The Dynamic Effects of Group Support Systems on Group Meetings

BRUCE A. REINIG AND BONGSIK SHIN

BRUCE A. REINIG is an Associate Professor of Information Systems at San Diego State University. He received his Ph.D. in Management Information Systems from the University of Arizona in 1996. His research interests include the use of computer technology to support group decision-making and collaborative work.

BONGSIK SHIN is an Associate Professor of Information Systems at San Diego State University. He received his Ph.D. in Management Information Systems from the University of Arizona in 1997. His research interests include telework and collaborative technologies.

ABSTRACT: A number of theoretical models have been presented in group support systems (GSS) literature, which suggest that various GSS structures such as anonymity and simultaneity, influence group interaction, which in turn influences group productivity and meeting outcomes. Examples of such theories include the adaptive structuration theory and the balance of forces model and they could generally be described as dynamic or procedural in nature. Much of the empirical research that tests such theories, however, is deterministic in that it often compares final outcomes between various levels of technological support without measuring and testing (1) the influence that the technological structures have on group interaction and group dynamics, and (2) the corresponding influence that group interaction has on meeting outcomes. This paper reports a study that examines the validity of such dynamic theories by examining the relationships between GSS structures, group dynamics, and meeting outcomes over time. Four process constructs (production blocking, free riding, sucker effect, and evaluation apprehension) and three meeting outcome constructs (group cohesion, affective reward, and self-reported learning) were initially selected for the study. Structural equation modeling was used to analyze longitudinal survey data gathered from an experiment conducted with naturally occurring groups. The model tested was found to be valid and GSS was found to be effective in reducing process losses. However, the findings also revealed that process losses vary in the degree to which they influence meeting outcomes and certain meeting outcomes, such as affective reward, were found to be heavily influenced by other meeting outcomes, such as group cohesion and self-reported learning. Theoretical implications of the study and methodology are discussed.

KEY WORDS AND PHRASES: adaptive structuration theory, computer-mediated communication, group support systems.

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A NUMBER OF THEORETICAL MODELS have been presented in group support systems (GSS) literature that suggest that various GSS structures, such as anonymity and simultaneity, influence group interaction, which in turn influences group productivity and meeting outcomes [21, 31, 66, 70, 74, 93]. Such theories could generally be described as dynamic or procedural in nature. However, much of the empirical research that tests such theories is deterministic in that it often compares final outcomes between various levels of technological support without measuring and testing (1) the influence that the technological structures have on group interaction and group dynamics, and (2) the corresponding influence that group interaction has on meeting outcomes. The hypothesis that GSS positively affects meetings has not been supported with empirical consistency (see Fjermestad and Hiltz [35] for an overview). Consequently, it is difficult to determine the validity of dynamic theories.

In the study presented here, we examine the integrity of a procedural research model describing the dynamic impact of GSS on meeting outcomes. We examine the influence of GSS technology on group processes and the corresponding effects that those processes have on meeting outcomes. To do this, we used a general research model that reflects the theoretical views of the adaptive structuration theory (AST) [31] in that it emphasizes the roll of social interactions in determining how technology ultimately affects group outcomes. Three outcome and four process variables were chosen for the study and relevant hypotheses were proposed. A longitudinal experiment was conducted consisting of eight tasks for a naturally occurring face-to-face group and a naturally occurring GSS group. The experiment took place over two consecutive academic semesters and longitudinal data were gathered in the form of post-session surveys. A path analysis using structural equation modeling (SEM) was conducted to validate the integrity of the research model. It was confirmed that GSS technology, in this particular study, improved the meeting process, which led to more favorable participant perceptions of meeting outcomes.

Literature Review and Theory

NUMEROUS THEORIES AND FRAMEWORKS have been introduced to describe how GSS improves various aspects of meeting performance through improved meeting dynamics. The balance of forces model [21] suggests that GSS alters the extent to which creativity is stifled or enhanced during group interactions, and this in turn affects meeting outcomes such as satisfaction and idea generation. Poole et al.'s [70] research model describes how GSS may influence the conflict interaction process, which then affects outcomes such as group consensus. Based on theories of communication, minority influence, and human information processing, Rao and Jarvenpaa [74] introduce causal models that depict how GSS use may affect meeting effectiveness given the nature of the individuals and tasks involved. The theory of adaptive structuration [31] suggests that the effectiveness of GSS is conditioned by how users appropriate the technology during social interaction rather than being automatically determined by its native features.

The models cited share similarities as well as differences. Some (for example [21]) are more narrowly focused than others (for example [74]) in the scope of technology features, process descriptions, and outcome variables. Some (for example [31]) are more dynamic and process-oriented than others (for example [74]). Despite their differences, these models share two similarities. First, GSS is an enabling technology that can promote constructive social interactions, which in turn will increase meeting performance. They are process-oriented and contribute to the understanding of how technology features such as anonymity and simultaneity affect group interactions. Second, they are similar in that GSS implications for a group meeting should be understood from the perspective of a particular situation. These models, in general, concur that meeting context, such as individual and task characteristics [66, 74, 92], reward system [6], facilitation [61, 91], and groups' internal structures [31], will moderate the degree to which GSS positively or negatively influence the outcome of a meeting.

Based on the aforementioned theories, numerous empirical studies have been conducted. However, most empirical studies have followed a deterministic, rather than procedural, research paradigm. Researchers have identified this gap between the theoretical models tested and the research methodologies used as one of the primary reasons for inconsistent empirical results [25, 35, 74]. That is, deterministic research methodologies often fail to account for the effect of a group's intermediate social dynamics.

More noticeably, most experiments employ a one-shot methodology with ad hoc groups [35, 58], completely ignoring the effects of time and history on GSS dynamics and performance. A number of studies (for example [17, 18, 58]), however, have demonstrated that outcomes differ for both GSS and face-to-face groups over time. That is, the results of a group effort in an initial meeting are not necessarily indicative of the results realized in later meetings. For example, in a study conducted by Chidambaram et al. [18], GSS participants reported less group cohesion than their face-to-face counterparts in initial meetings, but in subsequent meetings the GSS participants reported more group cohesion than the face-to-face participants did. Also, field research examining the use of GSS with naturally occurring groups over long periods have consistently reported positive results, including reductions in project completion times and labor costs savings [39, 66, 71, 83]. The positive findings of field research stand in stark contrast to the inconsistent findings from experimental research.

Whereas a majority of GSS research has used groups ranging in size from two to five participants, GSS has been shown to be most effective with larger groups in terms of improving quantity and quality of participation, participant satisfaction, and reducing process losses [65]. One reason for this is that airtime fragmentation increases as group size increases, and thus escalates the manifestation of process losses such as free riding, production blocking, and evaluation apprehension [36]. Dennis et al. [26] found that GSS-supported 18-member groups produced more unique and high-quality ideas than GSS-supported nine-member, and three-member groups did.

The use of small group sizes in experimental research is also not indicative of what takes place in the field [26]. Many field studies have used group sizes larger than 20

[9, 56, 63, 64], 30 [27, 28, 80], or even 40 or more participants [12, 87]. For example, Dennis et al. [28] report using GSS with business and health care groups ranging in size from 11 to 38 members for strategic planning purposes, including strategy formulation, strategy analysis, and environmental planning. Briggs et al. [12] report using GSS to support groups ranging from 40 to 50 members in military exercises aboard the USS *Coronado*.

Theory and Research Model

The research model we used for this study reflects the views of AST. AST emphasizes the dynamic and emergent nature of meeting outcomes and the importance of social interactions [31, 38]. Structures and appropriation compose the central concepts of AST. Structures represent formal and informal rules and resources provided by a technology and an institution [31, 55]. Internal characteristics of a group, features of an information technology (IT), tasks-related characteristics, and organizational environment compose major structures. Structures of GSS include its hardware and software features such as anonymity and simultaneity. Most GSS-supported meetings are conducted in an anonymous fashion; that is, the system does not attach the identity of the source of the comment. This feature can be controlled in that a system facilitator could require meeting participants to log in at the beginning of a meeting and subsequently attach their names to each comment and vote submitted. However, this is not usually done in practice as the anonymity feature is often cited as one of the principle advantages of GSS technology. The simultaneity feature allows all or a set of participants to submit comments and otherwise interact with the system at the same time. Unlike anonymity, there is no direct way for a system facilitator to control this feature except either activate or inactivate certain participants.

These structures are further defined according to their spirit. Spirit is the "general intent with regard to values and goals underlying a given set of structural features" [31, p. 126]. For example, spirits commonly associated with GSS would include the welcoming of open and frank discussion as well as equal access to participation.

Appropriation is the manner in which structures are used by participants. According to the AST, appropriation of a technology is not automatically determined by its designs and features, but selected by users. During the process of technology appropriation, new social structures are produced over time. Effective technology use is conditioned by the manner in which users appropriate structures of a technology, given other contingency structures. The contribution of GSS to the performance of a group session is therefore determined by the mode in which participants appropriate GSS features and by the extent to which the spirit of GSS features is substantiated as intended. Such participant attitudes toward a technology as faithfulness and level of consensus on its appropriation establish the mode of technology appropriation [31].

The manner in which a group appropriates technology changes over time as groups seek to realize a shared meaning of a system and how to best manage, or overcome, the various structures imposed by the system. One-shot groups do not have an expectation for future meetings, which can negatively affect the social dynamics of a group

[86]. Participants in groups that expect to meet multiple times tend to be friendlier, more cooperative, and engage in more self-disclosure [48]. The social information processing (SIP) theory specifically considers historic and temporal influences on group dynamics and relational development [85]. SIP theory is based on a number of assumptions including (1) that people develop interpersonal impressions of others through verbal and nonverbal interactions over multiple encounters, and (2) that this process takes longer using computer-mediated communication (CMC) channels than it does with face-to-face interaction [85]. SIP theory then proposes that interpersonal impressions will take longer to develop in groups without any history and that personalized communication takes longer to manifest in CMC groups than it does in face-to-face groups. Thus, time is expected to have an impact on both group dynamics and meeting outcomes.

Based on the preceding discussion, we present a procedural research model in Figure 1. The model depicts the basic tenet of AST and other process-oriented theories (for example [21, 32, 66, 70, 74, 93]) in that GSS structures directly affect a group's social interactions and dynamics. The exact nature of this relationship is dependent upon how the group appropriates structures such as anonymity and simultaneity. Such an appropriation, however, is not always consistent with the intentions of the designers of the technology. The model also depicts how the nature of the groups' social interactions and dynamics ultimately determine meeting outcomes such as satisfaction and group cohesion. The temporal effects suggested by SIP theory are also incorporated in the general model. As Walther [85] suggests and Chidambaram [17] demonstrates, the nature of a group's social dynamics and outcomes change over time. Thus, it is necessary to study and measure group dynamics and outcomes over multiple time periods to reveal the true nature of the relationships between these constructs. The relationships depicted by this model are translated into specific hypotheses in the next section.

Endogenous Measures and Hypotheses

THIS SECTION ADDRESSES HOW THE RESEARCH MODEL in Figure 1 was used to develop a set of structural equations for hypotheses testing (Figure 2). To do this, we identified specific constructs to represent the endogenous variables (that is, social interactions and meeting outcomes) and then developed hypotheses as to the nature of the relationship between the exogenous variables (that is, GSS structures and time) and the constructs identified. Hypotheses are also developed with regard to the relationships among the meeting outcomes.

To examine the relationship between GSS structures and social interactions, four process constructs were identified. These include production blocking, evaluation apprehension, free riding, and sucker effect.

Production blocking refers to the loss of ideas, or failure to generate or remember new ideas, while waiting for a turn to speak during a meeting [66]. GSS may reduce production blocking through the structure of group memory and simultaneity. Evaluation apprehension is the fear of being negatively evaluated by one's peers and often

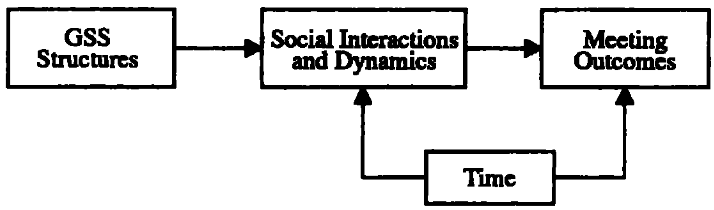

Figure 1. Procedural Research Model

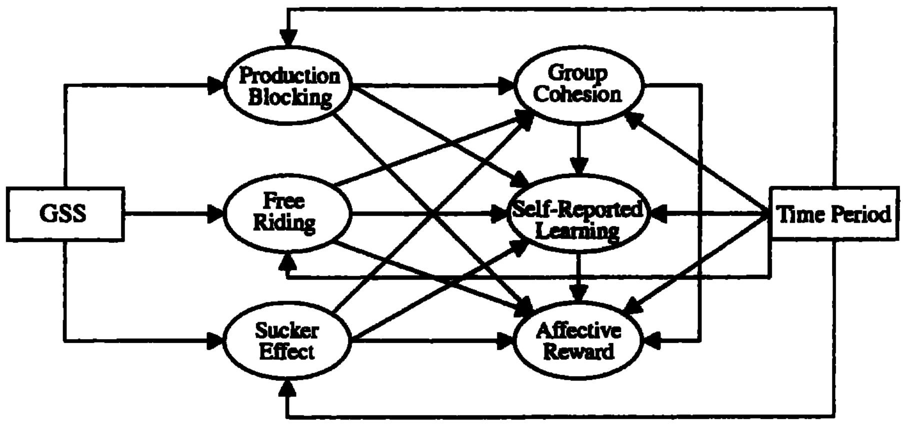

Figure 2. Structural Equations Tested

prevents participants from presenting their ideas or questions to a group [32, 43]. GSS may reduce evaluation apprehension through the structure of anonymity as it reduces the possibility of being identified by group members and thus allows ideas to be evaluated separately from the person who submitted them. Free riding occurs when individuals choose to minimize effort in a group setting. GSS may reduce free riding through the structure of simultaneity. Shepherd et al. [79] have shown that participants in GSS are motivated by social comparison [37, 68] and increase their participation to match the level of other members. The sucker effect occurs when hardworking individuals feel their efforts are being taken advantage of by other members [49, 77]. GSS may reduce the sucker effect through the structure of anonymity by lessening the ability of an individual to identify low-performing individuals, a necessary antecedent for the sucker effect to manifest. Based on the preceding discussion, Hypothesis 1 is proposed.

> *H1: Participants in GSS meetings will report less production blocking (H1a), free riding (H1b), sucker effect (H1c), and evaluation apprehension (H1d) than participants in face-to-face meetings.*

To examine the relationship between social interactions and meeting outcomes, three outcome constructs were identified in addition to the four process constructs previously discussed. The three outcome constructs include individual perception of group cohesion, self-reported learning, and affective reward. Group cohesion represents the degree of mutual cooperation, confidence, and trust that exists among group participants and can take the form of verbal or nonverbal support [18]. When participants experience social equality during a group session, they may become more focused and outspoken in expressing their views. This may increase task-related conflicts during a meeting, but groups that identify and resolve task-related disagreements may experience greater group cohesion than they would have if the disagreements were left uncovered due to pressures of conformity and evaluation apprehension [17]. Such supportive dynamics may become stronger when members are relatively homogenous, task motivated, and there is a strong peer stimulation that encourages individuals to perform better [21]. From this line of reasoning, it is expected that process losses that negatively influence group dynamics will reduce the level of cohesion among participants. Therefore, it is hypothesized that:

> *H2: Production blocking (H2a), free riding (H2b), sucker effect (H2c), and evaluation apprehension (H2d) are negative predictors of group cohesion.*

The educational implications of IT-enabled learning have recently been getting much attention among researchers as well [3, 4, 50, 52, 53, 54, 78]. The effects of IT on the learning process are often examined from the perspectives of the constructivist theory and its offspring such as the cooperative learning theory, which take a learner-centered instruction paradigm [54]. These models emphasize that active involvement through collaboration, participation, and sharing are crucial to individuals' becoming creative, critical, and productive learners.

Empirical attempts have been made to validate that a collaborative learning process, characterized by social support and feedback, might facilitate high-level reasoning, critical thinking, creativity, and knowledge acquisition among GSS participants [3, 53, 54]. During cooperative learning activities, participants work together in groups to understand concepts, to solve problems, and to engage in peer-to-peer feedback. By offering feedback to others, students may be exercising and testing their own mental models more fully and deeply than they otherwise would. Overall, these studies indicate that when the group process becomes more cooperative and synergetic, learning effectiveness can be improved.

Moreover, the reduction of production blocking enabled by the simultaneity and feedback capabilities of GSS may considerably improve a participants' ability to extend their mental model of a task, understanding of a problem, and knowledge acquisition [78]. With improved social dynamics, participants may be stimulated to engage actively in knowledge construction and assimilation [50], and to enhance their critical thinking and high-order cognitive processing [4, 53]. Collective learning may also be stimulated by the effective informational influence that GSS facilitates in exchanging messages [42]. Overall, these studies imply that the quality of group interplay composes a significant differentiator in individual learning. Therefore, we hypothesize that:

H3: Group cohesion (H3a) is a positive predictor of self-reported learning and production blocking (H3b), free riding (H3c), sucker effect (H3d), and evaluation apprehension (H3e) are negative predictors of self-reported learning.

The satisfaction construct has been repeatedly adopted as a representative benchmark to measure the success of an information system. This has also been true for GSS research. The importance of this dependent construct was recognized by Niederman et al.'s [62] study in which GSS facilitators indicated that satisfaction was one of three main performance measures of a group meeting. Various measures of satisfaction have been suggested. Briggs and de Vreede [11] identify satisfaction with product and satisfaction with process as the two main dimensions of meeting satisfaction. We chose a single construct related to meeting satisfaction called affective reward [10, 76] for inclusion as an outcome variable in our study. Affective reward is defined as "the positive emotional response sometimes associated with goal attainment" [76, p. 171] and is often expressed by participants after a successful meeting.

Process-oriented theories such as AST have often suggested relationships between group dynamics and satisfaction. For example, the balance of forces model [21] suggests that process losses, such as evaluation apprehension, free-riding, and production blocking, are creativity stifling forces that influence group interaction, which in turn influences participant satisfaction. Nunamaker et al. [66] identify process gains (such as synergy and objective evaluation) and process losses (such as evaluation apprehension and free riding), depending on whether they facilitate or hinder meeting effectiveness. Theoretical studies argued that the effectiveness of a group meeting is optimized with minimized process losses and maximized process gains [29, 66, 74]. It is reasonable to speculate that improved meeting effectiveness may influence the expression of gratification regarding the meeting. Thus, the following hypothesis is proposed.

H4: Group cohesion (H4a) is a positive predictor of affective reward. Production blocking (H4b), free riding (H4c), sucker effect (H4d), and evaluation apprehension (H4e) are negative predictors of affective reward.

Although regarded as a meeting outcome in this study, self-reported learning may also be viewed as an intermediate variable that may influence affective reward. Researchers have found that students who perceive an increase in learning express more favorable evaluations of the class experience in terms of the learning process and outcomes [4]. Therefore, it is hypothesized that:

H5: Self-reported learning is a positive predictor of affective reward.

Theories such as AST and SIP suggest that group dynamics and outcomes change over time. Groups work to understand technological structures and work to appropriate technology into the group process. New structures may emerge, thus making the process iterative and temporal. AST posits that changes in group dynamics and outcomes are neither universally positive nor negative. Some groups improve with time, some worsen, and others fluctuate depending on how participants actively select and reproduce structural features over time [31]. Groups could, for example, embrace anonymity and use it to openly share ideas and promote positive discourse. On the other hand, anonymity could be used to engage in off-task communication and flaming, and thus present more challenges than benefits [75].

SIP theory suggests that outcomes such as group cohesion can be realized as interpersonal development occurs over multiple time periods. The important consideration here is that both the social dynamics and meeting outcomes are procedural in nature and subject to change over time. For example, relational development might take longer to occur in GSS groups than in face-to-face groups [17]. On the other hand, GSS-supported meetings may have a longitudinal effect in reducing interpersonal conflicts and in increasing group cohesion [18, 60]. Such transitory changes may be prompted by developing patterns in social interactions and relationships, and temporal accumulation of knowledge and experience with technology structures [17, 31]. Therefore, the hypothesized relationship with time is nondirectional:

> *H6: Time will have a significant impact on group dynamics (production blocking [H6a], free riding [H6a], sucker effect [H6c], and evaluation apprehension [H6d]) and meeting outcomes (group cohesion [H6e], self-reported learning [H6f], and affective reward [H6g]).*

Research Method

A LONGITUDINAL EXPERIMENT WAS CONDUCTED using two classes held in consecutive semesters. Participants were students enrolled in an introductory management information systems (MIS) course offered at a large southwestern university. The first semester class had 23 students and the second semester class had 20 students. Both classes were similar with respect to gender, GPA, and age. At identical intervals throughout the semester, students debated eight ethical scenarios addressing MIS issues such as software piracy, database marketing, expert systems, and e-mail privacy [89]. The goal of the tasks was to make the students aware of ethical issues facing IT professionals, and teach them to apply ethical frameworks to those situations [51]. The two classes were identical with respect to course syllabus, assignments, lectures and exams, and instructor. With the exception of the eight scenarios, for which the GSS group met in an electronic meeting room, both classes were held in similar classrooms in the same building. From the nature of the experimental design, this research was a field study in which the experimental controls and data gathering were conducted in natural classroom settings [69]. A seven-point Likert scale post-experiment survey was used to measure individual perceptions of the process constructs and meeting outcomes following each of the eight tasks. Previously validated instruments were used [3, 10, 24, 72, 76] for all constructs except the sucker effect and three questionnaire items were used to measure each construct. The items used appear in the Appendix.

Although there was a possible history threat to this design since the classes did not run concurrently, we deemed it to be a reasonable choice, given the circumstances.

First, pilot tests suggested that strong resentment might have been a demoralizing factor when two classes were run concurrently, but only one was allowed to use GSS technology and the other was not. Previous GSS-supported learning research had revealed such a concern [3]. Also, interaction among students from the two classes was expected to be minimal since the honor students were from various colleges within a large university system and had little chance of encountering members of the other treatment. Post-semester interviews with the face-to-face participants confirmed that information sharing did not occur.

Experimental Procedure

The fall-semester class served as the face-to-face group and the spring semester class served as the GSS group. All aspects of the course were as similar as possible throughout both semesters; the communication medium used to discuss the eight ethical scenarios was the only exception to conformity. The tasks assigned were identified by the authors of the course text [51] to help students learn about the ethical issues facing information technology and to recognize the critical issues involved. The same instructor taught both sections and was able to maintain consistency in presentation, having taught the course nine times previously.

The scenarios were discussed during eight separate class periods throughout the semester. Scenarios were scheduled to coincide with topics covered in class. For example, the second scenario addressed e-mail monitoring, which was discussed the week after students set up their e-mail accounts and joined the class e-mail distribution list. The instructor handed out copies of the scenario to each student and then read it aloud to the class, asking if any clarification was necessary. At this point, the face-to-face group proceeded to discuss the scenarios in a traditional round table format and the GSS group used GroupSystems, a GSS developed by GroupSystems.com.

The anonymity feature provided by GroupSystems was used for the GSS group throughout the semester. The degree of true anonymity among group members may be different depending on the group size. Small group members may recognize each other's identity even under the anonymous GSS environment, easily defeating the purpose (or spirit) of GSS support. Given the relatively large group size in this case, we expected that the fundamental intention of GSS utilization, maintaining true anonymity among participants, was preserved.

All eight scenarios for both classes ran at least 20 minutes. In order to make the students individually accountable, an in-class writing assignment following every discussion required students to either defend the actions proposed as ethical or to condemn them as unethical. Students were randomly assigned a position to take, with the intention of motivating exploration and expansion of both sides of the debate. The questionnaire was given immediately after the scenario discussions and prior to the in-class writing assignments. Five minutes was allocated for the questionnaire and ten minutes was allocated for the in-class writing assignment.

Construct Validity

Survey items were first tested with exploratory factor analysis using Equamax rotation. All constructs except evaluation apprehension achieved high discriminant validity. One affective reward item also showed low reliability. The unreliable construct, evaluation apprehension, and the single affective reward item were subsequently excluded from further analysis. Exploratory factor analysis after the initial refinement confirmed discrimination among the selected constructs (see Table 1). Cronbach's alphas ranged from 0.72 to 0.83 for three-item scales and was 0.83 for the only four-item scale, indicating a reasonable degree of inter-item reliability [8, 23, 67].

The data were then analyzed using structural equation modeling. Because repeated measures were used to test the temporal influences suggested by the literature, versus the more common one-shot design, the assumption of independent observations was brought into question. However, an examination of the residual correlation matrix did not reveal any systematic biases that may be associated with the use of repeated measures. The assumption of linearity was satisfied and missing data occurred in only four of 316 survey responses and those four were subsequently dropped from the analysis. Because it is also generally recognized that all SEM assumptions are not satisfied in practice [33], the use of SEM was determined to be both justifiable and appropriate for testing the hypotheses depicted in Figure 2.

Results and Discussion

STRUCTURAL EQUATION ANALYSIS WAS PERFORMED on the model appearing in Figure 2 using AMOS 4.01. The model contains two uncorrelated exogenous variables, namely GSS and time period. GSS is a binary variable with a zero representing face-to-face and a one representing GSS. Time period is represented as one through eight, depending on the time period of the task. All of the item indicators for latent, endogenous constructs were significant at the $p < 0.000$ level.

As suggested by the literature, a variety of fit measures were examined to determine the appropriateness of the model [5, 7, 41, 47]. These measures are presented in Table 2 and include both the recommend value and the results obtained using AMOS. A χ^2 analysis for the model failed to achieve the recommend value ($\chi^2 = 511.45$, df = 170, $p < 0.00$). However, the χ^2 test should not be used to reject a model because of its sensitivity to sample size [5, 46]. That is, the test tends to yield significant results, suggesting that the model does not accurately represent the population, for large sample sizes and yields nonsignificant results, suggesting that the model does fit the population, for smaller sample sizes [14, 20, 40]. The relative χ^2, χ^2/df, was 3.01, which is well within the Wheaton et al. [90] recommendation of less than five and very near the Carmines and McIver [15] recommendation of less than three. The goodness-of-fit indexes were both close, GFI = 0.87 and AGFI = 0.83, to the recommended value of 0.90 [7, 41] and were comparable to, or exceeded, levels commonly accepted in the literature (for example [1, 2, 16, 45, 59, 82]). The AGFI value exceeded 0.80,

Table 1. Factor Analysis with Equamax Rotation and Cronbach's α

	Factor						
Item	1	2	3	4	5	6	Cronbach's α
pb1	**0.66**	−0.12	0.04	0.25	0.13	−0.00	0.829
pb2	**0.73**	−0.02	−0.03	0.36	0.01	−0.13	
pb3	**0.71**	−0.04	−0.12	0.33	0.07	−0.08	
ar1	−0.18	**0.53**	0.21	−0.12	−0.02	0.41	0.832
ar2	−0.03	**0.69**	0.30	−0.09	−0.08	0.15	
ar3	−0.00	**0.52**	0.26	−0.24	−0.07	0.35	
ar5	−0.13	**0.70**	0.29	−0.09	−0.18	0.13	
lm1	−0.02	0.24	**0.76**	−0.05	−0.03	0.20	0.829
lm2	−0.05	0.18	**0.68**	−0.14	0.07	0.14	
lm3	−0.05	0.41	**0.60**	−0.11	0.00	0.24	
fr1	0.41	−0.09	−0.13	**0.53**	−0.17	−0.16	0.775
fr2	0.28	−0.09	−0.07	**0.61**	0.11	0.01	
fr3	0.39	−0.11	−0.10	**0.71**	0.01	−0.09	
se1	−0.00	−0.00	0.01	0.02	**0.76**	−0.03	0.724
se2	0.03	−0.08	−0.04	−0.07	**0.72**	−0.17	
se3	0.11	−0.08	0.05	0.09	**0.49**	−0.12	
gc1	0.01	0.23	0.16	−0.18	−0.12	**0.62**	0.726
gc2	−0.16	0.07	0.17	−0.01	−0.16	**0.63**	
gc3	−0.01	0.26	0.22	0.03	−0.33	**0.47**	

Notes: pb = production blocking, ar = affective reward, lm = self-reported learning, fr = free riding, se = sucker effect, gc = group cohesion. Boldface indicated the heaviest factor loading for an item.

Table 2. Measures of Fit Results

Fit measure	Recommended value	AMOS result
χ^2	$p > 0.05$	170; $p < 0.00$
χ^2/df	< 5.00	3.01
GFI	> 0.90	0.87
AGFI	> 0.90	0.83
RMSEA	< 0.10	0.08

which is sometimes used instead of 0.90 as the recommended value for AGFI (for example [19, 45, 73, 81]). The root mean square error of approximation (RMSEA) of the model was 0.08, which is considered "reasonable" by Browne and Cudeck [13] and within their recommend value of 0.10. Overall, it was concluded that the model is suitable and valid. Significant, standardized, path coefficients appear in Figure 3. These coefficients represent the outcome of the tested hypotheses and are discussed in the following section.

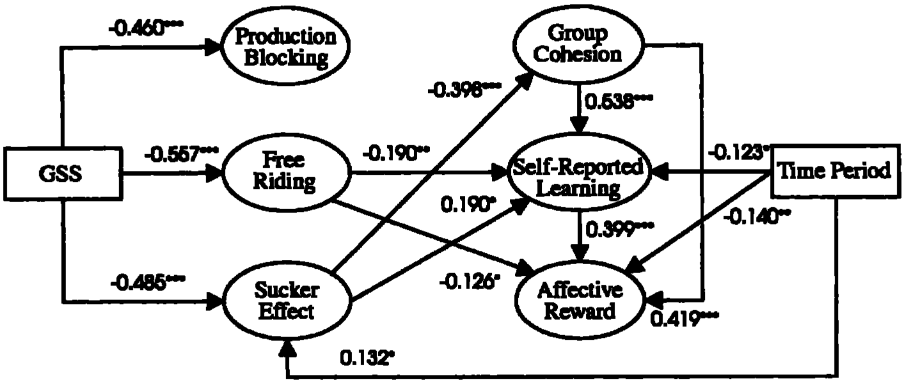

Figure 3. Significant Standardized Parameter Estimates. *Notes:* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Findings

With the exception of evaluation apprehension, which was not adequately measured and subsequently discarded, Hypotheses 1 was supported in its entirety. Namely, GSS reduced production blocking (H1a), free riding (H1b), and sucker effect (H1c). These findings are notable in that it suggests that the spirits of GSS were embraced by the GSS-supported group and meeting dynamics improved. These particular results also represent some of the largest, in terms of effect size, findings of the study. GSS usage can directly account for 21.2 percent of the variance of production blocking, 31.0 percent of the variance of free riding, and 23.5 percent of the variance of the sucker effect.

The results indicate only partial support for Hypothesis 2. Only the sucker effect (H2c), with a moderate effect size of 15.8 percent, was significant in reducing group cohesion. This finding illustrates the importance of employing a procedural methodology. Typically, researchers theorize that process losses, as a whole, account for variation in meeting outcomes. As shown here, however, the efficacy to alter meeting outcomes varies from process loss to process loss.

The results indicate partial support for Hypothesis 3. As hypothesized, group cohesion was a positive predictor of self-reported learning (H3a). This relationship had a large effect size with group cohesion accounting for 28.9 percent of the variance of self-reported learning. Free riding was a significant negative predictor of self-reported learning (H3c), however, the effect size was only 3.6 percent. Both of these findings support the basic tenets of cooperative learning theory, namely, that students learn through working in groups and playing an active role in the learning process [88]. One unanticipated finding is that the sucker effect was a positive predictor of self-reported learning. This is opposite of the hypothesized effect (H3d). In hindsight, one could reason that in order for students to feel taken advantage of by other students, and hence report a high sucker effect, they had to be engaged in the learning process and such engagement leads to self-reported learning, although this is entirely speculation.

The results suggested partial support for Hypothesis 4 and support for Hypothesis 5. Only one of the three process loss constructs influenced affective reward as hypothesized. Free riding had a significant, albeit small, negative impact on affective reward (H4c). However, group cohesion (H4a) and self-reported learning (H5) each positively influenced affective reward with moderate effect sizes of 17.6 percent and 15.9 percent, respectively. This finding suggests that affective reward may be influenced more by related outcomes than by process variables.

The results suggested partial support for Hypothesis 6. Of the seven nondirectional hypothesized relationships from time period, only three were significant and all with an effect size of less than 2 percent. Time period was a negative predictor of self-reported learning (H6f) and affective reward (H6g) and a positive predictor of the sucker effect (H6c). An important aspect of these findings is that time period had a significant impact on at least one process loss variable and at least one outcome variable. In addition to illustrating the importance of examining temporal influences on both group dynamics and meeting outcomes, the temporal findings complete the validation of the procedural research model in Figure 1. That is, there was statistical support for each of the four general relationships suggested in Figure 1.

Discussion

The procedural methodology employed in this study provides a dynamic explanation of the effects of GSS on process losses and the corresponding effect those process losses have on meeting outcomes. Structural equation modeling revealed support for the procedural model illustrated in Figure 1. GSS reduced the three process loss variables measured successfully in the study. A fourth process loss variable, evaluation apprehension, was not measured reliably. These findings lend support to much of the GSS literature, which suggests that the structures of anonymity and simultaneity can reduce some of the process losses that are known to occur in face-to-face meetings. The positive impact of GSS may have been possible because meeting participants consistently appropriated the technology in the manner intended by system designers [31]. Participants' use of technology was undoubtedly affected by factors such as the group characteristics, task types, and organizational setting in which the study took place.

Social interactions and group dynamics, as represented by the three process loss variables, were shown to significantly influence meeting outcomes. Free riding reduced both self-reported learning and affective reward. The sucker effect was shown to reduce group cohesion and increase self-reported learning. It is interesting to note that the meeting outcomes differed from each other in terms of their sensitivity to the process losses. For example, affective reward was influenced by free riding, whereas group cohesion was influenced by the sucker effect. Process losses differed substantially in their ability to predict meeting outcomes. Production blocking, for example, did not significantly impact any of the three meeting outcomes in this study. The richness of these findings illustrates the importance of a procedural methodology.

One finding of particular interest is that affective reward was influenced much more by outcome variables than by process variables. This may explain why Fjermstad and

Hiltz [35] report a great deal of inconsistency regarding satisfaction-related constructs in their meta-analysis of GSS research. That is, much of the literature on satisfaction-related constructs focus on the influence of GSS structures instead of other outcome variables. Briggs and de Vreede [11] and de Vreede et al. [84] suggest that meeting satisfaction is caused by perceived interest accommodation. In the educational context, self-reported learning is an important dimension of perceived interest accommodation. Thus, the finding that self-reported learning is a predictor of affective reward may offer support to the theoretical relationships proposed by Briggs and de Vreede [11] and de Vreede et al. [84].

Participants' self-reported learning and affective reward were highly associated with group cohesion. This result supports findings that participants report greater satisfaction when participating in a group with a supportive evaluative tone than a critical evaluative tone [21, 44]. The relationship between the process constructs and learning, and between group cohesion and learning may have to be interpreted with caution, because they are likely to be highly dependent on the task type. The tasks in the study presented here, were designed to encourage a great deal of interaction and, consequently, may have led to better meeting outcomes than other tasks.

Empirical studies that have investigated the effects of GSS use over an extended period of time are rare [18, 69]. We believe that the longitudinal approach is especially important in GSS research because participants' judgment can be masked by such biases as the "fascination effect" [52] or protracted development of group affiliation among participants in GSS settings [17]. In this study, temporal effects were shown to significantly influence both social interactions and meeting outcomes, although these relationships were not as strong as one might have expected. Time was shown to significantly impact the sucker effect, self-reported learning, and affective reward. Estimation of the research model indicates that despite the observed longitudinal effect on process quality and outcomes, GSS meetings showed a steady advantage over traditional meetings in lowering group process losses.

Limitations of the Study

The study results must be understood from the perspective of meeting contingencies including task, group, and other social structures that can greatly affect participants' social interactions [6, 30, 57]. For instance, El-Shinnawy and Vinze [34] empirically showed that GSS and task characteristics (such as judgmental versus intellective tasks) interacted to affect group processes and outcomes.

Tasks used in this study were specifically designed to encourage participation and discussion by students. Discussing ethical issues of a technology is a judgmental task with no straightforward answer and in general is not as complicated as decision-making or problem-solving tasks. Accordingly, subjects might not have had a chance to fully capitalize on GSS potentials. The technology effect might have been more substantial if people had been given more challenging tasks. Furthermore, as participants were honor students with high GPAs, we expected a high level of homogeneity in their academic motivation, intelligence, attitude, and domain knowledge. Such homogeneity might have contributed considerably to the productive and proactive meetings sustained throughout the semester.

Another possible bias may have resulted from the fact that one instructor was involved in the experiment, which may have created a potential maturity effect [22] as the instructor became more knowledgeable and effective because of the lecture repetition, thereby affecting student performance. However, since the instructor had taught the same course nine times previously, we expected that the maturity effect was low.

This study incorporated only constructs that reflect negative dynamics (such as, free riding, sucker effect, and production blocking) in a group meeting. Further investigation could include positive dynamics, such as synergy, and their corresponding effects on meeting outcomes.

Implications for Future Research

The study has a number of implications for future research. First, there have been few studies that focused on the interplay among process variables and meeting outcomes. According to McGrath [57], group interaction is expected to affect the social and psychological properties of individuals. Further research investigating these interactions is merited, as it will lead to a richer understanding of how technology ultimately affects outcomes. Second, since the deterministic research paradigm has been dominant in GSS research, more procedural-oriented studies are necessary to enrich our understanding of GSS use. Researchers could, for example, investigate various GSS structures (such as anonymity and simultaneity) to see which significantly influence process variables. The study presented here has grouped all of the GSS structures into a single variable. We do not know, for example, if it is anonymity, simultaneity, or both, that reduces free riding. Third, we emphasize the value of research that takes advantage of longitudinal data to observe temporal changes in the participants' reaction to GSS. All of these suggestions help direct future GSS research to a richer understanding of the complexities of group meetings and the role of technology in those meetings.

Whereas the findings of this study lend support to AST specifically and procedural GSS theories in general, it also serves to motivate the development of deterministic theoretical models as well. Because AST suggests that the manner in which GSS is appropriated will likely vary from group to group, task to task, and setting to setting, we would not expect to find the relationships observed in Figure 2 to exist in all group meetings. It would be more reasonable to generalize the model appearing in Figure 1, which suggests that the influence of GSS on group outcomes is ultimately determined by its impact on group dynamics over time. To consistently understand and predict relationships among specific constructs, however, researchers need to develop robust deterministic models of the individual constructs, such as the one for meeting satisfaction proposed by Briggs and de Vreede [11]. Such models would serve to complement procedural models such as AST by helping to explain the interdependence among outcome variables and why process losses vary in the degree to which they influence group outcome variables.

The results of this study have implications for managers as well as researchers. For example, managers need to be aware that the benefits associated with GSS use will not automatically occur when GSS technologies are employed. Rather, they need to carefully consider the impact that the technology may have on a particular group and if the participants will appropriate the technology as intended. To do this, managers need to carefully examine the cohesion among group members, as group cohesion can directly impact important outcomes, such as affective reward. Even in such cases where GSS is being used effectively, however, managers should be aware of the potential temporal changes and that outcomes will not necessarily be consistent over time.

Conclusion

This study investigated the potential of GSS to improve meeting outcomes by reducing process losses often associated with face-to-face meetings such as production blocking, free riding, and the sucker effect. It was confirmed that GSS does indeed reduce such process losses, although it is not clear which of the GSS structures (such as anonymity or simultaneity) was responsible for these reductions. These findings were consistent over time with two large naturally occurring groups. However, the degree to which these findings can be generalized is limited by contextual factors such as participant demographics, organizational setting, and the nature of the task.

This study revealed that such a reduction in processes losses did indeed lead to superior meeting outcomes such as group cohesion, affective reward, and self-reported learning. However, process losses varied significantly in their ability to influence outcome variables. Further, some outcome variables, such as affective reward, appeared to be more related to other outcome variables, such as group cohesion, than to the process losses measured in this study.

This research study shows the benefits of procedural, longitudinal methodologies and the results provide insight into how GSS may ultimately influence meeting outcomes. We believe that these findings contribute to a richer understanding of GSS and serve to complement the findings often reported in one-shot deterministic research methodologies.

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Appendix

Survey Items

Affective Reward

ar1: The process we used was . . . (extremely fulfilling / extremely unfulfilling)
ar2: This was a boring session. (strongly agree / strongly disagree)
ar3: We really accomplished something here today. (strongly disagree / strongly agree)
ar4: It felt like we won. (strongly agree / strongly disagree)
ar5: I did *not* enjoy myself. (strongly disagree / strongly agree)

Evaluation Apprehension

ev1: The members of my work group view my ideas as . . . (not at all valuable / highly valuable)
ev2: In regard to offering contributions to the discussion, I was . . . (very apprehensive / not at all apprehensive)
ev3: There were times when I refrained from participating because I felt others might not accept my ideas. (strongly disagree / strongly agree)

Free Riding

fr1: To be honest, I just took it easy and let the other members of the group do most of the discussing. (strongly disagree / strongly agree)
fr2: How satisfied are you with your own performance on this task? (very dissatisfied / very satisfied)
fr3: How much do you feel you participated in idea generation? (not much at all / a lot)

Group Cohesion

gc1: To what extent were the people in this work group helpful to you in getting the job done? (not at all helpful / very helpful)
gc2: To what extent do you trust the members of this work group? (a great deal of trust / no trust at all)
gc3: To what extent do you look forward to being with this work group? (not at all / a great deal)

Learning

lm1: Increased understanding of basic concepts. (strongly agree / strongly disagree)
lm2: Learned factual material. (strongly agree / strongly disagree)
lm3: Learned to identify central issues. (strongly agree / strongly disagree)

Production Blocking

pb1: When I thought of an idea, I . . . (could express it immediately / had to wait to express it)

pb2: Did you express your ideas . . . (soon after you thought of them / after waiting awhile)

pb3: I got my ideas out as soon as they occurred to me. (strongly agree / strongly disagree)

Sucker Effect

se1: In today's discussion, I felt as though others took advantage of the fact that I was willing to participate and they did not participate themselves. (strongly agree / strongly disagree)

se2: I had to do more than my fair share of the discussion because others were not willing to participate. (strongly disagree / strongly agree)

se3: Certain members of the group did not participate as much as they should have. (strongly disagree / strongly agree)

Note: Items on the questionnaire were scrambled.