huang, K.K. Wei, R.T. Watson, L.H. Lim and R. Bostrom, Transforming a lean CMC medium into a rich one: an empirical investigation in small groups, *Proceedings of the Seventeenth International Conference on Information Systems* (1996) 265–277.
69. H.G. Hwang and J. Guynes, The effects of group size on group performance in computer-mediated decision making, *Information and Management*, 26(4) (1994) 189–198.
70. S.L. Jarvenpaa, V.S. Rao and G.P. Huber, Computer support for meetings of groups working on unstructured problems: a field experiment, *MIS Quarterly*, 12(4) (1988) 645–665.
71. R. Joyner and K. Tunstall, Computer augmented organizational problem solving, *Management Science*, 14(4) (1970) B-212–225.
72. S. Kahai and R.A. Cooper, The effect of computer-mediated communication on agreement and acceptance, *Journal of Management Information Systems*, 16(1) (1999) 165–188.
73. V. Karan, D.S. Kerr, U.S. Murthy and A.S. Vinze, Information technology support for collaborative decision making in auditing: an experimental investigation, *Decision Support Systems*, 16 (1996) 181–194.
74. D.S. Kerr and U.S. Murthy, Group decision support systems and cooperative learning in auditing: an experimental investigation, *Journal of Information Systems*, 8(2) (1994) 85–96.
75. S. Kinney and A. Dennis, Reevaluating media richness: cues, feedback, and task, *Proceedings of the Twenty-Seventh Hawaii International Conference on Systems Sciences*, 4 (1994) 21–30.
76. S.T. Kinney and R.T. Watson, The effect of medium and task on dyadic communication, *Proceedings of the Thirteenth International Conference on Information Systems* (1992) 107–117.
77. R.C.W. Kwok and M. Khalifa, Effect of GSS on knowledge acquisition, *Information and Management*, 34 (1998) 307–315.
78. S.K. Lam, The effects of group decision support systems and task structures on group communication and decision quality, *Journal of Management Information Systems*, 13(4) (1997) 193–215.
79. H. Lewe, Computer support and facilitated structure in meetings—an empirical comparison of their impact, *Proceedings of the Twenty-Ninth Annual Hawaii International Conference on System Sciences*, 3 (1996) 24–33.
80. L.H. Lim and I. Benbasat, The debiasing role of group support systems: an experimental investigation of the representativeness bias, *International Journal of Human–Computer Studies*, 47(3) (1997) 453–471.
81. L.H. Lim, K.S. Raman and K.K. Wei, Interacting effects of GDSS and leadership, *Decision Support Systems*, 12(3) (1994) 199–211. L.H. Lim, K.S. Raman, K.K. Wei, Does GDSS promote more democratic decision-making? The Singapore experiment, *Proceedings of the Twenty-Third Annual Hawaii International Conference on System Sciences*, 4 (1990) 59–68.
82. M. Losada, P. Sanchez and E.E. Nobel, Collaborative technology and group process feedback: their impact on interactive sequences in meetings, *Proceedings of the Conference on Computer Supported Cooperative Work* (1990) 53–64.
83. S.L. Loy, W.E. Pracht and J.F. Courtney, Effects of a graphical problem-structuring aid on small group decision making, *Proceedings of the Twentieth Annual Hawaii International Conference on System Sciences*, 1 (1987) 566–574.
84. A.P. Massey and D.L. Clapper, Element finding: the impact of a group support systems on a crucial phase of sense making, *Journal of Management Information Systems*, 11(4) (1995) 149–176.
85. T.W. McGuire, S. Kiesler and J. Siegel, Group and computer-mediated discussion effects in risk decision making, *Journal of Personality and Social Psychology*, 52(5) (1987) 917–930.

86. P.L. McLeod and J.K. Liker, Electronic meeting systems: evidence from a low structure environment, *Information Systems Research*, 3(3) (1992) 195–223. L.C. Austin, J.K. Liker and P.L. McLeod, Who controls the technology in group support systems? Determinants and consequences, *Human–Computer Interaction*, 8 (1993) 217–236.
87. P.L. McLeod, R.S. Baron, M.W. Mart and K. Yoon, The eyes have it: minority influence in face-to-face and computer-mediated group discussion, *Journal of Applied Psychology*, 82(5) (1997) 706–718.
88. R.J. Mejias, D.R. Vogel and M.M. Shepherd, GSS meeting productivity and participation equity: a U.S. and Mexico cross-cultural field study, *Proceedings of the Thirtieth Hawaii International Conference on Systems Sciences*, 2 (1997) 469–478.
89. B.E. Mennecke and J.S. Valacich, Information is what you make it: the influence of group history and computer support on information sharing, decision quality, and member perceptions, *Journal of Management Information Systems*, 15(2) (1998) 173–197. B.E. Mennecke, J.A. Hoffer and J.S. Valacich, An experimental investigation of group history and group support systems use on information sharing performance and user perceptions, *Proceedings of the Twenty-Eighth Hawaii International Conference on System Sciences*, 4 (1995) 153–162.
90. S.M. Miranda and R.P. Bostrom, The impact of group support systems on group conflict and conflict management, *Journal of Management Information Systems*, 10(3) (1994) 63–95. S.M. Miranda and R.P. Bostrom, The impact of group support systems on group conflict and conflict management: an empirical investigation, *Proceedings of the Twenty-Sixth Hawaii International Conference on System Sciences*, 3 (1993) 83–94.
91. R. Ocker and J. Fjermestad, Web-based computer-mediated communication: an experimental investigation comparing three communication modes for determining software requirements, *Proceedings of the Thirty-First Hawaii International Conference on Systems Sciences*, 1 (1998) 88–97.
92. R. Ocker, J. Fjermestad, S.R. Hiltz and K. Johnson, Effects of four modes of group communication on the outcomes of software requirements determination, *Journal of Management Information Systems*, 15(1) (1998) 99–118. R. Ocker, J. Fjermestad, S.R. Hiltz and M. Turoff, An exploratory comparison of four modes of communication for determining requirements: results on creativity, quality and satisfaction, *Proceedings of the Thirtieth Hawaii International Conference on Systems Sciences*, 2 (1997) 568–577.
93. R. Ocker, S.R. Hiltz, M. Turoff and J. Fjermestad, The effects of distributed group support and process structuring on requirements development teams: results on creativity and quality, *Journal of Management Information Systems*, 12(3) (1996) 127–153. R. Ocker, S.R. Hiltz, M. Turoff and J. Fjermestad, Computer support for distributed asynchronous software design teams: experimental results on creativity and quality, *Proceedings of the Twenty-Eighth Hawaii International Conference on System Sciences*, 4 (1995) 4–13.
94. R.J. Ocker and G.J. Yaverbaum, Asynchronous computer-mediated communication versus face-to-face collaboration: results on student learning, quality and satisfaction, *Group Decision and Negotiation*, 8(5) (1999) 427–440.
95. B.A. Olaniran, Group performance in computer-mediated and face-to-face communication media, *Management Communication Quarterly*, 7(3) (1994) 256–281.
96. B.A. Olaniran, A Model of Group satisfaction in computer-mediated communication and face-to-face meetings, *Behavior and Information Technology*, 15(1) (1996) 24–36.
97. J.S. Olson, G.M. Olson and D.K. Meader, What mix of video and audio is useful for remote real-time work? *Proceedings of Computer Human Interaction* (1995) 362–368.
98. J.S. Olson, G.M. Olson, M. Storrosten and M. Carter, How a group-editor changes the character of a design meeting as well as its outcome, *Proceedings of the Conference on Computer-Supported Cooperative Work*, October (1992) 91–98.
99. O. Petrovic and O. Krickl, Traditionally-moderated versus computer supported brainstorming:

a comparative study, *Information and Management*, 27 (1994) 233–243.
100. A. Pinsonneault, H. Barki, R.B. Gallupe and N. Hoppen, Electronic brainstorming: the illusion of productivity, *Information Systems Research*, 10(2) (1999) 110–133.
101. K.S. Raman, B.C.Y. Tan and K.K. Wei, An empirical study of task type and communication medium in GDSS, *Proceedings of the Twenty-Sixth Hawaii International Conference on Systems Science*, 4 (1993) 161–168.
102. V.S. Rao, Effects of teleconferencing technologies: an evaluation exploration of comprehension, feedback, satisfaction and role-related differences, *Group Decision and Negotiation*, 4 (1995) 251–272. V.S. Rao, Dimensions of satisfaction in teleconferencing: an exploratory analysis, *Proceedings of the Twenty Seventh Hawaii International Conference on System Sciences*, 4 (1994) 124–133.
103. H.S. Rhee, H. Pirkul, V. Jacob and R. Barhki, Effects of computer-mediated communication on group negotiation: an empirical study, *Proceedings of the Twenty-Eighth Hawaii International Conference on System Sciences*, 4 (1995) 270–279.
104. C. Saunders and S. Miranda, Information acquisition in group decision making, *Information and Management*, 34 (1998) 55–74.
105. R. Sharda, S.H. Barr and J.C. McDonnell, Decision support system effectiveness: a review and an empirical test, *Management Science*, 34(2) (1988) 139–157.
106. C.L. Sia, B.C.Y. Tan and K.K. Wei, Can a GSS stimulate group polarization? An empirical study, *IEEE Transactions on Systems, Man and Cybernetics*, 29(2) (1999) 227–237.
107. J. Siegel, V. Dubrovsky, S. Kiesler and T.W. McGuire, Group processes in computer-mediated communication, *Organizational Behavior and Human Decision Processes*, 37 (1986) 157–187.
108. A.I. Shirani, M.H.A. Tafti and J.F. Affisco, Task Technology fit: a comparison of two technologies for synchronous and asynchronous group communication, *Information and Management*, 36(3) (1999) 139–150.
109. C.A.P. Smith, S.C. Hayne and R. Connole, Decision making under time pressure: an investigation of the performance of computer supported groups, *Twelfth International Conference on Decision Support Systems* (1992) 203–212.
110. C.A.P. Smith and S.C. Hayne, Decision making under time pressure: an investigation of decision speed and decision quality of computer-supported groups, *Management Communication Quarterly*, 11(1) (1997) 97–127.
111. C.A.P. Smith, S.C. Hayne, V. Arnold and S.G. Sutton, An investigation of the effect of computerized support systems on managerial group decision making under time pressure, *Advances in Management Accounting*, 6 (1998) 17–37. S.G. Sutton, C.A.P. Smith, V. Arnold and S.C. Hayne, Audit group decision-making: the impact of time pressure and group support systems, *Audit: The Audit Automation Magazine*, 42 (1997) 18–21.
112. J.Y. Smith and M.T. Vanecek, Dispersed group decision making using nonsimultaneous computer conferencing: a report of research, *Journal of Management Information Systems*, 7(2) (1990) 71–92. J.Y. Smith and M.T. Vanecek, A nonsimultaneous computer conference as a component of group decision support systems, *Proceedings of the Twenty-Second Hawaii International Conference on System Sciences*, 4 (1989) 370–377.
113. J.Y. Smith and M.T. Vanecek, Computer conferencing and task-oriented decisions: implications for group decision support, *Information and Management*, 14 (1988) 123–132.
114. J.L. Sosik, Effects of transformational leadership and anonymity on idea generation in computer-mediated groups, *Group and Organization Management*, 22(4) (1997) 460–487. J.L. Sosik and B.J. Avolio, Inspiring group creativity: comparing anonymous and identified electronic brainstorming, *Small Group Research*, 29(1) (1998) 3–31. J.J. Sosik, B.J. Avolio and S.S. Kahai, D.I. Jung, Computer-supported work group potency and effectiveness: the role of transformational leadership, anonymity, and task interdependence, *Computers in Human Behavior*, 14(3) (1998) 491–511. J.J. Sosik, B.J. Avolio and S.S. Kahai, Effects of leadership style and anonymity on group potency and effectiveness in a group decision support system

environment, *Journal of Applied Psychology*, 82(1) (1997) 89–103. J.J. Sosik, S.S. Kahai and B.J. Avolio, Transformational leadership and dimensions of creativity: motivating idea generation in computer-mediated groups, *Creativity Research Journal*, 11(2) (1998) 111–121. J. Sosik, S. Kahai and B. Avoilo, Leadership style, anonymity, and creativity in group decision support systems: The mediating role of optimal flow, *Journal of Creative Behavior*, in press.

115. R. Steeb and S.C. Johnston, A computer-based interactive system for group decision making, *IEEE Transactions on Systems Man Cybernetics*, 11(8) (1981) 544–552.
116. S. Straus, Getting a clue: the effects of communication media and information distribution of participation and performance in computer-mediated and face-to-face groups, *Small Group Research*, 27(1) (1996) 115–142.
117. S.G. Straus and J.E. McGrath, Does the medium matter? The interaction of task type and technology on group performance and member reactions, *Journal of Applied Psychology*, 79(1) (1994) 87–97. S.G. Straus, Testing a typology of tasks: an empirical validation of McGrath's (1984) group task circumplex, *Small Group Research*, 30(2) (1999) 116–187.
118. K.S. Suh, Impact of communication medium on task performance and satisfaction: an examination of media-richness theory, *Information and Management*, 35 (1999) 295–312.
119. B.C.Y. Tan, K.S. Raman and K.K. Wei, An empirical study of task dimension of group support systems, *IEEE Transactions on Systems, Man, and Cybernetics*, 24(7) (1994) 1054–1060. B.C.Y. Tan, K.K. Wei and K.S. Raman, Effects of supported and task type on group decision outcome: a study using SAMM, *Proceedings of the Twenty-Fourth Hawaii International Conference on System Sciences*, 4 (1991) 537–546. B.C.Y. Tan, K.K. Wei and K.S. Raman, Impact of GDSS and task type on consensus in small group meetings, *Proceedings Collaborative Work, Social Communication and Information Systems* (1991) 33–51.
120. B.C.Y. Tan, K.K. Wei and R.T. Watson, Dampening status influence using a group support system: an empirical study, *Transactions of the Thirteenth International Conference on Decision Support Systems* (1993) 77–89.
121. B.C.Y. Tan, K.K. Wei, R.T. Watson and R.M. Walczuch, Reducing status effects with computer-mediated communication: evidence from two distinct national cultures, *Journal of Management Information Systems*, 15(1) (1998) 119–142.
122. B.C.Y. Tan, K.K. Wei and R.T. Watson, The equalizing impact of a group support system on status differentials, *ACM Transactions on Information Systems*, 17(2) (1999) 77–100.
123. C.K. Tryan, J.F. George and J.F. Nunamaker, Group support for technical review teams: an exploratory investigation, *Proceedings of the Twenty-Sixth Hawaii International Conference on System Sciences*, 4 (1993) 102–111.
124. J.S. Valacich, A.R. Dennis and T. Connolly, Idea generation in computer-based groups: a new ending to an old story, *Organizational Behavior and Human Decision Processes*, 57 (1994) 448–467.
125. J.S. Valacich, B.E. Mennecke, R.M. Wachter and B.C. Wheeler, Extensions to Media Richness Theory: a test of task-media fit hypothesis, *Proceedings of the Twenty-Seventh Hawaii International Conference on Systems Sciences*, 4 (1994) 11–20.
126. J.S. Valacich, D. Paranka, J.F. George and J.F. Nunamaker, Communication concurrency and the new media: a new dimension for media richness, *Communication Research*, 20(2) (1993) 249–276.
127. J.S. Valacich and C. Schwenk, Devil's advocacy and dialectical inquiry effects on group decision making using computer-mediated versus verbal communication, *Organizational Behavior and Human Decision Processes*, 63(2) (1995) 158–173.
128. J.B. Walther, Relational aspect of computer-mediated communication: experimental observations over time, *Organizational Science*, 6(2) (1995) 186–203. J.B. Walther and J.K. Burgoon, Relational communication in computer-mediated interaction, *Human Communications Research*, 19(1) (1992) 50–88. J.B. Walther, Longitudinal experiment on relational tone in computer-mediated and face to face interaction, *Proceedings of the Twenty-Fifth Hawaii Interna-*

tional Conference on Systems Science, 4 (1992) 220–231.
129. M.E. Warkentin, L. Sayeed and R. Hightower, Virtual teams versus face-to-face teams: an exploratory study of a web-based conference system, *Decision Sciences*, 28(4) (1997) 975–996.
130. R.T. Watson, G. DeSanctis and M.S. Poole, Using a GDSS to facilitate group consensus: some intended and unintended consequences, *MIS Quarterly*, 12(3) (1988) 463–477. M.S. Poole and G. DeSanctis, Microlevel structuration in computer-supported group decision making, *Human Communication Research*, 19(1) (1992) 5–49. M.S. Poole, M. Holmes and G. DeSanctis, Conflict management in a computer-supported meeting environment, *Management Science*, 37(8) (1991) 926–953. M.S. Poole, M. Holmes, R. Watson and G. DeSanctis, Group decision support systems and group communication: a comparison of decision making in computer-supported and non-supported groups, *Communications Research*, 20(2) (1993) 176–213.
131. R.T. Watson, T.H. Ho and K.S. Raman, Culture a fourth dimension of group support systems, *Communications of the ACM*, 37(10) (1994) 44–55.
132. S.P. Weisband, Group discussion and first advocacy effects in computer-mediated and face-to-face decision making groups, *Organizational Behavior and Human Decision Processes*, 53 (1992) 352–380.
133. S. Weisband, Overcoming social awareness in computer-supported groups: does anonymity really help? *Computer Supported Cooperative Work*, 2 (1994) 285–297. S. Weisband, S.K. Scheidner and T. Connolly, Computer-mediated communication and social information: status salience and status differences, *Academy of Management Journal*, 38(4) (1995) 1124–1151.
134. M. Winniford, Issues in automated voting, *Proceedings of the Twenty-Fourth Hawaii International Conference on System Sciences*, 4 (1991) 621–630.
135. J.G. Wood and J.T. Nosek, Discrimination of structure and technology in a group support system: the role of process complexity, *Proceedings of the International Conference on Information Systems*, 3 (1994) 187–199.
136. R.E. Yellen and M. Winniford, C.C. Sanford, Extroversion and introversion in electronically-supported meetings, *Information and Management*, 24 (1995) 63–74.
137. I. Zigurs, M.S. Poole, and G.L. DeSanctis, A study of influence in computer-mediated group decision making, *MIS Quarterly*, 12(4) (1988) 625–644.

References

[1] R.F. Bales, Interaction Process Analysis, University of Chicago Press, Chicago, 1950.
[2] A.R. Dennis, B.H. Wixom, Investigating the moderators of the group support system use with meta-analysis, Journal of Management Information Systems 18 (3) (2001–2002) 235–257.
[3] G. DeSanctis, R.B. Gallupe, A foundation for the study of group decision support systems, Management Science 33 (5) (1987) 589–609.
[4] G. DeSanctis, S. Poole, Understanding the differences in collaborative systems use through appropriation analysis, Proceedings of the Twenty-Fourth Annual Hawaii International Conference on System Sciences 3 (1991) 750–757.
[5] G. DeSanctis, S. Poole, Capturing the complexity in advanced technology use: adaptive structuration theory, Organizational Science 5 (2) (1994) 121–147.
[6] J. Fjermestad, An integrated framework for group support systems, Journal of Organizational Computing and Electronic Commerce 8 (2) (1998) 83–107.
[7] J. Fjermestad, S.R. Hiltz, An assessment of group support systems experimental research: methodology and results, Journal of Management Information Systems 15 (3) (1999) 7–149.
[8] J. Fjermestad, S.R. Hiltz, Group support systems: a descriptive evaluation of case and field studies, Journal of Management Information Systems 17 (3) (2001) 115–160.
[9] J. Fjermestad, T.S. Seah, Using an executive information system to analyze group support systems: a preliminary implementation, Proceedings of the Third Americas Conference on Information Systems, 1997, pp. 563–565.
[10] A.B. Hollingshead, J.E. McGrath, Computer-assisted groups: a critical review of the empirical research, in: R.A. Guzzo, E. Salas (Eds.), Team Effectiveness and Decision Making in Organizations, Jossey-Bass, San Francisco, 1995.
[11] J.E. McGrath, A.B. Hollingshead, Groups Interacting with Technology, Sage, Thousand Oaks, CA, 1994.
[12] T.W. McGuire, S. Kiesler, J. Siegel, Group and computer-mediated discussion effects in risk decision making, Journal of Personality and Social Psychology 52 (5) (1987) 917–930.
[13] P.L. McLeod, An assessment of the experimental literature on electronic support of group work: results of a meta-analysis, Human–Computer Interaction 7 (1992) 257–280.
[14] J.F. Nunamaker, A.R. Dennis, J.S. Valacich, D.R. Vogel, J.F. George, Electronic meeting systems to support group work, Communications of the ACM 34 (7) (1991) 41–61.

[15] R. Ocker, J. Fjermestad, S.R. Hiltz, K. Johnson, Effects of four modes of group communication on the outcomes of software requirements determination, Journal of Management Information Systems 15 (1) (1998) 99–118.
[16] A. Pinsonneault, K.L. Kraemer, The impact of technological support on groups: an assessment of the empirical research, Decision Support Systems 5 (1989) 197–216.
[17] A. Pinsonneault, K.L. Kraemer, The effects of electronic meetings on group processes and outcomes: an assessment of the empirical research, European Journal of Operations Research 46 (1990) 143–161.
[18] M.S. Poole, G. DeSanctis, Use of group decision support systems as an appropriation process, Proceedings of the Twenty-First Annual Hawaii International Conference on System Sciences, 1989, pp. 149–157.
[19] M.S. Poole, G. DeSanctis, Understanding the use of group decision support systems: the theory of adaptive structuration, in: J. Fulk, C. Steinfield (Eds.), Organizations and Communication Technology, Sage, Newbury Park, CA, 1990.
[20] V. Sambamurthy, G. DeSanctis, An experimental evaluation of GDSS effects on group performance during stakeholder analysis, Proceedings of the Thirty-First Annual Hawaii International Conference on Systems Science 3 (1989) 79–88.
[21] J. Siegel, V. Dubrovsky, S. Kiesler, T.W. McGuire, Group processes in computer-mediated communication, Organizational Behavior and Human Decision Processes 37 (1986) 157–187.
[22] B. Whitworth, R.B. Gallupe, R. McQueen, Generating agreement in computer-mediated, Group Small Group Research 32 (5) (2001) 625–666.
[23] I. Zigurs, K.A. Kozar, An exploratory study of roles in computer-supported groups, MIS Quarterly 18 (3) (1994) 277–297.

Jerry Fjermestad is an Associate Professor in the School of Management, New Jersey Institute of Technology. Jerry received his BA degree from Pacific Lutheran University, his MS from Polytechnic University, his MBA from Iona College, and his PhD from Rutgers University in information systems. His current research interests are in collaborative technology, decision support systems, data warehousing, and enterprise information systems. Jerry's works have been published in the *Journal of Management Information Systems*, *International Journal of Electronic Commerce*, *Group Decision and Negotiation*, *the Journal of Organizational Computing and Electronic Commerce*, *Information & Management*, *Logistics Information Management*, *Journal of Computer Mediated Communication* and the *Proceedings of Hawaii International Conference on System Sciences*.