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An Integrated Framework for Group Support Systems

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In this article, I consolidate the work of prior frameworks for group support systems and present the results of that consolidation using the major factors of contextual, intervening, adaptation, and outcome variables. The end result is a comprehensive list of factors that have been studied or suggested, organized into the preceding 4 categories. The model proposed offers a control system type interpretation of the 4 factor dimensions.

integrative, framework, model, group support systems (GSS)

1. INTRODUCTION

Computer-based systems that support group decision making are the result of the integration of communication, information processing and computer-based group structuring or support [1–3]. The goal of group support systems (GSS) is to help organizational teams make faster, more satisfying, and ultimately better decisions than those made in face-to-face, manually supported meetings [4–6].

The purpose of this article is to review the major research models that have been used for studying GSS and to derive and present an integrated, comprehensive factor model. As DeSanctis and Gallupe [1] stated, a common perspective regarding the purpose and characteristics of these systems is required. In the short time since the publication of their foundation paper, the number of research models has more than quadrupled (from 3 to 16). There has also been a shift in the research emphasis from technology to process interaction of the technology, task, and the group to produce outcomes. Different outcomes (the dependent

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measures) have been observed depending on the initial set of independent variables and the group processes (potentially influenced by intervening variables) that result in a specific adaptation or "structural adaptation" [3] to the provided technology.

Prior frameworks or research models have focused on specific attributes to provide for the hypotheses being tested, and consequently, no overreaching framework exists that provides insights into how the attributes are related and integrated. Most researchers cite one of the major frameworks [1, 3, 4, 7–9], which have many commonalities; several have been enhanced and revised over the last 10 years. All of these are input–process–output models with some twists. In essence, no general theory of GSS has emerged [10]. The difficulty results from the multidimensions in which these collaborative systems can be configured. A common language and framework is needed to design, test, and implement new systems so that the goal of GSS can be achieved—which is to help people make faster, more satisfying, and ultimately better decisions than can be made in face-to-face, manually supported meetings [4].

The objective of this article is to provide an integrated framework for research on GSS. In Section 2, I discuss the antecedents of GSS. Next, in Section 3, a summary of the prior frameworks is organized and presented. Section 4 presents the proposed framework. A summary and conclusion is presented in Section 5.

2. THE ANTECEDENTS OF THE GSS FRAMEWORKS

One of the first frameworks to deal with information and decision process was Leavitt's [11] *diamond model.* This model presents a dynamic view of the relations between an organization's structure, the tasks, the people, and the technology. According to Leavitt, a change in one of the components implies changes in the other organizational components.

Konsynski and Stohr [12] expanded this model to include information technology in the center of the diamond with the environment surrounding and interacting with the whole model (Figure 1). Information technology from their perspective is the glue that relates to all of the other organizational components. The framework's role is to provide guidance for developing normative and descriptive theories of organizational interaction.

Before there was computer-based technology there were general models of group performance [13, 14] that were developed to understand the *interaction process* with the intent of improving performance. Hackman and Morris [13] suggested that the fundamental assumption underlying this input–process–output model (Figure 2) is that the input factors (at Time 1) affect performance (at Time 2) through some kind of interaction process. The interaction processes were difficult to measure until they addressed the question of how group interaction mediates input-performance relations. Furthermore, they suggested that intermediary or summary variables (Figure 3) can be used and that the group processes are affected by the interventions, which in turn lead to measurable differences in group productivity.

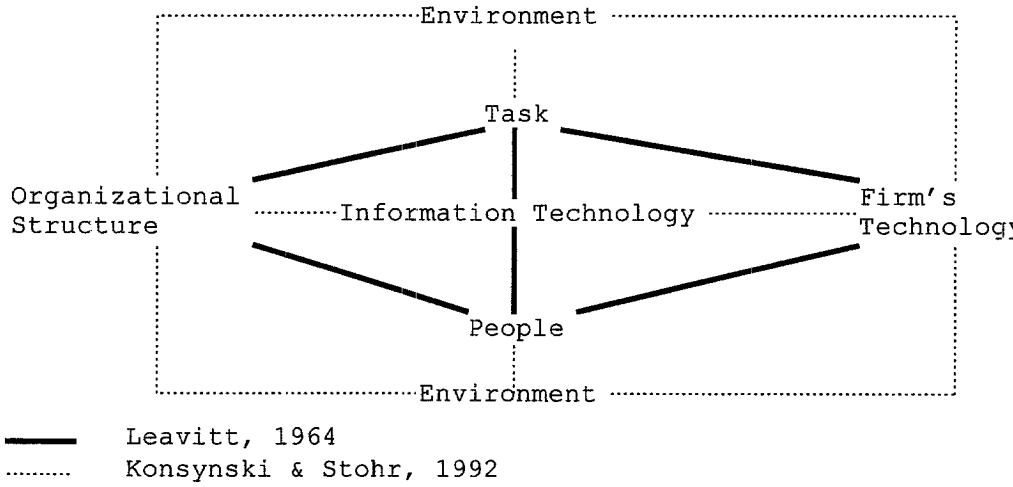

Figure 1. The organization interaction framework [11, 12].

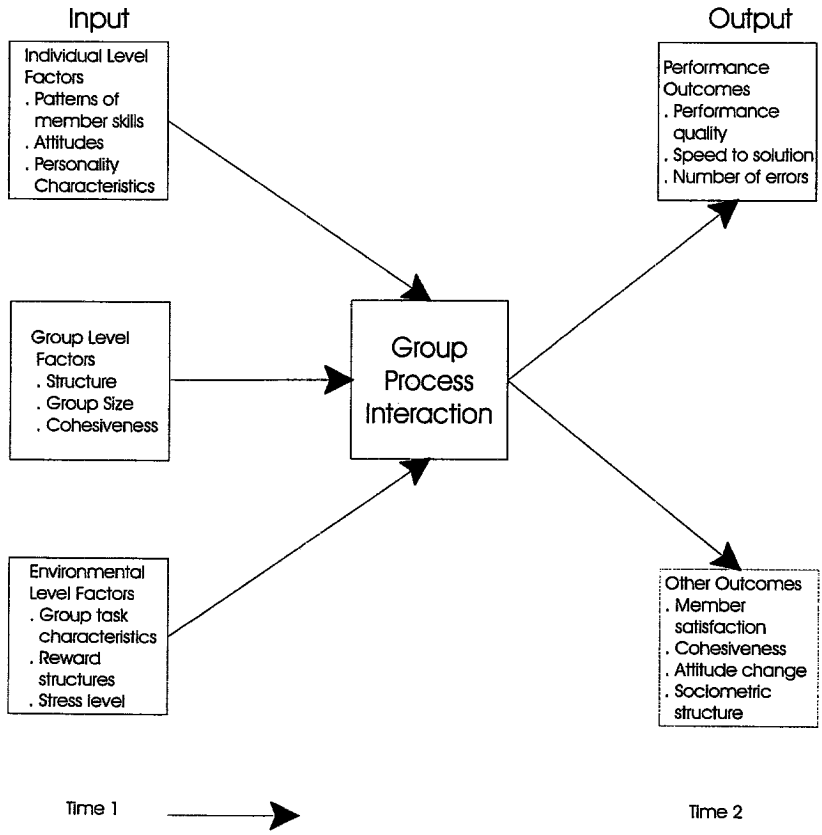

Figure 2. An initial framework for group support systems. Adapted from Hackman and Morris [13]. Used with permission.

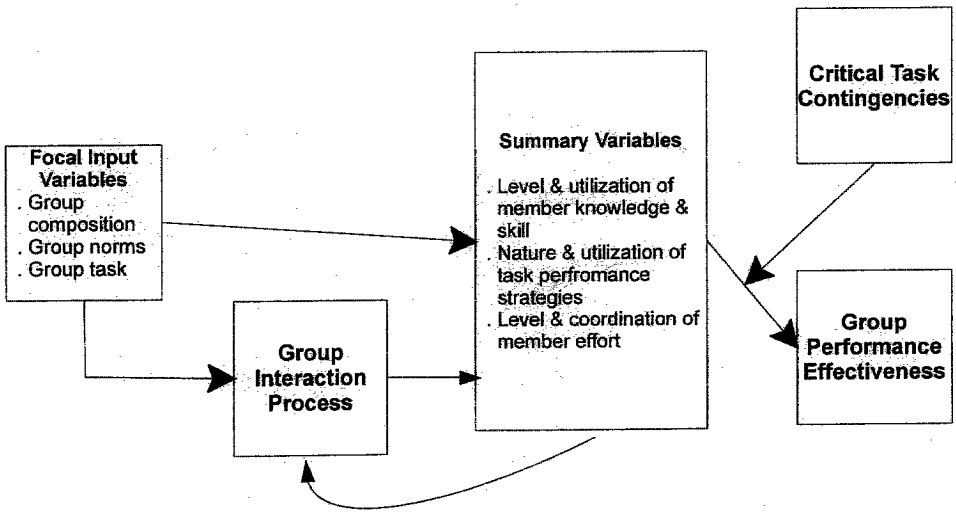

Figure 3. The summary variable interaction process. Adapted from Hackman and Morris [13]. Used with permission.

3. A SUMMARY OF PRIOR THEORETICAL MODELS AND FRAMEWORKS

The integrated factors model is derived from a set of representative theoretical frameworks. A comprehensive search of the literature was undertaken including publications from *Management Science, MIS Quarterly, Decision Support Systems, Small Group Research, Journal of Organizational Computing, Information & Management, Organizational Science,* and several scholarly book chapters. This set was chosen from the literature as the one that seems to provide complete coverage of factors present in the literature as a whole. Two basic types of frameworks are presented: those derived from theory (Table 1) and those derived from meta-analysis (Table 2).

3.1 DeSanctis and Gallupe [1, 15]

The objective of GSS is defined as improving the group decision-making process by removing communication barriers, providing the necessary techniques for structuring decision analysis, and facilitating the formulation of a solution by directing the pattern, timing, or content of the discussion [1, 15]. Group decision making occurs when two or more individuals are assigned the tasks of detecting a problem, evaluating it, generating alternative solutions, evaluating solutions, and/or formulating strategies for implementing solutions. Simon [16] and Keen and Scott-Morton [17] call this the intelligence, design, and choice phases of decision making.

3.2 Jelassi and Beauclair [5]

These authors defined a GSS as an interactive computer-based information system that is used to augment group decision making within organizational settings. The decision tasks range from structured to unstructured. GSS are designed to support the data handling, modeling, and dialogue requirements of groups.

Table 1
Group Support System Frameworks: A Comparison

Author	*Contextual*	*Intervening*	*Adaptation*	
DeSanctis and Gallupe [1, 15]	Group size: smaller to larger Proximity: dispersed to face-to-face Task: planning, creating, intellective, preference, cognitive conflict, and mixed motive Technology: Levels: communication exchange, uncertainty reduction, information filtering and structuring Settings (time–place): decision rooms, legislative sessions, local decision network, computer conferencing	Interaction Learning adjustments Patterns of information exchange Effects of participation Effects on cohesiveness Effects on power & influence Tradeoffs on performance and satisfaction		Outcomes Decision quality and timeliness Satisfaction with decision Cost Ease of implementation Member commitment to implementation Group's willingness to work together again
Jelassi and Beauclair [5]	Proximity: dispersed to close Time: synchronous to asynchronous Orientation: face-to-face or not face-to-face Context: individual, group, and environmental Technology: speed, control, and communication	Situational Task complexity Group size Political climate	Group process issues Diffusion of responsibility Deindividuation Pressure–consensus Coordination	Outcomes Efficiency Effectiveness Satisfaction
Gray [18]	Inputs Group level Prior experience as a group Level of cohesiveness Group size Leadership type Group facilitator's role Individual level Member skills Attitudes Personality traits Expectations Perceived status Technical Hardware features Software features Telecommunications System configuration	Group decision process Information processes Information retrieval Information sharing Information use Type of decision technique Ordinary process Nominal group Delphi Brainstorming Social judgment analysis Statistical aggregation Group dynamics Norms development Participation Communication patterns Power relationships Conflicts		Outputs Secondary outcomes Extent of DGSS use Attitudes Level of consensus Decision confidence Satisfaction with DGSS Number of group meetings Performance outcomes Decision quality Decision speed

(continued)

Table 1 (Continued)

Author	*Contextual*	*Intervening*	*Adaptation*
	Contextual Task characteristics: limited, ongoing Proximity: close, distant Organizational reward Time pressure Training–support for GDSS		
Dennis, George, Jessup, Nunamaker, and Vogel [4]	Group: Group size, history, experience, cohesiveness, formal–informal, ongoing–ad-hoc, and individual characteristics Task: type, rational, political, and complexity Context: environment, culture, incentives, rewards EMS: presence or absence Tools: EBS and so forth Methods: design, support, mode, and so forth Environments: size, proximity, and time	Process Degree of structure Anonymity Leadership Participation Conflict Number of sessions Nontask behavior	Outcomes Satisfaction with process Satisfaction with outcome Outcome quality Time required Number of alteratives Number of comments Consensus Confidence
Pinsonneault and Kraemer [7, 52]	Personal: attitude, abilities, background Situational: membership, group development stage, and existing social networks Group structure: norms, power, size, anonymity, cohesiveness, and facilitator Technology: anonymity, type, degree of support, and facilitation Task characteristics: complexity, source, type and degree of uncertainty	Group process Decision: participation, depth–analysis, consensus, and time Communication: efficiency Clarifications, information exchange, and comments Interpersonal relationships Structure: imposed technology	Task related Decision–Quality, quantity Implementation: cost, ease, and commitment Attitude: acceptance, comprehension, satisfaction Group related Satisfaction Willingness to work again

Poole and DeSanctis [3]	Technology: Face-to-face versus dispersed support Level of sophistication: Level 1, Level 2, or Level 3 Degree of structure: rules or procedures Degree of control: leaders, facilitators, or assistants Context: Nature of group's task: degree of task knowledge and task type- generating, choice, execution, and negotiating Degree of agreement on values Group compositioin: power, leadership, time pressure	Use of social technology Structural features General spirit Use of group structures Rules Resources	Appropriation process Using technology faithfully or ironically Attitudes the group has to the technology: level of comfort and level of respect Level of consensus Control of system: intended to unintended	Outcomes Quality of the group's judgment on plan or decision Member consensus on the decision Member satisfaction with the meeting process and the group's decision
Hiltz [19, 20], Hiltz, Dufner, Holmes, and Poole [21]	GDSS: medium, tools, procedures, training, proximity, synchronous to asynchronous, and interface Task: type, equivocality, analyzability, time, difficulty, importance, and enjoyability Individual: attitudes, values, demographics, self-consciousness, interpersonal skills, and initial quality Group: size, homogeneity, initial consensus, and structure	Resultant communication dimensions Bandwidth Information richness Social presence Constraints Ease of use	Group adaptation process Level of effort Dropouts–handling Emergent structure Structuration: Use Attitude Control Consensus	Outcomes Quality: completion, correctness, improvement Consensus Satisfaction: group, task, individual, technology, interface, communication medium, and procedures

(continued)

Table 1 (Continued)

Author	*Contextual*	*Intervening*	*Adaptation*	
Applegate [24]	Context Environmental: competition, uncertainty Organizational: infosystem, leadership, culture, and so forth Group Leader: style, attitude, skills, power, and position Members: attitude, skills, power, and job tenure Structure and process: norms, size, history, and so forth Task Analyzability: high to low Type: generation, negotiation, choice, and execution Predictability: high to low Technology Settings Levels: communication exchange, uncertainty reduction, information filtering and structuring	Group member perception Task: importance, visibility, understanding, commitment Individual: values, personal needs, skills, motivation, ability, level of interest, degree of frustration	Process gains–losses Participation Influence Coordination Power, cohesion, clarity, and social–task balance Process effectiveness Level of effort Skills Level of knowledge Appropriateness of task Sufficiency resources Time Money People Skills	Outcome effectiveness Performance: client satisfaction, quality, complexity, quantity, and speed Satisfaction: with outcome, process, group, and technology Group viability: satisfaction, adaptation, learning, and strength
Nunamaker, Dennis, Valacich, Vogel, and George [8]	Group: size, proximity, time dispersion, composition, and cohesiveness Task: task activities and complexity Context: organizational culture, time pressure, evaluative tone, and reward structure Technology-EMS Process support: communication infrastructure, group memory, anonymity, parallel communication, and media Task support: information and computation infrastructure Task structure: techniques, rules, or models Process structure: techniques, rules, and procedures	Process variables Process gains Synergy, learning, stimulation, more information, better communication and objectives Process losses Cognitive overload: attention blocking, conformance pressure, and deindividuation Coordination problems: diffusion of responsibility, and incomplete task analysis		Outcomes Efficiency Effectiveness Satisfaction

McGrath [22], McGrath & Hollingshead [9]	Input factors Member attributes: cognitive, affective, conative, demographic Group attributes: heterogeneity, status Task–project: properties of the task or project Technology: properties of the hardware, software, communications for information input and task support Context: Physical variables: heat, noise Sociocultural: general cultural norm Temporal: deadlines, weekends, seasons Input factor interactions Member with: group, task, context Group with: task, technology, context Task with: technology, context Technology with: context	Organizing concepts Information processing systems Inception: project selection–assignment Problem solving: techniques, procedures, algorithms Conflict resolution: policy aspects Execution: goal attainment quantity, quality, speed Consensus generating systems Inception: group interaction, choice Problem solving: role-net definition Conflict resolution: power–payoff distribution Execution: interaction Motivating and regulating behavior Inception: member's participation, loyalty, commitment Problem solving: position and status attainment Conflict resolution: contribution–payoff relations Execution: participation in activities	Process variables participation Amount by time, members, topic Distribution by time, members, and topic Information processing Sharing, redundancy, integrative, complexity Consensus generating Disagreement: amount, intensity Conformity: pressure Normative regulation Commitment, satisfaction, solidarity	Outcome factors task performance Effectiveness: quality, quantity, speed, costs User reactions Process satisfaction Outcome satisfaction Member relations Attitudes Feelings of impersonality

(continued)

Table 1 (Continued)

Author	*Contextual*	*Intervening*	*Adaptation*	
Mennecke, Hoffer, and Wynne [26]	Meeting inputs Task characteristics: type, degree of structure, degree of complexity, rational versus political Individual member characteristics: attitudes, experiences, abilities, expertise Group characteristics: development, history, size, gender composition, leadership, status and power Meeting context: organizational culture, environment, incentives and rewards	Meeting process Facilitation process, gender, mode, duration Technology support types of tools methods design environmental setting degree of technical support Structural factors Duration of session Anonymity Number of sessions Proximity Heuristic restrictiveness and comprehensiveness Synchronous to asynchronous Sociotechnical issues Leadership Domination Ambiguity Participation Conflict Status	Feedback loop: group learning Meeting input Meeting process Meeting output	Meeting outputs Group performance Task accomplishments Decision quality Number of ideas generated Degree of consensus Individual Perceptions Attitudes Satisfaction Decision confidence Participation Group development Cohesion Leadership Norm development Status and power Member support Group well being
DeSanctis and Poole [27]	Structure of information technology Structural features: restrictiveness, level of sophistication, comprehensiveness Spirit: decision process, leadership, efficiency, conflict management, atmosphere Other sources of structure Task Organization environment	Social interaction Appropriation of structures Appropriation moves Faithfulness of appropriation Instrumental uses Attitudes toward appropriation	Emergent structure AIT outputs Task outputs Organization environments outputs	Decision outcomes Efficiency Quality Consensus Commitment New social structures Rules Resources

	Group's internal system Styles of interacting Knowledge and experience with structures Perceptions of others knowledge Agreement on appropriations	Decision processes Idea generation Participation Conflict management Influence behavior Task management		
Zigurs and Kozar [28]	Input variables Task performed Task qua task: objective properties—complexity Task as behavior: criteria for individual success Task as behavior description: described by what the participants actually do Task as ability requirements: the focus on personal abilities Group members Individual characteristics: age, gender, intelligence, personality, physical Structural characteristics: group size, cohesiveness, status, roles, norms Technological environment Support for communication versus support for process Configuration of communication over time and space	Interaction process Characteristics of interaction Idea stimulation Reduced production blocking Wider-ranging behavior Simultaneous conversations Continuing commentary Structured process	Interaction process Intermediate role outcomes Role assumption—technology Actual roles of participants Task related roles: recorder, proceduralists, evaluator, information–opinion seeker, information–opinion giver, idea generator, explainer Group-building roles: gatekeeper, motivator, mediator, follower, tension-releaser	Outcomes Task outcomes Correctness Efficiency of process Creativity of ideas Degree of consensus Group outcomes Satisfaction with process Satisfaction with outcome Perceived conflict Cohesiveness Motivation Morale and trust
Hollingshead and McGrath [29]	Input variables Group and member attributes Tasks, projects, and purposes Communication technology	Operating conditions Degree of anonymity Modalities available Time pressure New group members Change in task Change in division of labor Change in allocation of rewards Change in key group norms	Process variables Distribution of participation among members, over time and among functions Amount of participation, total amount, amount on-task, amount uninhibited, amount off-task, amount critical	Task product features Time Number of solutions Solution quality User reactions Rated satisfaction with process and outcomes Rated effectiveness Member relations Attraction Feelings of alienation, impersonality, and so forth

Note. GDSS = group decision support systems; EMS = electronic meeting systems; EDS = electronic decision systems; AIT = advanced information technology.

Table 2
Meta-Analysis Frameworks

Author	*Contextual*	*Intervening*	*Adaptation*	*Outcomes*
McLeod [30]	Contextual variables Group member characteristics: skill Situational factors: purpose for the group Group structures: hierarchy Technology: GSS Task characteristics: complexity	Group process Task strategy: depth of analysis Communication strategy: task oriented communication Interpersonal relations: degree of participation		Group outcomes Task outcomes: quality Member outcomes: satisfaction
Benbasat and Lim [31]	Meeting inputs (independent variables) Task characteristics Task complexity Solution multiplicity Group characteristics Member proximity Group size Formal hierarchy Group history Contextual factors Reward Technological factors Level of support Facilitation Improvements in design			Meeting outputs (dependent variables) Performance Decision quality Number of alternatives Time to reach decision Satisfaction Satisfaction with process Satisfaction with outcome Confidence with outcome Structural products Consensus Equality of influence

Note. GSS = group support systems.

3.3 Gray [18]

Gray [18] developed a very extensive model consisting of inputs, the group decision process, and outputs. Included within the outputs were secondary outcomes (attitudes, levels of consensus, etc.) that feed forward to the performance outcomes. This model was the first to show the interrelations among the outcome factors.

3.4 Dennis, George, Jessup, Nunamaker, and Vogel [4]

The Dennis et al. [4] approach emphasized the overlap of the technology to support meetings. An integrative concept (electronic meeting systems) was defined to include technology that supports decision-making activities and communication. The model consists of group processes and outcomes, methods, and environment.

3.5 Pinsonneault and Kraemer [7]

This framework consists of four factors: the context, the process, task related outcomes, and group related outcomes [7]. The primary theoretical argument is that the technological support facilitates group process through enhancing group capabilities, removing barriers to group interaction, improving the group in its task, and building or reinforcing the social values of the group by improving task performance effectiveness.

3.6 Poole and DeSanctis [3]

Groups are organized around common social activities such as decision making, work, socializing, establishing power, and meeting individual needs. If technologies are added to support groups in their endeavor, the nature of groups will not be changed. Groups will still pursue the same practices, make decisions, and engage in many activities such as socializing, joking, and so forth, but there will just be another set of variables that they can interact with—the GSS.

3.7 Hiltz [19, 20]; Hiltz, Dufner, Holmes, and Poole [21]

Computer-mediated communications systems also use the computer to structure, store, process, and distribute human communication and decision-making activities [22, 23]. The asynchronous mode expands the DeSanctis and Gallupe [1] model to include a third level (asynchronous) to the member proximity dimension.

3.8 Applegate [24]

Applegate [24] presented a model for study of the transfer and assimilation of GSS in organizations. Transfer and adoption are the methods by which the willingness to use an innovation are measured. Assimilation, then, is viewed as an adaptation and learning process. In this respect, studying the assimilation of new technologies (GSS) is the same as studying how the technologies affect decision making.

3.9 Nunamaker, Dennis, Valacich, Vogel, and George [8]

The Nunamaker et al. [8] model is an extension of the Dennis et al. [4] model. The model places a greater emphasis on the process losses and gains in terms of process support, process structure, task structure, and task support.

3.10 McGrath [25]; McGrath and Hollingshead [9]

McGrath and Hollingshead [9] built on the concepts of the time, interaction, and performance theory developed by McGrath [25]. The framework consists of four primary factors: input, organization concepts, process variables, and outcomes. The theory and resulting framework stress the interactive relations between the variables, rather than a main effects difference. One of the most interesting points of the framework is that the process variables can be regarded as both independent or dependent variables depending on the intended purpose.

3.11 Mennecke, Hoffer, and Wynne [26]

Mennecke, Hoffer, and Wynne [26] developed the first hybrid GSS framework and defined it in the context of a meeting. The hybrid framework integrates the relations between the meeting inputs (task, individual and group characteristics, and meeting context) with the meeting process (facilitation, technological support, structural factors, and sociotechnical issues) to produce meeting outputs (group performance, individual perceptions, and group development). The model also proposes that group member socialization and group learning may occur both during and subsequent to other meetings. This feedback will then redefine how the groups use the GSS and work with the task and the group.

3.12 DeSanctis and Poole [27]

DeSanctis and Poole [27], building on the earlier model [3], described the structures and processes that interact among advanced information technology (AIT), social structures, and human computer activity. The adaptive structuration theory framework includes dimensions of structure (AIT, organizational, the group's internal system), social interaction (appropriation and decision processes), the emergent sources of structure and outcomes (decision and new social structures).

3.13 Zigurs and Kozar [28]

Zigurs and Kozar [28] presented an integrative input–process–output research framework. The input factors consist of the task performed, group member characteristics, and the technological environment. The process factors are conceptualized as an interaction process between an initial set of variables and an intermediate set of role outcomes. The outcome variables consist of task and group related outcomes. This framework makes two significant contributions: First, it is the first framework that examines roles in a GSS environment; second, it is the second framework that stresses an inherent interrelation among the process variables.

3.14 Hollingshead and McGrath [29]

The Hollingshead and McGrath [29] framework is both a simplification and an enhancement of their earlier model [9]. It is simpler in that many of the factors (variables) have been regrouped and enhanced via a transformation from a theoretical to a research framework.

3.15 McLeod [30]

This is a meta-analysis of 42 studies conducted between 1980 and 1990 [30]. The theoretical framework is derived from Pinsonneault and Kraemer's [7] model. The results suggest that there is a relation between the input and outcome variables. Use of the GSS technology tends to increase decision quality, decision time, equality of participation, and the degree of task focus. There are negative impacts on consensus and satisfaction as well.

3.16 Benbasat and Lim [31]

Benbasat and Lim's [31] model is a meta-analysis based on 31 papers published between 1970 and 1992. The results of the analysis suggest that there is a definite relation between the input factors and the outcomes—namely that the use of GSS technology improves decision quality, the number of decision alternatives, and equality of participation. Negative effects were also observed for decision time, consensus, and satisfaction.

4. A PROPOSED FRAMEWORK FOR INTEGRATING GSS

A review of the current research on the impacts of GSS reveals that the alternative frameworks for evaluation can be reconceptualized as consisting of four major categories of variables as shown in Table 3: *contextual* or *independent* variables; *intervening* variables, which also have been labeled as *moderating* or *mediating* variables; *group adaptation processes*, which can be either independent or dependent variables; and *outcomes* or dependent variables. The dynamic relations among these sets of factors are shown in the theoretical model in Figure 4.

The contextual factors are all external or driving variables that comprise the environment or conditions for the decision-making task. For any one experiment, they are fixed or controlled. These variables are static in nature and do not change their values throughout the GSS activity.

Intervening factors represent the emergent structuring of the group interaction derived from and adding to the set of conditions created from the context of the group decision sessions. For example, the methods used by the group may vary as to session length and number of sessions. These factors can change from session to session and thus, are dynamic rather than static.

The second set of dynamic factors is the adaptation or interaction process of the group. These are the variables that are controlled by the group on an individual or a collective basis. From a general systems theory standpoint, they can be thought of as the control variables of the system. The changes in these variables, either

Table 3
Theoretical Framework for Analyzing GSS

Input	*Process*		*Output*
Contextual Factors	*Intervening Factors*	*Adaptation Factors*	*Outcome Factors*
Context Environment: competition, uncertainty, time pressure, evaluative tone Organizational: information system, age, goals, reward structure, organizational size, and so forth Cultural: American, British, Chinese, Hawaiian, Singaporian, and so forth Group Group characteristics: size and salience, ad hoc, established Composition: heterogeneity, organizational and job tenure, shared norms, member status, history and 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, and 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 and experience with structures, perceptions of others knowledge	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 and problem solving Nature and utilization of task performance strategies Level and utilization of member knowledge and skill Level and coordination of member effort Task: importance, visibility, understanding, and commitment Individual: values, personal needs, level of interest, and degree of	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 Process losses Free riding Evaluation apprehension Attenuation blocking Information overload	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 Consensus

- Task
  - Type: generate, choose, negotiate, and execute; gain–loss
    - Characteristics:
      - Structure: structured to unstructured
      - Equivocality: high to low
      - Complexity: high to low
      - Enjoyability: high to low
      - Analyzability: high to low
      - Importance: high to low
      - Predictability: high to low
    - Source: internal to external
    - Degree of task knowledge
    - Degree of agreement on values
- Technology
  - Communications mode: FtF, CMC, GSS, DSS, text, graphics, voice, image, sound, and video
  - Design: room configuration, interface, embeddability, extensibility, flexibility, functionality and usability
  - Process structures: anonymity, time, proximity, settings, procedures, control and structure; for example sequential versus parallel process; Levels 1, 2, and/or 3, structural features—restrictiveness, comprehensiveness, agenda setting NGT, DI, DA, facilitator, chauffeur, moderator
  - Task support (tools): agenda, electronic brain storming, voting, cognitive feedback, and so forth
    - interest, and degree of frustration
  - Psychological differences
  - Biases
- Organizing concepts
  - Information processing systems
  - Consensus generating systems
  - Behavior motivation and regulation
- Operating conditions
  - Modalities available
  - Changes in task, rewards, norms and division of labor
    - Information overload
    - Flaming
    - Dominance
- Intermediate role outcomes
  - Role assumption by technology
  - Actual roles of participants
  - Task-related and group-building: recorder, gatekeeper, follower, information–opinion seeker, information–opinion giver, proceduralist, motivator, explainer, evaluator
  - Values
- Consensus
  - Decision agreement
  - Commitment
- Usability measures
  - Learning time
  - Willingness to work together again
  - System utilization
  - Number of errors
  - Design preference

Note. GSS = group support systems; ftf = face-to-face; CMC = computer-mediated communications; DSS = decision support systems; NGT = nominal group technique; DI = dialectical inquiry; DA = devil's advocate.

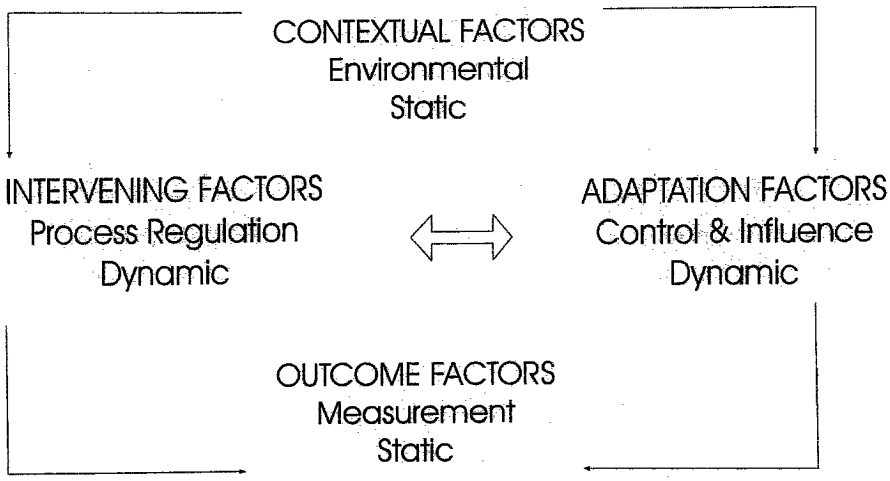

Figure 4. A factors oriented control model of group support systems.

independently or in concert with the contextual factors, act to influence the intervening variables. The variables can thus be an outcome and intermediate outcome or independent variable [9].

Finally, the outcomes are the results of the interplay of the intervening factors and adaptation of the group with the contextual factors. These are, of course, static variables that measure the results of the system process.

In the context of the above dimensional breakdowns for the factors that describe the system, we have a control system or cybernetic type of representation of the GSS environment. Many of the confusions of classification that appear in the literature are readily resolved by the associated properties of what are static and what are dynamic factors. For example, task when considered at the macro level, is usually a static contextual variable; however, task at the micro level may involve the observation of many different subtasks that can dynamically change as a part of the process. As a result, alternative investigations can easily differ in their classification of such a variable. Very often, such distinctions are left implicit because of the lack of any common factors model utilized by all investigators. In a given situation, some of the factors in the intervening and adaptive dimensions can be assumed to be static and treated as implicit or moved to the contextual dimension. The period of time used for a group activity is probably the crucial determinant for the factors that are dynamic in nature. This also impacts on the level (micro to macro) at which one must treat a factor (e.g., task).

4.1 Contextual Factors

The contextual category consists of four subfactors: *context, group, task,* and *technology,* which are in the immediate group environment [7] and the global group environment [24]. Applegate [24] suggested that it is the proper integration of these primary contextual variables through the intermediate stages (intervening and adaptation) that affects the outcomes of the group decision process.

Context factors consist of three levels: *environmental, organizational* [24], and *cultural.* The environmental subfactors refer to competition from other groups or organizations, the amount of uncertainty with regard to the outcomes and purpose of the group, time pressure, and evaluative tone. The organizational subfactors are the existing organization's information systems, organizational goals, reward structure, and organizational size. The cultural components are relatively new and consist of the different cultures (i.e., American, British, Hawaiian, etc.).

The group factors consist of group and individual variables. Group characteristics include group size, proximity, and time dispersion [1]. Composition includes the mix of heterogeneity, status, experience, and organizational accomplishments that members bring to a group meeting. Leadership is a combination of the superior–subordinate relationships and individual leadership characteristics. Member characteristics refer to the attitudes, character, values, power, and skills of an individual. Meeting structure consists of roles, goals, norms, anonymity, and intergroup–intragroup processes. The initial levels refer to the premeeting levels of cohesiveness, task understanding, consensus, agreement, styles of interacting, perceptions, and knowledge and experience. Group structures refer to the different styles of interacting, knowledge and experience with structures, and perceptions of other members knowledge.

Task factors include: *type, characteristics, task knowledge,* and *degree of agreement* on values [3]. Type refers to McGrath's [14] task circumplex model. The task characteristics are: analyzability, uncertainty, equivocality [32], complexity, enjoyability, predictability [19], and source [7]. Task knowledge refers to the levels of cause and effect knowledge that the group has. The degree of agreement on values is the extent to which the group members agree on standards for judging an acceptable choice or outcome [3, 33, 34].

Technology factors are the *communication mode* [8, 19], *design* [4, 35], *process structures* [1], and *task supports* (*tools*). Communication mode refers to the process supports [8] such as media richness [32], text, graphic, voice, image, sound, and video capabilities of the technology [35]. Design consists of the configuration of the decision room [1], the interface [19], embeddability, extensibility, and flexibility of the software [35], and usability of the entire system [36]. Process structure consist of time (synchronous to asynchronous) [37], proximity [1, 27], settings [24], procedures, and anonymity [7, 33]. Levels are also process structures [8] and refer to communication exchange, uncertainty reduction, information filtering, structuring in terms of restrictiveness and comprehensiveness [27], and processing capabilities of the technology [1]. The task supports [8] include electronic brain storming, agenda preparation, voting, and cognitive feedback.

4.2 Intervening Factors

The intervening category of variables are the first part or phase of the interaction process. The group interacts with the group, task, context, and technology through this set of intervening variables—and then, contingent upon this interaction, adaptation occurs. These variables are moderating or mediating sets of variables [9, 29] that can affect changes in the adaptation and outcome variables either

during the session or in subsequent sessions [26]. Adaptation results in the group's display of the decision process outcomes in terms of losses or gains [8, 37].

Intervening factors include two major categories: *methods* and *summary* constructs. Methods represent the basic tools of the experimenter (experimental design, task implementation, session length, number of sessions, order of treatment—very important in repeated measures designs—and training [4, 20]). These sets of experimenter controlled variables can affect how the groups function and thus are intervening factors. The summary variables consist of resultant communication dimensions [21, 33], group member perceptions and problem solving [9, 13, 24, 29], organizing concepts [9, 29], and operating conditions [29].

The resultant communication dimensions consist of bandwidth, social presence, and information richness [32, 39]. There have been relatively few studies that have investigated this set of variables. Perhaps this will change given the new era of multimedia technology.

Group member perception and problem solving refers to how an individual interacts with the group and the task. The task perceptions are the interaction of the individual and the group with the task: the double interact [40] or the double contingency effects [20]. In this respect it is the shared importance, visibility (personal gain or group gain through successful performance), understanding, and commitment. Individual perceptions consist of values, personal needs, level of interest, and degree of frustration. These variables can dramatically affect the group outcomes. For example, the larger the group, the greater the potential for process losses, simply because coordinating a large group is more difficult. Hackman and Morris's [13] main thesis is that this variable set can be manipulated to improve performance. In one study, Hackman and Kaplan [41] manipulated performance strategies and found that groups given a 5 min strategy session displayed more conflict, had more interpersonal problems, showed higher flexibility in dealing with the task, and more important, were able to change their procedures during the session if they were doing poorly. Thus, these variables have a dual nature. In one instance, they can be intervening variables that provide feedback to the group interaction process and can change from session to session or even within a session and are dynamic rather than static. In another instance, the variables can be used as independent variables as in the Hackman and Kaplan [41] experiment or an experiment by Connolly, Jessup, and Valacich [42] in which evaluative tone was used to study group performance. Problem-solving behavior is also particularly meaningful in asynchronous GSS [43] in which individuals are able to undertake problem-solving activities independent of the group process. This factor includes such aspects as psychological differences, biases, and differing strategies for information processing [44] and problem-solving behavior.

McGrath and Hollingshead's [9] organizing concepts provide the linkage between the intervening and adaptation factors. This set of variables is dynamic and can only be measured at discrete intervals. If there are sufficient temporal and motivational aspects available to the group then changes (adaptation) can be measured due to a context factor or a combination of context factors. These variables include information processing systems, consensus generating systems, and processes that motivate and regulate behavior. In a later work, Hollingshead and McGrath [29] renamed the variables for operating conditions that consist of

the degree of anonymity, time pressure, and changes in the task, division of labor, and so forth.

It is interesting that no other researchers explicitly discuss any intervening factors. However, Nunamaker et al. [8] included process and task supports as contextual factors. This is essentially a "black box" approach that assumes intervening factors are constant or they are being used as adaptation variables.

4.3 Adaptation Factors

Adaptation is the second phase or part of the interaction process. Adaptation incorporates the basic elements of the group adaptation process and structuration theory [3, 45, 46], process gains and losses [4, 8, 24], and intermediate role outcomes [28]. Three levels of adaptation are included within the model.

Group adaptation processes refers to *structuration*—the emergent structure [20, 27] developed by the group and its individual members, process variables [9, 29], and process issues [5]. Structuration theory is an attempt to explain how technology affects the group process and resultant outcomes [19]. In Mennecke et al.'s [26] model, adaptation is the feedback loop or organizational learning that occurs between the input, intervening, and outcome factors within a session or between sessions. Use of social technology consists of the structural features and general spirit provided by the technology at the first instance [3, 46]. The spirit also is an interaction; part of it can be explained as the Hawthorne effect, part by previous knowledge of the system or the technology in general, and part by how the group projects itself. Use of group structures refers to the interaction of the rules, procedures, and resources that the group decides to make, use, modify, and or reject [3].

Process gains include synergy, learning, and clarity [8]. Process losses includes free riding, evaluation apprehension, attenuation blocking, information overload, flaming, and dominance [1, 4, 8, 24].

The intermediate role outcomes include the assumptions that the technology can assume roles and that the participants can alter or accept these roles [28]. Zigurs and Kozar [28] reported that the technology can assume such roles as: recorder, proceduralist, gatekeeper, motivator, mediator, and information–opinion seeker. The roles that the group members can assume are task related (recorder, proceduralist, idea generator, etc.) and group-building roles (gatekeeper, motivator, mediator, follower, etc.).

4.4 Outcome Factors

Outcomes are the resultant goals, achievements, and outputs from the group decision process [4–6]. They are the result of the interplay of the intervening factors and adaptation of the group with the contextual factors. These are, of course, the static variables that measure the results of the system process. The variables can also be independent lag variables for the next session [26, 47, 48]. The outcomes consist of five subfactors: efficiency measures (e.g., calendar time to decision), effectiveness measures (e.g., decision quality), satisfaction measures

(e.g., participation, cohesiveness, and process satisfaction), consensus, and usability of the system and methods.

Effectiveness can be measured on many different dimensions, which include decision quality, timeliness of the decision, group and individual satisfaction with the decision, ease of implementation, commitment to implementation, and/or the group's willingness to work together in the future [1, 4, 7]. Simpler models consisting of efficiency, effectiveness, consensus, new social structures, and satisfaction are also presented [3, 5, 8, 9, 26–29].

Applegate [24] developed three measures of outcome effectiveness: *performance, satisfaction,* and *group viability.* Performance refers to client satisfaction, complexity, quantity, quality, and speed of the results. Satisfaction measures are the group or individual satisfaction with the outcome, process, the group, and the technology. Group viability refers to satisfaction adaptation, learning, and strength. These measures are measures of organizational interpretation and action [49].

Hiltz [19, 20] reminded us that outcome effectiveness is paradoxical in nature and in this respect there can be many performance or effectiveness trade-offs. Positive effects will emerge only if group interaction facilitates them.

5. SUMMARY AND CONCLUSIONS

To build a science of group support systems, it must be possible to compare the findings of different studies to build a general theory. The first step in building and testing a general theory is to have a common theoretical framework and a common language. A theoretical framework is not a theory; a theory posits causal and conditional relations among concepts.

The factors model may be considered a *prototheory.* It predicts contingent relations of the form:

- `if the` GSS technology (tools and embedded structures) is appropriate to the group, tasks, and environmental context;
- `and if` intervening factors are appropriate (such as adequate training, the right experimental design, with the right number of sessions and length);
- `and if` the group's adaptive structuration of the tools and procedures provided is faithful, so that the intended process gains are achieved and process losses avoided;
- `then` GSS will lead to certain desirable outcomes (such as better decisions).

Not included in this prototheory as diagrammed are certain paradoxes that have been observed in past studies, such as the fact that often, even if decision quality is improved by GSS, participants have less confidence in their decisions or are satisfied less with the decision-making process or outcomes. Unless longitudinal rather than single-session studies are conducted, the GSS researchers will not know if these results are due to unfamiliarity with the medium (in which

case members' perceptions will change over time), or to intrinsic characteristics of the technology at the present state of the art, such as decreased "social presence."

A next step in building a general theory is to compare different empirical studies to see what factors have actually made significant differences in outcomes and what the apparent causal relations are. McGrath and Hollingshead [9] suggested that the next step is to build a systematic map of all of the experimental information. Such a map would constitute both an integration of research knowledge and a detailed agenda for subsequent research. This would enable us to cut down to a more parsimonious set of factors and to begin to list some general causal predictions. In fact, several investigations are in progress [9, 29, 50, 51]. Furthermore, we need to be aware of the different ways in which these theoretical constructs have been measured and to begin to use common measures in different studies to be able to directly compare and contrast results. In particular, it is important to collect and report comparable data on adaptation processes. Indeed, the shift in emphasis to understanding process and its complexities that has occurred in recent GSS research is making the adaptation factors key to the emerging theoretical paradigm.

REFERENCES

[1] G. DeSanctis and R. B. Gallupe, "A foundation for the study of group decision support systems," *Management Science*, vol. 33, no. 5, pp. 589–609, 1987.

[2] G. P. Huber, "Issues in the design of group decision support systems," *MIS Quarterly*, vol. 3, no. 3, pp. 195–204, 1984.

[3] M. S. Poole and G. DeSanctis, "Understanding the use of group decision support systems: The theory of adaptive structuration," in *Organizations and Communication Technology*, J. Fulk and C. Steinfield, Eds. Newbury Park, CA: Sage, 1990, pp. 173–193.

[4] A. R. Dennis, J. F. George, L. M. Jessup, J. F. Nunamaker, and D. R. Vogel, "Information technology to support electronic meetings," *MIS Quarterly*, vol. 12, pp. 591–618, Dec. 1988.

[5] M. T. Jelassi and R. A. Beauclair, "An integrated framework for group decision support system design," *Information and Management*, vol. 13, pp. 143–155, 1987.

[6] K. L. Kraemer and J. L. King, "Computer-based systems for cooperative work and group decision making," *ACM Computing Surveys*, vol. 20, no. 2, pp. 115–146, 1988.

[7] A. Pinsonneault and K. L. Kraemer, "The impact of technological support on groups: An assessment of the empirical research," *Decision Support Systems*, vol. 5, pp. 197–216, 1989.

[8] J. F. Nunamaker, A. R. Dennis, J. S. Valacich, D. R. Vogel, and J. F. George, "Electronic meeting systems to support group work," *Communications of the ACM*, vol. 34, no. 7, pp. 41–61, 1991.

[9] J. E. McGrath and A. B. Hollingshead, *Groups Interacting With Technology*. Thousand Oaks, CA: Sage, 1994.

[10] J. S. Valacich, L. M. Jessup, A. R. Dennis, and J. F. Nunamaker, "A conceptual framework of anonymity in group support systems," *Group Decision and Negotiation*, vol. 1, no. 3, pp. 219–241, 1992.

[11] H. J. Leavitt, *Managerial Psychology*. Chicago: University of Chicago Press, 1964.

[12] B. R. Konsynski and E. A. Stohr, "Decision processes: An organizational view," in *Information Systems and Decision Processes*, E. A. Stohr and B. R. Konsynski, Eds. Los Alamitos, CA: IEEE Computer Society Press, 1992, pp. 27–50.

[13] J. R. Hackman and C. G. Morris, "Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration," in *Group Processes*, L. Berkowitz, Ed. New York: Academic, 1978, pp. 1–55.

[14] J. E. McGrath, *Groups: Interaction and Performance*. Englewood Cliffs, NJ: Prentice Hall, 1984.

[15] G. L. DeSanctis and R. B. Gallupe, "Group decision support systems: A new frontier," *Data Base*, vol. 16, no. 2, pp. 3–9, 1985.
[16] H. A. Simon, *The Science of Management*. New York: Harper, 1960.
[17] P. G. Keen and M. S. Scott-Morton, *Decision Support Systems: An Organizational Perspective*. New York: Addison-Wesley, 1978.
[18] P. Gray, "Group decision support systems," *Decision Support Systems*, vol. 3, pp. 233–242, 1987.
[19] S. R. Hiltz, "Distributed group support systems," in *Proc. Coordination Theory and Collaboration Technology Workshop*, 1991, pp. 69–76.
[20] S. R. Hiltz, "Distributed group support systems," Grant proposal submitted to the National Science Foundation, 1990.
[21] S. R. Hiltz, D. Dufner, M. Holmes, and M. S. Poole, "Distributed group support systems: Social dynamics and design dilemmas," *Journal of Organizational Computing*, vol. 2, no. 1, pp. 135–159, 1991.
[22] S. R. Hiltz, M. Turoff, and K. Johnson, "Using a computerized conference system as a laboratory tool," *SIGSOC Bull*, vol. 13, no. 4, pp. 5–9, 1982.
[23] E. B. Kerr and S. R. Hiltz, *Computer-Mediated Communication: Status and Evaluation*. New York: Academic, 1982.
[24] L. M. Applegate, "Technology support for cooperative work: Framework for studying introduction and assimilation in organizations," *Journal of Organizational Computing*, vol. 1, no. 1, pp. 11–39, 1991.
[25] J. E. McGrath, "Time, interaction, and performance (TIP) a theory of groups," *Small Group Research*, vol. 22, no. 2, pp. 147–174, 1991.
[26] B. E. Mennecke, J. A. Hoffer, and B. E. Wynne, "The implications of group development and history for group support system theory and practice," *Small Group Research*, vol. 23, no. 4, pp. 524–572, 1992.
[27] G. DeSanctis and M. S. Poole, "Capturing the complexity in advanced technology use: Adaptive structuration theory," *Organization Science*, vol. 5, no. 2, pp. 121–147, 1994.
[28] I. Zigurs and K. A. Kozar, "An exploratory study of roles in computer-supported groups," *MIS Quarterly*, vol. 18, no. 3, pp. 277–297, 1994.
[29] A. B. Hollingshead and J. E. McGrath, "Computer-assisted groups: A critical review of the empirical research," in *Team Effectiveness and Decision Making in Organizations*, R. A. Guzzo and E. Salas, Eds. San Francisco: Jossey-Bass, 1995, pp. 46–78.
[30] P. L. McLeod, "An assessment of the experimental literature on electronic support of group work: Results of a meta-analysis," *Human-Computer Interaction*, vol. 7, pp. 257–280, 1992.
[31] I. Benbasat and L. Lim, "The effects of group, task, context, and technology variables on the usefulness of group support systems: A meta-analysis of experimental studies," *Small Group Research*, vol. 24, no. 4, pp. 430–462, 1993.
[32] R. L. Daft and R. H. Lengel, "Organizational information requirements, media richness, and structural design," *Management Science*, vol. 32, no. 5, pp. 554–571, 1986.
[33] W. R. Scott, *Organizations: Rational, Natural and Open Systems*. Englewood Cliffs, NJ: Prentice-Hall, 1981.
[34] J. D. Thompson, *Organizations in Action*. New York: McGraw-Hill, 1967.
[35] M. Chen and Y. I. Liou, "The design of an integrated group support environment," in *Proc. HICSS, Vol. IV*, 1991, pp. 333–342.
[36] J. D. Gould and C. Lewis, "Designing for usability: Key principles and what designers think," *Communications of the ACM*, vol. 28, no. 3, pp. 300–311, 1985.
[37] S. R. Hiltz and M. Turoff, "Structuring computer-mediated communication systems to avoid information overload," *Communications of the ACM*, vol. 28, no. 7, pp. 680–689, 1985.
[38] R. B. Gallupe, G. DeSanctis, and G. W. Dickson, "Computer-based support for group problem-finding: An experimental investigation," *MIS Quarterly*, vol. 12, pp. 277–296, June 1988.
[39] R. E. Rice and G. Love, "Electronic emotion: Social emotional content in a computer-mediated communication network," *Communication Research*, vol. 14, no. 1, pp. 85–108, 1987.
[40] K. E. Weick, *The Social Psychology of Organizing*. Reading, MA: Addison-Wesley, 1979.
[41] J. R. Hackman and R. E. Kaplan, "Interventions into group process: An approach to improving the effectiveness of groups," *Decision Sciences*, vol. 5, pp. 459–480, 1974.

[42] T. Connolly, L. M. Jessup, and J. S. Valacich, "Effects of anonymity and evaluative tone on idea generation in computer-mediated groups," *Management Science*, vol. 36, no. 6, pp. 689–703, 1990.
[43] M. Turoff, "Computer-mediated communication requirements for group support," *Journal of Organizational Computing*, vol. 1, pp. 85–113, 1991.
[44] I. Benbasat and R. N. Taylor, "Behavioral aspects of information processing for the design of management information systems," *IEEE Transactions on System, Man, and Cybernetics*, vol. SMC–12, no. 4, pp. 439–450, 1982.
[45] M. S. Poole, D. R. Seibold, and R. D. McPhee, "Group decision-making as a structurational process," *Quarterly Journal of Speech*, vol. 71, pp. 74–102, 1985.
[46] M. S. Poole and G. DeSanctis, "Use of group decision support systems as an appropriation process," in *Proc. HICSS 21*, 1989, pp. 149–157.
[47] A. Gopal, R. P. Bostrom, and W. W. Chin, "Applying adaptive structuration theory to investigate the process of group support systems use," *Journal of Management Information Systems*, vol. 9, no. 3, pp. 45–69, 1993.
[48] V. Sambamurthy and W. W. Chin, "The effects of group attitudes toward alternative GDSS designs on the decision-making performance of computer-supported groups," *Decision Sciences*, vol. 25, no. 2, pp. 231–241, 1994.
[49] R. L. Daft, R. L. Weick, and K. E. Weick, "Toward a model of organizations as interpretation systems," *Academy of Management Review*, vol. 9, no. 2, pp. 284–295, 1984.
[50] E. W. Christensen and J. Fjermestad, "Challenging group support systems research: The case for strategic decision making," *Group Decision and Negotiation*, vol. 6, no. 1, pp. 351–372, 1997.
[51] J. Fjermestad and S. R. Hiltz, "Experimental studies of group decision support systems: An assessment of variables studied and methodology," in *Proc. HICSS 30, Vol. II*, 1997, pp. 45–65.
[52] A. Pinsonneault and K. L. Kraemer, "The effects of electronic meetings on group process and outcomes: An assessment of the empirical literature," *European Journal of Operations Research*, vol. 46, pp. 143–161, 1990.