USING COLLABORATION TECHNOLOGY TO FACILITATE FACE-TO-FACE AND DISTRIBUTED TEAM INTERACTIONS

By

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A Dissertation Submitted to the Faculty of the

COMMITTEE ON BUSINESS ADMINISTRATION

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY
WITH A MAJOR IN MANAGEMENT

In the Graduate College

THE UNIVERSITY OF ARIZONA

2004

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ACKNOWLEDGEMENTS

Obtaining a Ph.D. degree is a great learning experience, filled with challenges and excitement. Many individuals have contributed to this learning experience throughout the past several years. I appreciate everyone's help, but have only enough space to acknowledge a few individually.

I am deeply indebted to Dr. Jay F. Nunamaker, my dissertation advisor, for his consistent encouragement, research support and mentoring. Without his continuous support during the past four years, I would be nowhere close to completion of my doctoral study. I have learned a lot from Dr. Nunamaker's insights into research and the academic career, and experienced academic growth under his guidance.

I would like to thank my other dissertation committee members: Dr. Robert O. Briggs, Dr. Gail Corbitt (California State University at Chico), Dr. Therani Madhusudan, Dr. Judee K. Burgoon, and Dr. Kyle J. Tusing for their valuable suggestions and feedback. Dr. Briggs has provided very detailed guidance for every stage of my dissertation study. He was always available when needed. I especially enjoyed enlightening intellectual arguments with him. I also am grateful for Dr. Gail Corbitt, who helped me collect data. Collaborating with Dr. Burgoon helped me to understand that there is always room for improvement and that there is always a standard of excellence for which a researcher should strive.

My special thanks are due to Dr. Stanley Gardiner and Dr. James Sager (California State University at Chico), who like Dr. Corbitt helped me with data collection, and to Dr. Pat Jones, who helped with my data analysis.

I am also greatly indebted to all the staff at the Center for the Management Information (CMI); I enjoyed working with them and learning from them. I especially would like to thank Betty Albert, Dr. James Lee, Terry McKenna and Ana Lopez, who were models of collaboration and support.

I am grateful for the help from all MIS Department faculty members and staff.

I would like to thank all my fellow Ph.D. students for their encouragement, assistance, and friendship, particularly Mick Mcquaid, Ming Lin, Jinwei Cao, Kathy Broneck, Jana Crews, Karl Weirs, and John Kruse.

I am grateful for my husband's consistent support and encouragements and would like to thank my parents and all other family members for their love.

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ABSTRACT

This study adopted an action research approach to investigate the efficacy of Focus Theory, a general theory of group productivity, in the context of project team interactions supported by GSS. Focus Theory specifies that three processes consume attention resources to accomplish a group task: communication, information access, and deliberation. Guided by Focus Theory, the study examined the ways in which these processes were manifested, facilitated, and/or inhibited during group interactions, as well as how these processes and other Focus Theory constructs affected group productivity when teams engaged in FtF, synchronous-distributed, and asynchronous-distributed interactions. The objective of the study was to gain understanding of distributed team interactions through the lens of Focus Theory and to offer insights into the theory, the practice of geographically separated project teams, and collaboration technology design.

Distributed groups using text for communication lost nonverbal cues that could have been used to interpret the meaning of a message. The study indicated that identification of the message sender and specification of the time and date of a message allowed more accurate interpretation of that message. It was found that distributed teams did not understand the team goals and interaction procedures as well as FtF teams. Group process structure support and interaction facilitation were more important for distributed interactions than for FtF interactions because of the need for explicit communication in distributed teams. Access to relevant information was important for keeping interactions moving forward, and a permanent group memory provided by GSS facilitated group activity tracking.

Focus Theory had both explanatory power and theoretical limitations. The study indicated that three processes consumed attention resources, although it was difficult to separate their effects or to measure the attention resources allocated to each. Focus Theory does not differentiate between cognitive effort and cognitive load, making it difficult to test the theory's validity. The three processes may not be equally important in all group interaction scenarios, a possibility not specified by Focus Theory.

This dissertation discusses the implications of the study for further development of the theory, insights for researchers of collaboration, guidelines for collaboration technology designers, and everyday tips for practitioners.

CHAPTER 1 INTRODUCTION

1. 1 Background

Projects and project management (PM) are critical to the success of many organizations because projects are an important constituent of business (Lundin & Hartman, 2000). The rise of global organizations and global inter-organizational partnerships has meant that more and more project teams now consist of members who are geographically separated (Evaristo & Fenema, 1999; Jonsson, Novosel, Lillieskold & Eriksson, 2001). Geographic separation causes problems, one of which is that FtF interactions are greatly reduced or eliminated, making communication among distributed team members and coordination of group effort more important, but more difficult to achieve.

To alleviate these problems, teams are turning to a variety of collaboration technologies such as online chat, email, electronic message board, audio conferencing, video conferencing and group support systems (GSS) to facilitate distributed interaction. Online chat, email, electronic message boards, and GSS support communication in text format. Online chat allows participants to engage in synchronous communication, whereas email and electronic message board are usually used for asynchronous communication. Web-based GSS can support both synchronous and asynchronous communication. Audio conferencing and video conferencing support voice communication.

However, geographically separated teams experience problems that hamper their productivity, even when using collaboration technologies. For example, studies have

indicated that FtF groups outperformed distributed groups in terms of comprehensiveness of discussion (e.g., Smith & Vanacek, 1989), effectiveness of reaching agreement (e.g., Hiltz, Johnson, Turoff, 1986), and negotiation (e.g., Hollingshead, McGrath, O'Conner, 1993).

Part of the difficulty may be that interactions of geographically separated teams differ from those of face-to-face (FtF) teams in ways that have not yet been fully examined in light of a theoretical model of group productivity nor has collaboration technology been satisfactorily configured to support distributed interactions.

Two areas that investigate distributed team interactions are distributed Group Support Systems (GSS) and computer mediated communication (CMC). These two research streams have different emphases. CMC is more concerned with communication; GSS research is more concerned with group problem solving and decision making. GSS researchers have studied how some input factors (e.g., group, task, technology, and context) interact to affect group process, which in turn affects group outcomes (Nunamaker, Dennis, Valacich, Vogel & George, 1993; Nunamaker, Dennis, Valacich, Vogel & George, 1991). Two research themes have appeared in prior studies investigating distributed GSS. One is the development of relationships in distributed teams (e.g., Burke & Chidambaram, 1995; Chidambaram, Bostrom & Wynne, 1990-1991; Ocker, 2001). The other is exploration of how GSS features/tools and problem solving techniques affect group outcomes in distributed interactions (e.g., Cho, Turoff & Hiltz, 2003; Fjermestad, Hiltz, Ford, Ocker, Ferront, Worrell & Johnson, 1995; Kim,

Hiltz & Turoff, 2002; Ocker, Fjermestad, Hiltz & Johnson, 1998; Ocker, Hiltz, Turoff & Fjermestad, 1996).

Distributed GSS studies that emphasized on relational development have tended to focus on the input and output of communication and have treated communication as a "black box" (Burke & Chidambaram, 2003). Studies that emphasized the second research theme have helped us understand which GSS features/tools and problem solving techniques have worked more efficiently/effectively for distributed teams. These GSS studies of distributed communication have documented what could happen to participants' perceptions and group outcomes in different interaction contexts, but did not systematically examine why a particular context affected group productivity in certain ways. Consequently, very little is known about the mechanism of group productivity and how to enhance distributed group performance.

CMC studies have investigated the phenomenon of group performance and also attempted to examine the mechanism that caused the phenomenon. Several theories have guided most CMC studies, including social presence theory (Short, Williams & Christie, 1976), media richness theory (Daft & Lengel, 1986; Daft, Lengel & Trevino, 1987), social information process theory (Walther, 1996), theory of media synchronicity (Dennis & Valacich, 1999), and principles of interactivities (Buller & Burgoon, 1996; Burgoon, Bonito, Bengtsson, Ramirez, Dunbar & Miczo, 1999). These theories and principles have specified how properties of communication media and other communication contexts affect communication processes and outcomes in predictable patterns. In general, CMC studies have mainly examined the communication process of group

interactions, but there may be other types of processes involved in-group interactions that affect group productivity and have not been examined. This study was an attempt to examine other possible types of processes and their effects on group productivity.

The study examined group productivity in a framework guided by Focus Theory, a theory of group productivity. The results offer insights into the theory, the practice of geographically separated project teams, and collaboration technology design.

As a general theory about productivity of groups which engage in intellectual work, Focus Theory (Briggs, 1994) suggests that team productivity is a function of cognitive effort (attention) over time. Focus Theory is based on an assumption that attention is a limited resource. The total amount of attention demanded for a cognitive process is affected by a person's motivation (goal congruence) and distractions. Goal congruence is the degree to which the perceived vested interest of the individuals constituting a team is congruent with the goals of the team. Three cognitive processes are necessary to accomplish a task: communication, information access, and deliberation. The attention allocation for three processes interferes with one another. Allocating more attention to one process may reduce the attention that can be allocated to the other two processes. Furthermore, the three processes may co-vary because making one process harder will make the others harder and making one process easier will make the others easier. For example, it is easy for the FtF group to communicate, the immediate feedback of the FtF communication makes deliberation process easier. A model of Focus Theory is displayed in Figure 1.1.

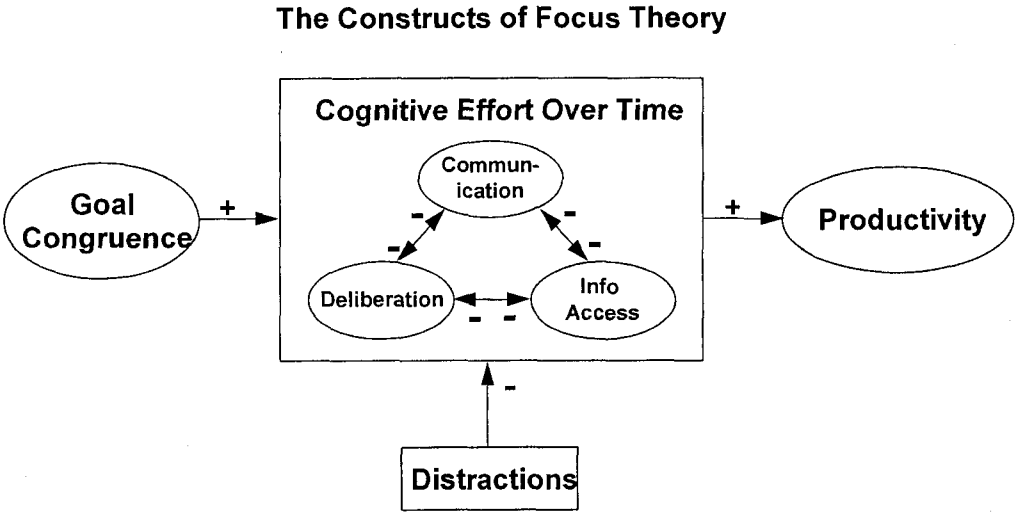

Figure 1.1 Model of Focus Theory

From (Briggs, 1994)

Focus Theory is not technology specific but its reasoning logic implies that technology may improve group productivity by reducing distractions, increasing group goal congruence, and/or facilitating any or all of three processes. Some collaboration technologies, such as video conferencing and audio conferencing, support only communication. Other technologies, such as email and electronic message board may support information access in addition to communication. However, these technologies usually do not provide process structure to support the group deliberation process. In contrast, GSS support all three processes. It facilitates communication in text format by allowing participants to log onto the system and post messages anytime and anywhere so long as they have an Internet connection. GSS provides a permanent group memory which helps with information access. Participants can access information before, during,

and after interactions. GSS facilitates group deliberation by providing task and process structure and support.

Guided by Focus Theory, this study adopted an action research approach to investigating group productivity for groups facilitated by GSS in three modes: FtF, synchronous-distributed and asynchronous-distributed. Focus Theory was subjected to empirical testing in a limited setting in an attempt to gain a better understanding of Focus Theory. The study clearly was exploratory in nature.

1.2 Research Questions

1) How are Focus Theory constructs manifested during group interactions in different modes, and why?

2) In what ways is the theory useful and in what ways is it limited in terms of explaining observed phenomena, how can it be improved?

3) How are the three processes manifested, facilitated and/or inhibited during group interactions in different modes? Given the theoretical foundation and observed findings, how could collaboration technology be designed and deployed to enhance performances of the people engaged in distributed team interactions?

1.3 Research Approach

This study adopted a multi-methodological approach specified by Nunamaker and his colleagues (Nunamaker, Chen & Purdin, 1990-1991) that involves grounded theory development (e.g., conceptual frameworks, mathematical models), observation (e.g., field research, surveys, case studies, action research), experimentation (e.g., controlled

laboratory experiments, computer simulations, field-based quasi-experiments), and systems development (e.g., prototyping, product development, technology transfer).

Focus Theory provided the conceptual framework for the study. GSS tools were configured by using Cognito, a web-based GSS produced by GroupSystems.com. Action research (Argyris, Putnam & Smith, 1985; Baskerville & Wood-Harper, 1996) was selected as the research methodology to allow the researcher to participate and observe group interactions. Action research is similar to the case study methodology in that both allow researchers to gain in-depth understanding of phenomena of interest. However, a significant difference between them is that in case study methodology the researcher attempts to remain external to the phenomena and studies them from a distance, adopting an objective point of view. In action research, researchers participate in the phenomena, study them from within instead from outside. The researchers adopt a participant's point of view (Baskerville & Wood-Harper, 1996).

This study adopted an action research approach, however, the study design followed a Latin Square design like that of a longitudinal field experiment. Data were collected for six weeks (or six interaction sessions for each team). There were 13 teams in the study, and each team experienced group interactions in all three modes, using the same mode for two weeks consecutively. This design allowed the researcher to investigate group interactions through the lens of Focus Theory to observe how teams varied in distraction, goal congruence, and cognitive effort in different modes as well as in different durations of group evolvement. Reasons for the possible variations in how the three processes (communication, information access, and deliberation) were manifested,

facilitated and/or inhibited by technologies and other factors (e.g., group norms, familiarity with technology) in different modes at different times of group evolution, and relationships among the constructs of Focus Theory also were examined.

Focus Theory was the framework for the investigation and served as a guide for the researcher's understanding of the results of the study. A closer look at Focus Theory reveals that its constructs are at different levels. Productivity must be considered measure at the team or group level since aggregated individual productivity does not make much sense when an entire group needs to accomplish a single task and produce a group deliverable. Other constructs are measures at the individual level and the group measure can be the aggregate of individual measures. For example, it would be difficult to measure group cognitive effort, although individual cognitive effort can be measured and averaged or summed to reflect a measurement at the group level.

Two types of data are collected in this study. Quantitative data were collected by a questionnaire. Qualitative data were collected by the author's field observations, online observations, interviews, and participants' online anonymous feedback about their group interactions supported by GSS. It was assumed that quantitative data would reveal the way that different constructs were manifested in interactions, and that qualitative data would reveal why a particular construct was manifested in certain ways in a particular interaction scenario, as well as how these constructs affected group productivity. The purpose of collecting different types of data was to triangulate the data in hope of providing increased validity for the study.

1.4 Importance and Contributions of the Study

Globalization of business and technology advancement increase the utilization of distributed projects and other types of teamwork. Distributed teamwork relies heavily on collaboration technologies to facilitate distributed group interactions. Understanding group interactions by examining them in the framework of a theoretical model of group productivity is important for the design of appropriate technology to support the effective practice of computer-assisted group interactions. Prior research in distributed GSS has revealed differences in participants' perceptions and group outcomes in different interaction contexts, but has not systematically examined why a particular context affected group productivity in certain ways.

CMC studies have systematically explored how certain communication media features and other factors affected group performance and perceptions but have mainly focused on group communication processes, which may be only one part of the big picture of group productivity and inadequate to fully explain group productivity.

Three expected contributions were expected from this study: 1) gaining understanding of distributed team interactions in the context of project team interactions facilitated by GSS; 2) gaining understanding of efficacy of Focus Theory: its explanatory power of observed phenomena, and possible theoretical limitations; 3) providing some suggestions and guidance for collaboration software design. The purpose of the study was to build understanding and improve practice.

1.5 Organization of the Dissertation

The remainder of this dissertation is organized as follows. Chapter 2 is the literature review, which includes a brief explanation of why choosing project rather than other types of teamwork as the study context and a description of related GSS and CMC studies. Chapter 3 describes the research methodology, subjects, study design, study procedure, and data collection. Chapter 4 presents data analysis and discusses the results. Chapter 5 discusses the study's limitations, contributions, and suggests future research directions.

CHAPTER 2 LITERATURE REVIEW

This study examined group productivity in the context of project team interactions supported by GSS, with an emphasis on distributed group interactions. A better understanding of productivity in this context should help project managers understand what factors may affect group productivity in what ways and then select collaboration technology that will facilitate group interactions accordingly. Understanding productivity also will help technology designers understand what factors need to be considered, what system features need to be implemented, and in what ways and under what conditions these features may affect group productivity. However, a literature review of GSS and CMC studies revealed that the phenomenon of group productivity facilitated by technology has not been systematically examined and fully explained by researchers who have investigated group interactions.

Both GSS and CMC studies have investigated group outcomes by examining group productivity to a certain degree or from a certain aspect, but studies in neither area has systematically examined group productivity in an explicit manner. The following sections will explain in detail the theoretical models that have been created, point out how they relate to group productivity, why they may fall short of explaining the phenomenon of group productivity, and describe how Focus Theory model is appropriate for use in studying group productivity.

The chapter is organized as follows. Sections 1 and 2 review GSS and CMC studies of group productivity. Section 3 explains Focus Theory in more detail, and Section 4 summarizes the literature review.

2. 1 Group Support Systems

GSS studies have investigated how group outcome can be improved by providing group task and process support. GSS are networked computer systems and software that provide general-purpose collaboration tools that help groups conduct group processes such as divergent thinking (e.g., generating ideas) and convergent thinking (e.g., achieving consensus building, group discussion, group negotiation). The general-purpose nature of the tools makes GSS useful in a variety of group activities and problem solving situations. GSS usually allow multiple participants to communicate in text format at the same time either from the same or different locations. Group outcome is a broad term, which includes group productivity (e.g., number of ideas generated, quality of ideas, comprehensiveness of information exchange, decision quality, time used for decision making or problem solving), and participant perception of group process and outcome (e.g., satisfaction with group process and outcome, group cohesiveness). Distributed GSS also investigates interpersonal relationship development among group members.

Many prior GSS studies explicitly or implicitly adopted an input-process-output model (Nunamaker et al., 1993; Nunamaker et al., 1991) to investigate how input factors affect process, which in turn affects output. The model is a high-level view of GSS, which states that the effects of GSS on group process and outcome are contingent on the interaction of four categories of input constructs. The input factors include group, task, context, and technology. *Group characteristics* are group features such as group size, group history, group proximity, group cohesiveness, and group composition. Dimensions of *task characteristics* include task type, task complexity, task clarity, and activities

required to accomplish the goal. *Context characteristics* are features of a group interaction environment, examples of which include organizational culture, reward structure, time pressure, and performance evaluative tone (e.g., supportive or critical). *Technology* specifies the technology used, such as GSS, email, online chat, or manual. If GSS technology is used, the specific tool and tool features should be described. The interactions of these four types of input factors affect group process and outcome. Group outcome may include group productivity, but the model is not explicit about this.

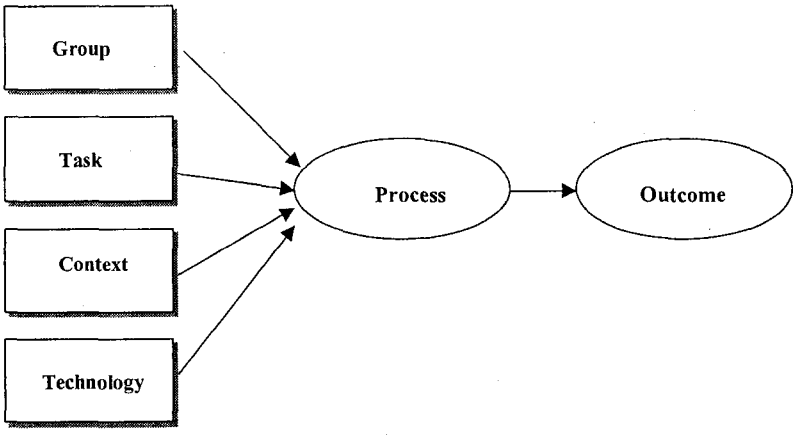

Figure 2.1 GSS Research Model

From (Nunamaker et al., 1993; Nunamaker et al., 1991)

The model looks straightforward at first, but close examination reveals its flaws as a theoretical model. First, the model specifies that four categories of input interact to affect process. However, the model diagram does not show whether and how these categories of input factors interact. In addition, the four input categories can be infinitely decomposed into other categories or factors. For example, group category can be decomposed into group size, group history, group proximity, group heterogeneity, and so

on. Other input categories can be similarly decomposed and it would be very difficult to examine how thousands of different combinations of input factors might affect group process and outcome. Second, process is presented as a black box. What does process mean? Of what does a process consist? How do input factors affect a particular process? Nothing is specified. Third, group outcome is not specified either: what should be included in group outcome?

The input-process-output model is a descriptive model rather than causal model. It cannot be used to predict what will happen to the group process and outcome in a particular instance, given certain input factors. GSS studies that adopted this model provided testimony of the effects GSS technology on group outcome but remained silent on why these effects occurred. This held true with studies that investigated FtF interactions as well as those that examined distributed interactions.

Much prior GSS research focused on FtF interactions, and those studies that were experiments usually compared groups supported by GSS with manual groups (groups not supported by GSS). Such input factors as how group size, group composition, task types, task complexities and interaction procedures affected GSS groups and manual groups were investigated. Although they touched upon group productivity to a certain degree, (for example, measured number of total ideas generated (e.g., Connolly, Jessup & Valacich, 1990; Connolly, Routhieaux & Schneider, 1993), number of unique ideas generated (e.g., Aiken, Krosp, Shirani & Martin, 1994; Connolly et al. 1993), and decision qualities (e.g., George, Easton, Nunamaker & Northcraft, 1990; Dennis 1993, 1996; Dennis & Valacich, 1994)). These studies primarily revealed what happened with

group outcomes and did not explain why, from a theoretical perspective, group outcomes happened in certain ways.

More recent studies have started to investigate distributed interactions. Appendix A presents a table that lists some empirical distributed GSS studies in which two research themes seem apparent. One theme was to compare the relational development in FtF groups with that in distributed groups (e.g., Burke & Chidambaram, 1995; Chidambaram et al., 1990-1991; Ocker, 2001). The other was to investigate how certain GSS tools/features or problem solving styles work for distributed modes (e.g., Cho et al., 2003; Fjermestad et al., 1995; Kim et al., 2002; Ocker et al., 1998; Ocker et al., 1996).

Studies about the first research theme focused on participants' perceptions instead of group productivity. Some of them did not even report group productivity measures (e.g., Burke & Aytes, 1998; Burke, Chidambaram & Aytes, 2002). These studies did not examine group productivity or the relationship between participants' perception and group productivity.

Studies about the second research theme only revealed the result of group productivity when particular input factors (e.g., interaction mode, problem solving techniques) were present, not which particular input factor affected the group productivity in a certain way. These studies measured participant perceptions and judgments about interactions among group members (e.g., perceived group cohesiveness, perceived communication effectiveness, perceived conflict management) and the effects of technology properties (e.g., perception of communication interface), yet they measured group productivity without explaining any cause-effect relationships between input

factors and group productivity. In contrast, the study reported here attempts explicitly to investigate group productivity under Focus Theory – a general theory about group productivity.

According to Briggs (Briggs, 1994), Focus Theory provides unifying explanations for GSS empirical results. For example, empirical GSS studies have indicated that large groups benefit more from GSS-facilitated interactions than small groups. Briggs (Briggs, 1994) also stated that team size in GSS use is a confounded variable, with opposing effects from attention demands for communication, deliberation, and information access. Parallel input increases team productivity by eliminating production blocking of airtime fragments and thus decreasing communication demand and allowing more attention to be allocated to deliberation and information access. On the other hand, parallel input increases communication demand in terms of typing and reading others' input. However, whereas opposing communication effects on productivity will yield different results in different situations, other GSS effects can be framed around cognitive effort and processes over time.

In addition to the input-process-output model, there are CMC theoretical models that have guided studies of technology facilitated interactions. These theoretical models did not address group productivity per se, but they incorporate propositions having implications for group productivity. Related empirical studies did test these implications to a certain degree or from a particular viewpoint, but such models focused only on the communication process and mainly examined how structural properties of communication media or interfaces affected group outcomes.

2.2 Computer-Mediated Communication

CMC includes broader study areas than GSS. In a strict sense, GSS research investigates only applications of GSS in group interactions, whereas CMC research examines all communication media: such as email, online chat, online bulletin boards, audio conferencing, video conferencing, and probably GSS. Whereas GSS research has studied in what ways group outcome could be improved by task and process support, CMC has investigated how structural properties of communication media or interface affect group outcome. Communication, which has been the only phenomenon under examination in CMC, may be only one part of the group productivity picture and may not fully explain group productivity.

Several theories have been developed to guide CMC research: social presence theory (Short et al., 1976), media richness theory (Daft & Lengel, 1986; Daft et al., 1987), social information process theory (Walther, 1996), theory of media synchronicity (Dennis & Valacich, 1999), and principles of interactivities (Buller et. al 1996; Burgoon, Bonito, Bengtsson, et al. 1999). Unlike an input-process-output model, which does not specify how input factors affect group process and outcome in a predictable pattern, CMC theories specify how particular communication media properties affect communication process and outcome in certain ways.

2.2.1 Social Presence Theory and Media Richness Theory

Social presence is the extent to which an individual feels the presence of a communication partner. Short and his colleagues (Short et al., 1976) argued that communication media convey different levels of social presence because of their

structural features. Structural features are also referred to as "bandwidth," which refers to the number of communication cue systems medium can support. Media that possess more bandwidth tend to produce more social presence. For example, FtF communication supports all communication cues (verbal, nonverbal, and visual cues) and produces strong social presence. In contrast, computerized media do not provide full support of nonverbal or visual cues and produce less social presence. Weaker social presence can restrict socio-emotional communication (e.g., Rice & Love, 1987; Burke & Chidambaram, 1999). As summarized by Walther (Walther & Parks, 2002), empirical studies guided by social presence theory found that a communication medium that supported low social presence, such as a text-based system, had increased task orientation. However, it appeared that it had been more difficult for computer-mediated groups to reach consensus or to reach agreement in socio-emotional terms.

Although social presence theory does not address group productivity explicitly, it specifies that more bandwidth leads to more social presence and only implies that more bandwidth and/or more social presence may improve or increase group outcome. However, this implication has not received much support from empirical studies.

Media richness theory (information richness theory) (Daft & Lengel, 1986; Daft et al., 1987) investigates the adequacy of a medium's support for two major communication situations: uncertainty and equivocality. Uncertainty occurs when a framework to interpret certain information exists, but the information is not available. Equivocality occurs when information is available but a framework to interpret it is not available or there exist multiple frameworks to interpret the information. Different

communication media have different levels of "richness," depending on immediacy of feedback, multiplicity of cue systems (e.g., verbal, visual cues), message personification (whether the message can be tailored to a particular individual versus a group of participants), and language variety (conversational versus formal language). FtF communication is the richest mode; computerized communication is usually lean. When communication uncertainty exists, communication participants need to locate and provide information, for which use of both lean and rich media can be effective. However, when communication equivocality exists, communication participants have to engage in discussion or negotiation to resolve the problem, a richer medium should be more effective. Media richness theory proposes that a fit between task and communication media is likely to improve group performance. This may imply that the fit between task and communication media will increase group productivity.

Empirical studies which tested media richness theory were intended to investigate how the task-media-fit operates in real communication activities. However, many studies investigated perceived media fit instead of actual media fit (Dennis & Valacich, 1999). In such studies, managers were presented some communication scenarios and asked to choose a preferred medium to use in communication scenarios (Daft et al., 1987; El-Shinnawy & Markus, 1992; Lengel & Daft, 1988; Rice & Shook, 1990; Trevino, Lengel, Bodensteiner, Gerloff & Muir, 1990; Trevino, Lengel & Daft, 1987). Dennis and Valacich (Dennis & Valacich, 1999) reported that some studies that had investigated actual media fit (Carnevale, Pruitt & Seilheimer, 1981; Dennis & Kinney, 1998; Kinney & Watson, 1992; Valacich, Mennecke, Wachter & Wheeler, 1994; Valacich, Paranka,

George & Nunamaker, 1993) had not been very supportive, suggesting that media richness theory cannot be relied on to explain group outcomes in general or group productivity in particular.

One theoretical limitation of social presence theory and media richness theory is that they adopt a static view of structural features of communication media and ignore the temporal dimension of communication media. The interaction between technology and participants is dynamic. Communication participants may embrace technology according to their expectations and habits and thereby make a lean medium richer, and overcoming to a certain degree the restrictiveness of that medium.

2.2.2 Social Information Processing Theory

Social information process theory proposes that communication participants can exchange socio-emotional information by using computerized communication media (e.g., GSS, email) to facilitate relational development. However, relational development via CMC is slower than via FtF communication (Walther, 1996). Although empirical studies generally have supported social information process theory (e.g., Walther, 1993; Walther, Anderson & Park, 1994; Walther & Burgoon, 1992), this theory does not address group productivity. Its implication for group productivity can be that group productivity will be increased when the group becomes familiar with communication technology. This plain statement about group productivity does not address the underlying mechanism of group productivity: Why will familiarity with collaboration technology and group members probably increase group productivity? The empirical

studies guided by social information process theory have not shed light on understanding of how groups can be more productive.

2.2.3 Theory of Media Synchronicity

Theory of media synchronicity (Dennis & Valacich, 1999) incorporates both static and dynamic views of communication media and adds some new perspectives. It explains the relationship between communication media and communication processes and proposes that teamwork involves two communication processes: conveyance and convergence. Conveyance refers to the process by which people express their ideas and exchange information. The goal of convergence is to achieve common understanding of information and recognition of achievement of mutual understanding. Dennis and Valacich (Dennis & Valacich, 1999) specified five characteristics of communication media that affect conveyance and convergence: immediacy of feedback, symbol variety, parallelism, rehearsability, and reprocessability. Immediacy of feedback refers to the speed of feedback. Symbol variety is identical to communication channel variety. For example, FtF communication provides more symbol varieties than email because its verbal and nonverbal channels support more symbols. Email that supports graphics accommodates more symbol variety than email that does not support graphics. Parallelism refers to the number of effective co-existent conversational channels. Rehearsability is the extent to which a communication medium allows communication participants to edit and change a message before sending it. Communication media such as email and GSS that save communication contents support high reprocessability.

This theory adopts a deterministic view of communication media, specifying that structural features of communication media affect the communication process. A communication medium that supports high synchronicity (high immediacy and low parallelism) is useful to the convergence process, whereas communication media that support low synchronicity (low immediacy and high parallelism) are useful for conveyance. The theory also regards communication medium capacity as dynamic, changing with the group interactions. When groups evolve and establish norms, they may need less synchronicity to carry out the same task.

Theory of media synchronicity looks like an extended media richness theory because it implies that the fit between media synchronicity and communication processes may increase group productivity, but the propositions of theory of media synchronicity have not been extensively tested and the efficacy of the theory remains to be seen. On the other hand, like other CMC theories, it has focused only on communication, which may be only one contributor to group productivity.

2.2.4 Studies about Principle of Interactivity

The principle of interactivity (Buller, Burgoon, et al, 1996; Burgoon, Bonito, Ramirez, et al., 2002) was developed by Burgoon and her colleagues to guide CMC studies. Its central premise is simple: "*human communication processes and outcomes vary systematically with the degree of interactivity that is afforded or experienced*" (Burgoon, Bonito, Ramirez, et al, 2002). Interactivity can be understood in two senses. the first is to view communication media or interface in the "*fixed, structural properties that afford or enable participants engage in interdependent interactions*" (Burgoon,

Bonito, Ramirez, et al, 2002). These interactivity properties include contingency (whether a communication interface produces answers contingent on a users' question), participation (whether users are participants or observers), synchronicity (whether communication occurs in real time or is delayed), proximity (whether users are geographically co-located or distributed), and richness of nonverbal cues and information.

In the second sense, interactivity refers to the communication participants' perception of the interactions during which structural properties and affordances have been manifested and experienced. Interactivity in this sense includes but is not restricted to "*involvement (cognitive, emotional, and behavioral engagement in an action), interaction ease and coordination (its smoothness and naturalness or difficulty and awkwardness), and mutuality (e.g., perceptions of connection, similarity, receptivity, understanding)*" (Burgoon, Bonito, Ramirez, et al., 2002). The principle of interactivity specifies that structural interactivity affects perceived interactivity, and interactivity (both structural and perceived) affects group processes and outcomes.

Studies of interactivity have examined how different communication contexts having different interactivity affordances affected group processes and outcomes. Communication contexts included computer interfaces (text, voice, text + voice + still graphics, text + voice + animated graphics) (e.g., Bengtsson et al., 1999), proximity and availability of nonverbal cues (e.g., Burgoon, Bonito, Ramirez, et al., 2002), and communication modalities (FtF, audio-video, audio, video, text) (e.g., Burgoon, Stoner, et al., 2003).

Unlike other studies that simply compared synchronous and asynchronous communication with FtF communication, these studies decomposed communication context into more fine-grained components (e.g., FtF communication in text only, FtF communication in oral only, distributed communication in text only, distributed communication in voice only), and helped improve understanding of how each component respectively affected perceived interactivity and outcome. These studies gained insights into the communication context at a more fine-grained level by identifying how a specific communication modality or interface feature affected group process and outcome.

Principle of interactivity is more concerned with how structural properties of communication context affect group outcome than with why these properties affect group outcomes in certain ways.

2.2.5 Summary of CMC Reviews

The common basic assumption about CMC theories is that technologies have particular structural features that influence participants' communication processes and outcome in a predictable pattern. These theories imply that if technology is appropriately employed to facilitate a communication process, group outcome will be improved. A limitation with regard to group productivity is that these theories focus only on communication, although other group processes may be involved in group interactions and affect group productivity in a systematic pattern. Another limitation is that because these theories are not causal models of group productivity per se, many studies guided by

these theories have focused on participants' perceptions of the communication process, of communication outcome, or of relational development rather than on group productivity.

Unlike prior GSS and CMC studies that only touched upon productivity, this study examined productivity explicitly under a theoretical model of productivity – Focus Theory, which is explained in more detail in the next section.

2.3 Focus Theory

Focus Theory includes mental effort as a component of team productivity, but it does not address the effect on team productivity of physical effort such as lifting a stone. The theory concerns itself only with team productivity, offering no accounting for participants' perceptions of such factors as perceived group cohesion. It is a parsimonious, bounded, general causal theory of team productivity. (Briggs, 1994) provides a very good overview of Focus Theory, describing it as

> *. . . parsimonious, having only five constructs. It is bounded in that its constructs do not infinitely divide into myriad other constructs; rather they logically derive from a few fundamental assumptions about the nature of people. It is general in that it doesn't answer the question, "how do we account for the productive use of this technology by teams?" but rather "what makes a team productive?" Focus Theory is unifying in that it offers a chain of reasoning to tie many other models and constructs used in GSS research back to a common foundation. It is explanatory in that it offers a chain of reasoning from its constructs to the likely productivity results of many manipulations, including technical innovations. p. 15*

The fundamental assumption of Focus Theory is that attention is a limited resource and that the total amount of attention for a cognitive process is affected by a person's motivation (goal congruence) and distraction. Goal congruence is the degree to which the perceived vested interest of an individual in a team is congruent with the goals of the team. Of the three processes necessary to achieve team productivity

(communication, information access, and deliberation) each demands cognitive effort over time (attention), and attention is a limited resource. The attention allocation to the processes interferes with one another, and increasing attention to one process suggests decreasing attention to the other two. "*Thus the limits of attention become a fundamental limit of team productivity. Further, the attention focused on theses processes is the direct cause of productivity. Focus Theory is so named because it attends to the focusing of team attention toward achieving team goals" (Briggs, 1994) p.17.*

2.3.1 Elaboration of Focus Theory

This section will explain all constructs in Focus Theory: goal congruence, distraction, communication, deliberation, information access, and team productivity.

The goal congruence construct is complex, and it is affected by many factors, which include desired certainty of success, perceived task difficulty, perceived effort required, perceived effort available, self efficacy, and desire for goals. The current study was not intended to test the validity of the goal congruence construct, but to treat goal congruence as a black box and to investigate the relationship between goal congruence and other constructs in the model. Whereas goal congruence determines how much cognitive effort a person is willing to invest in mental work, distraction includes any factor that diverts attention from the target process, such as noise.

In Focus Theory, communication takes into consideration the exchange of meanings among people, for which data communication equipment may sometimes be used. On the other hand, the theory treats such equipment as a black box, and considers

only how its use of such equipment might affect the attention resources of the participants.

Whether its processes are methodical or chaotic, deliberation in Focus Theory utilizes all cognitive processes except communication and information access to achieve a goal. A structured deliberation may consist of a series of processes such as defining the problem, identifying alternatives, evaluating alternatives, and choosing alternatives. A chaotic deliberation may identify alternatives before clearly defining a problem.

Definition of information is function-oriented. Information is defined as knowledge about one's course of action and having more information may increase the accuracy of expectation of a certain outcome related to one's course of action. However, searching, storing, organizing, and accessing information all consume attention resources.

Team productivity in Focus Theory measures the degree of goal attainment and has two components: team efficiency and team effectiveness. As a general theory about group productivity, Focus Theory is not technology specific, however, its reasoning logic implies that technology can be used to increase group productivity. Section 2.2.2 discusses this implication in detail.

2.3.2 Focus Theory and Collaboration Technologies

The reasoning logic of Focus Theory allows technology to intervene in the cognitive effort and processes by reducing distraction, facilitating communication, providing group memory, and structuring the deliberation processes. Three types of technological support can be used to facilitate distributed project interactions: conferencing technology, project management software technology, and GSS technology.

Although group members can communicate via video or audio conferencing, communication content is not recorded automatically for later access, and there is no built-in mechanism to structure the group process and facilitate deliberation. Most PM systems are web-based (Chen, Romano & Nunamaker, 2003); they support communication by providing online chat and electronic message boards. They support information access by posting project-related information online and providing document management functions. However, they do not provide deliberation support such as facilitation of divergent thinking (e.g., electronic brainstorming) or convergent thinking (e.g., organizing ideas, discussing ideas, evaluating ideas, building consensus). While GSS can support all three processes, it supports communication in text format. It also provides permanent group memory by keeping a record of whatever has been entered into the system thus facilitating information access. GSS supports deliberation by structuring the deliberation process into divergent and convergent thinking and by providing tools (e.g., electronic brainstorming tool, voting tool) to facilitate the thinking.

2.3.3 Focus Theory Related Studies

Only two studies have been done to gain better understanding of Focus Theory (Romano, Briggs, Nunamaker & Mittleman, 1999) and (Walsh, 1996). The Romano et al. study specified that Focus Theory provided theoretical guidance for investigation of distributed GSS interactions. However, their explanation was limited to discussion of how Focus Theory helped researchers select a technology to facilitate interaction, and did not discuss the ways that constructs of Focus Theory were manifested in interactions or whether Focus Theory has explanatory power for observed phenomenon.

Walsh's study (Walsh, 1996) investigated application of GSS to business process reengineering. It mainly focused on two constructs: goal congruence and information access and investigated whether goal congruence explained the amount of cognitive effort a participant might decide to put into the reengineering activity as well as whether increasing information access would be likely to improve group performance. The investigation was conducted mainly via observation and interviews; no quantitative data to measure constructs in Focus Theory were collected. The results of the study indicated that, while information access was important to group activities, goal congruence was not sufficient to explain the amount of cognitive effort participants decided to put into the reengineering activity. The author suggested that two factors affected the accord between cognitive effort: goal congruence and process accord. Process accord refers to participants' belief that business process reengineering, particularly reengineering techniques, can improve the business process.

This study goes beyond the above two investigations. It attempts to clarify the overall model of Focus Theory as well as to examine how three processes are manifested, facilitated and/or inhibited during group interactions, and how these processes and other constructs may affect group productivity.

2.4 Summary of Literature Review

Both GSS and CMC studies have examined group interactions supported by collaboration technology. GSS studies have aimed at discovering how to enhance group performance by task and process support, whereas CMC studies have examined how features of communication media or interfaces have affected group outcomes. Both types

of studies have investigated group productivity only to a certain degree or from a particular aspect, but the theoretical models that guided the researchers did not explicitly address group productivity, even though they had implications for group productivity.

Many prior GSS studies adopted an input-process-output model, specifying that different types of input factors interact with one another to affect group process and, in turn, affect group outcome. However, the model remains silent on how these factors interact with one another, and does not address what group process consists of and what factors should be included in group outcome. In addition, four types of input factors can infinitely be decomposed into other factors. The model therefore does not have parsimony to guide scientific investigations and is not about cause-effect. Studies guided by it testified only as to the potential effects (including group productivity) of certain input factors, but did not explain why such effects happened. The model cannot be used to predict group productivity, given certain input factors.

In contrast, Focus Theory is derived from several fundamental premises about human nature. It has only four constructs, which cannot be decomposed into a variety of other constructs. In addition, Focus Theory is explicit about the interaction process and specifies how three processes may interact with one another to affect group productivity.

Does the specification of these processes help us gain better understanding of group productivity? Which process may be a bottleneck for distributed group interaction?

CMC studies gained some insights into how communication media and other communication context factors affect group performance, including group productivity. However, CMC studies have focused only on the communication process, which may be

only one part of the big picture of group productivity and inadequate to fully explain group productivity. In contrast, since Focus Theory specifies that three processes to be necessary for group productivity (communication, information access, and deliberation), does examination of information access and deliberation offer new or additional insights into our understanding of the mechanism of group productivity when groups use collaboration technology to facilitate their interactions?

Focus Theory proposes that attention is a limited resource, that allocations of attention to three processes will interfere with one another, and that collaboration technology that can facilitate any or all of the three processes should increase the group productivity. Does this proposition have validity? How are three processes manifested and facilitated/inhibited during group interactions? How do these processes affect group productivity? Answering these questions should increase understanding of the mechanisms of group productivity. A global economy increasingly requires effective coordination among members of project teams that may be working at a single or multiple sites. Understanding those mechanisms is important for collaboration technology design and for the practice of group interactions. Project interaction was chosen as the context of the study, because non-trivial projects usually last for a period of time and provide opportunities to study how Focus Theory constructs are manifested, and how three processes are facilitated and/or inhibited over a period of time and at different stage of group development.

Chapter 3 describes the research methodology, study design, and subjects.

CHAPTER 3 RESEARCH METHODOLOGY

This study adopted a multi-methodological approach developed by Nunamaker and his colleagues (Nunamaker et al., 1990-1991) that involves grounded theory development (e.g., conceptual frameworks, mathematical models), observation (e.g., field research, case studies, action research), experimentation (e.g., controlled laboratory experiments, computer simulations, field-based quasi-experiments), and systems development (e.g., prototyping, product development, technology transfer). In this model, theory building was the objective. In this methodology a theory is developed to guide a study and systems are built to serve as proofs-of-concept for the theory. Systems are evaluated in different environments (e.g., lab experiments, field experiments, case study, action research) to test the systems and the theory.

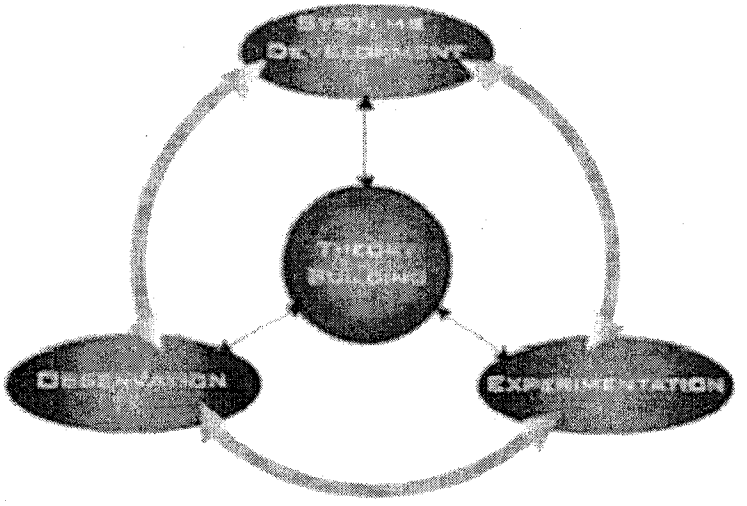

Figure 3.1 Multi-methodological Approach to IS Research

(Nunamaker et al., 1990-1991)

Focus Theory provided the conceptual framework for this study. Although it did not involve system development, it needed to have GSS tools configured to support group interactions. Cognito, a web-based group support system produced by GroupSystems, was used in the study. Action research allows a researcher to participate actively and to observe GSS-facilitated group interactions in different modes. The rest of the chapter proceeds as follows. Section 3.1 introduces action research and explains why it is a valid and appropriate methodology to examine group productivity for group interactions supported by collaboration technology. Section 3.2 describes the subjects and study design, section 3.3 presents study procedure, and section 3.4 explains GSS configuration for group interactions.

3.1 Action Research

This section describes action research, explains why it was chosen as an appropriate research methodology for the study, notes its differences from other research methodologies, and illustrates principles for a rigorous action research.

Action research can be defined as "*an inquiry into how human beings design and implement action in relation to one another*" (Argyris et al., 1985) p 4. Dual outcomes of action research are action (solving a problem or initiating change) and research (theory) (de Vreede, 1996). In other words, action research attempts to improve practice and theory.

3.1.1 Action Research Origin and Nature

Action research was developed after World War II in the social sciences by Kurt Lewin (Lewin, 1946; Lewin, 1947), who was credited with developing the method for

conducting studies in social psychology by using field theory (Baskerville & Wood-Harper, 1996; Baskerville & Wood-Harper, 1998). Variations of action research have since been developed and practiced (Baskerville & Wood-Harper, 1996). For example, Argyris and his colleagues (Argyris et al., 1985) used the term "action science" to refer to organizational action research and organizational learning. There was debate among researchers about whether action research is a scientific approach. Susman and Evered (Susman & Evered, 1978) discussed action research and compared it with positivist science, concluding that action research is a valid scientific research methodology. Baskerville and Wood-Harper discussed applying action research to the IS field as a philosophical issue. They concluded that action research is "*a method that could be described as a paragon of the post-positivist research methods. It is empirical, yet interpretive. It is experimental, yet multivariate. It is observational, yet interventionist.*" (Baskerville & Wood-Harper, 1996). Recently, IS researchers have started to apply action research as a research methodology (e.g., Briggs, Adkins, Kruse, Nunamaker, Mittleman & Miller, 1999; de Vreede, 1996; Romano et al., 1999).

Action researchers actively participate and intervene in the phenomena of interest, applying the theory to guide intervention/action, and building and testing the theory in the action. Participation and intervention thus are two characteristics of action research. Participation does not imply that objectivity is disregarded by action researchers per se, rather it implies that in certain situations, a researcher's active participation contribute to in-depth understanding of a phenomenon of interest. Action research differs from

participant observation in that action researchers intervene an action whereas researchers in participant observation do not.

Action research is similar to case study methodology in that both of them allow researchers to gain in-depth understanding of a phenomenon of interest. Action research may actually be seen as a subset of case study research (Galliers, 1991). The difference between them is that action research encourages a researcher's active participation and intervention of study phenomena, whereas case study methodology inhibits participation and intervention.

3.1.2 Selecting Action Research Approach as the Research Methodology

Action research was selected as the research strategy for this study because it is appropriate for examining the study inquiry. According to Yin (Yin, 1994) p. 3., while there is no perfect research strategy, every strategy has advantages and disadvantages. Yin listed five research strategies: experiment, survey, archival analysis, history, and case study and recommended that when determining which of them to use investigators look at the three conditions: "*a) the type of research question posed, b) the extent of control an investigator has over actual behavioral events, and c) the degree of focus on contemporary as opposed to historical events*" (Yin, 1994) p. 4.

In general, history research tends to use archival analysis. The question of "what" to investigate contemporary event can be addressed by survey and archival analysis. The questions of "how" and "why" to investigate contemporary events need to be addressed by using experiment or case study. When the control of the investigation is high, experiments can be used, and when the control is low, case study methodology can be

used. Action research was selected for this study because, like case study methodology, it allows the researcher to answer "how" and "why" questions without exerting too much control of the study environment.

Use of action research as the research methodology can also be justified by the criteria specified by Benbasat and his colleagues, who wrote that case study research methodology is appropriate for the following study situations (Benbasat, Goldstein & Mead, 1987):

1) There is a need to study a phenomenon in its natural settings. As indicated in the literature review, most GSS and CMC studies have involved lab experiments with students as subjects, and their tasks have been contrived tasks. This study also used students as subjects in a setting that was not entirely "natural" since it was not in real organizations. The distributed-asynchronous mode was simulated instead of being "real" because participants were co-located and could meet FtF regularly. However, the setting was "natural" to a certain degree, because the tasks for groups were real and non-trivial.

2) The study inquiry has an emphasis on "how" and "why" questions. This study focused on "how" questions: how Focus Theory constructs are manifested during group interactions, how three processes are manifested and facilitated or inhibited by collaboration technology, and how Focus Theory can be used to explain the observed phenomenon.

3) Lack of previous study and theory understanding. As discussed in the literature review, although GSS and CMC studies have investigated group productivity, they only have touched upon productivity without examining the mechanism of

productivity. Many GSS studies adopted an input-process-output model to investigate how several categories of input factors affect group process, which in turn affects group outcome. Such studies testified only to what would happen to group outcome when certain input factors were presented but did not reveal why group productivity actually was. The input-process-output model was shown not to be able to predict group productivity given certain input factors at a particular state.

Theoretical models (social presence theory, media richness theory, social information exchange theory, theory of media synchronicity, and principle of interactivity) that guided CMC studies did not address group productivity per se, even though they had implications for it. One limitation of these theoretical models is that they examine only communication, which maybe just part of the big picture of group productivity.

Although Focus Theory was developed specifically to examine group productivity, few studies to understand it have been done in empirical settings. In view of a widespread lack understanding of the phenomenon of group productivity and of the theory of group productivity, an action research approach was selected over case study methodology to address this deficiency because it allows the researcher to participate in a phenomenon of interest, to intervene in the practice of decision making, to evaluate the intervention, and to evaluate the theoretical model used to guide the study. Consistent with the purpose of action research to improve practice and improve the theory, the study examined group productivity in the context of group interaction supported by collaboration technology, and it emphasized group interactions in distributed format.

Prior GSS and CMC studies that investigated distributed interactions reported mainly what had happened to group outcomes and participants' perceptions about communication process and outcome. They seldom reported what might be done to improve group performance, given a certain interaction scenario. Guided by Focus Theory, this study examined how the three processes are manifested, and how they can be facilitated by technology. If group interactions were seen as being non-productive, the researcher needed to think about a possible reason or a way to improve group productivity. The researcher's active participation and intervention, and participants' ability quickly to adapt to the interactive environment could be encouraged, rather than controlled. The next section will explain action research in detail.

3.1.3 Action Research Process

The action research process is a cycle: diagnose, action planning, action taking, evaluating, and specifying learning (Susman, 1983). Diagnosing refers to the identification of the primary problems that need to be solved. Guided by the theory, researchers and participants plan and implement actions, and researchers evaluate the implementation. The newly acquired knowledge from evaluation can be utilized in three ways: 1) assimilated into accumulated knowledge; 2) if evaluation indicates a practice is unsuccessful, the additional knowledge can provide a foundation for further action research intervention; and 3) additional insights into the theoretical framework will provide important knowledge for future research. (Susman, 1983) In this study, the iterative process was implemented at the micro-level. Group interactions were observed and evaluated, changes were suggested and implemented, improvements were noted and

these steps were repeated as the effects of changes were further observed. Insights into the theory are summarized at the end of the study.

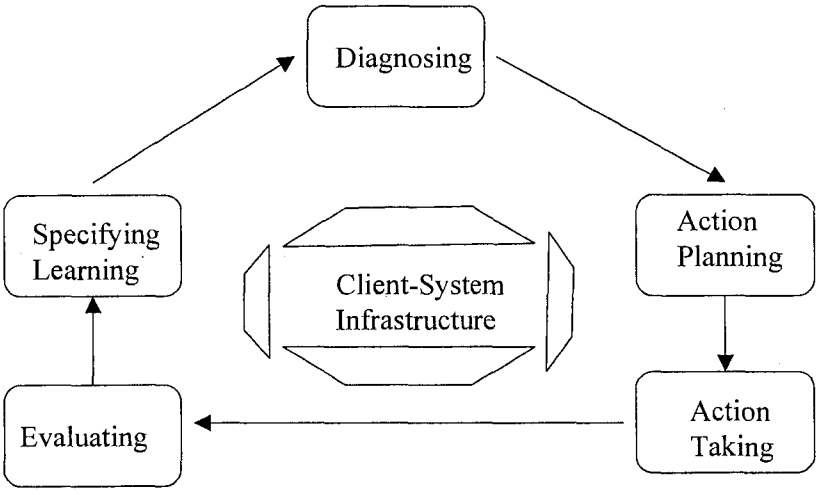

Figure 3.2 Action Research Cycle

Adapted from (Susman, 1983)

There are three types of researcher involvement in action research: collaborative involvement, experts involvement, and facilitation involvement. For collaborative involvement, researchers participate equally with subjects in the study; there is no distinction between them. Experts involvement distinguishes researchers from participants by making the researchers responsible for resolving immediate problems. Facilitation involvement implies that researchers act as experts in the activity, but the burden of major problem solving rests upon the participants and the researchers' role is to facilitate the problem solving process (Baskerville & Wood-Harper, 1998). In this study, facilitation involvement was adopted, the researcher acted as a group interaction facilitator. Section 3.4 will describe the facilitation role more fully.

3.1.4. Characteristics of Rigorous Action Research

The researcher involvement in a phenomenon of interest suggests that action research lacks objectivity, which is the study prerequisite for most other research methodologies. Baskerville and his colleagues (Baskerville & Wood-Harper, 1996) stated that action researchers face additional challenges in maintaining rigor in research. They specify several characteristics of rigorous action research. Some applicable ones are introduced here: establishment of a formal research agreement, planned measurement methods, maintaining collaboration and subject learning, promoting iterations, and restrained generalization.

1) Establishment of a formal research agreement refers to obtaining "informed consent" from subjects. Participants in this study were informed of the study's intentions before it started.

2) A major characteristic of rigorous action research is planned measurement methods. According to Baskerville (Baskerville & Wood-Harper, 1996), measurement methods are critical "*for credibility since it is ultimately impossible for the researchers to sustain claims of validity in their data analysis if the data cannot be produced for examination*". Argyris et al (Argyris et al., 1985) p. 239 suggested several reliable data collection techniques such as audio-taped observation, interviews, and participant-written cases. In this study, two types of data were collected. The quantitative data were collected by using a group activity questionnaire and qualitative data are collected in the format of field notes, interviews notes, and participants' anonymous comments and feedback. When Yin (Yin, 1994) talked about case study rigor, he emphasized the importance of

triangulation of data, a criterion which the author believes can also be applied to action research. Section 3.4 describes in detail the data collected in this study.

3) The objective of maintaining the collaboration between researchers and subjects is to allow subjects to offer researchers insights concerning actions. In this study, the researcher participated in every FtF and synchronous-distributed group interaction session, took field notes, and talked to participants about their feedback and suggestions after sessions.

4) Iteration is a characteristic of action research. It is recommended to plan the action, implement and evaluate the action and theory iteratively. As has been mentioned, iteration was implemented in this study at the micro-level.

5) Traditional criteria for reliability and generalization may not be applicable to action research. Kirk and Miller (Kirk & Miller, 1986) suggested that synchronic reliability was the more useful characteristic of qualitative research. This type of reliability "*is based on the consistency of observations within the same time period*"(Baskerville & Wood-Harper, 1996). Baskerville et al. (1996) also suggested that action researchers can legitimately generalize their findings on the basis of research validity (the degree to which the research accomplished its intended goals within its scientific paradigm). However, such generalization is restrained by limited number of observations. In this study, the rule of consistency of observations was observed, as described in detail in section 3. 4.

In summary, action research is a valid and scientific investigation methodology. It is an appropriate research approach to examine group productivity for groups that are

supported by collaboration technology. Collection of different types of data for triangulation of findings increases validity of such a study.

3.2 Subjects and Study Design

Data were collected in Fall 2003 from two MIS undergraduate classes at a. western U.S university: class 220 (later referred to as Class), and class 210 (later referred to as Class 2). Participants in each class completed semester-long software projects, on which the entire class worked as a team to develop or to implement a system. Everyone in a class was supposed to get exactly the same project grade that would constitute 20% of his/her final grade. Students were informed of the intention of the study before data collection and had agreed to participate. Some course credits were given to participating students. The two classes had different instructors and the researcher worked as the coordinator and facilitator for the process tracking sessions of both class projects. Most of the students were juniors or seniors.

Class 1 helped a fictitious company implement SAP, an ERP system. Nineteen students in the class were divided into five sub-teams: FI (financial and accounting), PP (process planning), SD (sales and distribution), MM (manufacture), and PMT (project manager team). All teams had three members except SD, which had six. Class 2 developed a web-based system to track their business school's courses and instructor assignments of those courses. The class had 40 students, who were divided into eight sub-teams: DES (design), SW (software development), DOC (documentation), DB (database), TST (testing), QA (quality assurance), IMP (implementation), and MGN

(management). The team sizes were from three to six students (DOC and TST had four members, DES, DB, and IMP had five members, and QA and SW had six members).

The two classes first spent several weeks learning concepts related to their project. They then defined system requirements and started to design or configure a system. Classes met routinely twice a week to check project progress. These class meetings were manual FtF meetings without GSS support. Data were not collected for meetings at the class level. Each individual team had a weekly project process tracking session to check the progress of their specific tasks, using Cognito, a web-based GSS. Data were collected at the team and individual levels.

The study utilized a Latin Square design in which each team experienced all three interaction modes during a six-week period. Each team was in one of three groups: Group A, Group B, or Group C. Group A included the PMT (Class 1), SW, TST, and DOC teams. Group B included the SD (class 1), FI (class 1), DES, QA, and MGN teams, and Group C included the PP (Class 1), MM(Class 1), DB, and IMP teams.

Week	Group A	Group B	Group C
1	FtF	Syn - Dis	Asyn - Dis
2	FtF	Syn - Dis	Asyn - Dis
3	Syn - Dis	Asyn - Dis	FtF
4	Syn - Dis	Asyn - Dis	FtF
5	Asyn - Dis	FtF	Syn - Dis
6	Asyn - Dis	FtF	Syn - Dis

Table 3.1 Groups and Order of Mode

Three groups followed different orders of interaction mode, as shown in Table 3.1. Each team experienced the same interaction mode for two consecutive weeks. The sequence of the interaction modes for Group A was FtF, synchronous-distributed

(referred to as Syn–Dis), and asynchronous-distributed (referred to as Asyn–Dis). The order for Group B was Syn-Dis, Asyn-Dis, and FtF. The order for Group C was Asyn-Dis, FtF, and Syn-Dis.

Five students took Classes 1 and 2 at the same time and participated in GSS-facilitated project process tracking sessions twice a week. These five students were (by pseudo-name): LL, YH, AD, TD, and EK. YH was in the Class 1 SD and in the Class 2 DES team, both of which belonged to group B. TD was in the Class 1 FI team and the Class 2 MGN team, both in group B. The remaining of three students participated in two different modes in the same week. In addition, all team leaders of FI, MM, PP, and SD also participated the PMT sessions and also experienced two different modes in the same week. Questionnaire data were collected after each of these sessions, data from these participants were treated differently than those from others.

Four types of data analysis were performed on quantitative data in this study: ANOVA (demographic data), construct inter-items reliability test, factor analysis of constructs (goal congruence, cognitive effort, and distraction), and repeated measure analysis for constructs (e.g., goal congruence, cognitive effort, distraction). One assumption of ANOVA and repeated measure analysis is the independence of observations. Therefore, LL, AD, and EK were excluded from the Class 1 and Class 2 data files for ANOVA and repeated measure analysis. YH and TD were excluded from the Class 1 data file but were retained in the Class 2 data file because these subjects had repeated experience with the same mode in a particular week. Four team leaders of Class 1 (FI, MM, PP, SD team leaders) were excluded from the ANOVA and repeated measure

analysis. No assumption of independence of observations for reliability test and factor analysis was made. LL, YH, AD, TD, and EK were excluded from the Class 2 data file, but kept in the Class 1 data file. The team leaders for Class 1 FI, MM, PP, and SD were excluded from the MGN data file but kept in their individual team files.

Even though this study is an action research, design of the study looks like an experiment in terms of layout and the random assignment of teams into different groups. However, it was not a strictly controlled experiment, because session duration, tasks for each session, team size, and the group process were not controlled. The repeated Latin Square design allowed the researcher to observe how group norms, modes, and order of mode use affected the group processes, and how processes affected group productivity.

There were no significant difference among members of the three groups in terms of age, number of full-time working years, self-rated computer literacy (computer experience), and previous GSS usage. Self-rated computer literacy/experience was measured by three items, the inter-item reliability of this construct was reported in Chapter 4 and section 4.1.1. Table 3.2 presents the ANOVA table and table 3.3 lists mean and standard deviations and table 3.3. The average age of all participants was approximately 26 years, and the average number of full-time working years was slightly more than four years.

Variable	**DF**	**F**	**Sig**
Age	(2, 42)	1.31	.282
No. of Working Years	(2, 42)	.06	.946
No. of GSS usage before the study	(2, 42)	.12	.890
Computer Literacy	(2, 43)	.18	.836

Table 3.2 ANOVA Table of Group Demographic Information and Computer Usage

Variable	Group	No. of participants	Mean	Standard Deviation
Age	A	16	27.75	5.74
	B	18	25.72	4.71
	C	11	24.91	3.24
	Total	45	26.24	4.86
No. of Working Years	A	16	4.47	5.85
	B	18	4.39	4.46
	C	11	3.86	4.12
	Total	45	4.29	4.83
No. of GSS usage before the study	A	16	1.31	2.41
	B	18	1.61	1.14
	C	12	1.50	1.68
	Total	46	1.48	1.77
Computer literacy	A	16	2.00	1.07
	B	18	2.24	1.46
	C	12	2.19	0.96
	Total	46	2.14	1.19

Table 3.3 Mean and SD of Group Demographic Information and Computer Usage

3.3 Study Procedure

Training in GSS usage was provided for each class before the first week of data collection and lasted approximately 40 minutes for each class. The author explained the study objective, the study process, and Cognito usage with a PowerPoint slide show. Students then logged into a FtF trial interaction session held in the computer lab in order to gain hands-on experience in use of the software. Cognito allows session leaders more privileges than regular session participants, and team leaders were supposed to be session leaders for their teams, so two additional group training sessions were held for team leaders. Some additional individual team leader training sessions were held for some team leaders who had been unable to attend the group team leaders training session due to class schedule conflicts.

Each class met at its regular time twice a week. A usual class period was 75 minutes. Each class tracked its project progress by checking the individual teams' progress, and discussed issues that needed to be addressed. Typically, instructors and project managers conducted these meetings. Each class had three project managers, one of whom was responsible for overall project management and coordination. The other two worked with individual teams and closely coordinated routine project tasks with team leaders. Class-level meetings were FtF without GSS support. The author attended each class meeting during the data collection period to become familiar with the students, their projects, project progress, and problems and concerns that might arise. However, the author usually did not actively participate in the meetings at the class level. The author talked with instructors each week in short informal FtF meetings about project progress and student feedback.

Teams held one formal weekly project tracking session to check their progress, solve problems, and discuss issues, using Cognito. The teams also met in other times to engage in actual day-by-day work for the project. For example, although the SW (software) team might have only one formal weekly project tracking session, team members might meet more often actually to write and debug codes. Cognito-facilitated group interaction focused on project management functions, not on the actual work of the project, even though some team members worked on their projects during some sessions. One concern before the data collection was that teams might bypass the Cognito-facilitated sessions and hold additional weekly project tracking sessions without the author's knowledge. This seldom happened, mainly for two reasons. 1) The instructor

demonstrated full support for using Cognito. In the original syllabi of two classes, students' participating in Cognito-facilitated sessions did not contribute to their final grade. Two instructors modified the syllabi to make participation in Congito-facilitated sessions as 10 percent of their final grade. The instructors also indicated to their students that learning collaboration in distributed environments is important for real organizations, so the Cognito-learning experience would be valued by job recruiters. 2) Students usually were taking 3 to 5 classes, and many of students worked part-time. Most students had very tight schedule, it was difficult to find several time slots for the team to meet during a week period. The author observed that students worked hard to make distributed group interactions as efficient and effective as possible and did not try to bypass distributed group interactions. Some team sessions were very short, lasting for only five to ten minutes, most often when no major tasks were ongoing and the team was waiting for another team's output. For example, it took the Class 2 design team three weeks to finalize the design, but while the design team was working on the design, the software and database teams did not have much to do, and their sessions were very short because they did not have much to talk about.

For individual team sessions, the team leader and the author set up the session in Cognito before each session. The team leader usually filled out the Agenda Form (see Appendix D) to list agenda items for each session and entered these agenda items into the system. After the session, the team leader indicated which items had been fully discussed. The number of fully discussed items was the measure of the session effectiveness. All session participants filled out a group activity questionnaire (see Appendix B) after each

session. The author conducted informal, unstructured brief interviews with some participants, and all participants were encouraged to log in an online asynchronous session to provide anonymous feedback about the session. Student interviews and participation in anonymous feedback were optional. The author had created a website for posting team session information that included PowerPoint training slides, a team's session schedule, email addresses for everyone on the team, and session notes downloaded from the Cognito server.

In FtF mode, all team members assembled in one computer room and everyone usually had access to GSS. Participants engaged in oral discussion, and entered comments and notes into the system. The author sat in the same computer room, observing group interactions, providing facilitation if necessary, and taking field notes.

For the synchronous-distributed mode, a team was split in two, with half of participants staying in one computer room and the other half moving to another computer room. Every participant usually had access to GSS, although two participants sometimes shared a computer. Participants in the same room could talk to one another, but they could communicate with team members in the other room only through text provided by GSS. The author visited both rooms, coordinating the session, providing support, and taking field notes. FtF and synchronous-distributed sessions usually lasted for approximately 5 – 60 minutes.

Asynchronous-distributed sessions usually lasted for 48 hours. Some sessions were longer if participants misunderstood the session schedule or if some participants did not log in the system as expected. Participants logged into the system from anywhere and

at any time to enter comments and engage in discussions. They were encouraged to log in four times during a 24-hour period but the actual number of log-ins varied by individual and session. The author logged in to the session frequently to check progress and remind participants to log in if they had not done so or if they had logged in too few times.

After the session, the author interviewed some session participants in an informal and unstructured way and took notes about their suggestions and comments on the group interaction. An asynchronous meeting also was set up to allow students to enter feedback and comments about each project process tracking session. Students were told that the comments would be anonymous in hope of encouraging candid and honest responses. All session notes were posted on the project management website for students to review.

3.4 GSS Configuration for the Group Interaction Sessions

A brief introduction to Cognito, a web-based GSS used in the study, may be helpful for understanding the group interaction procedure and structure. Cognito server is hosted by the Center for the Management of Information, the University of Arizona. All participants have the Cognito server URL, username, and password to log in the system. Participants needed to download and install Cognito on a particular computer when logging in for the first time. After successfully logging in, participants saw a screen with two panes. The left pane listed topics for the group's interaction; the right pane listed sub-topics associated with a particular topic on the left pane. A sample screen is displayed in Figure 3.3.

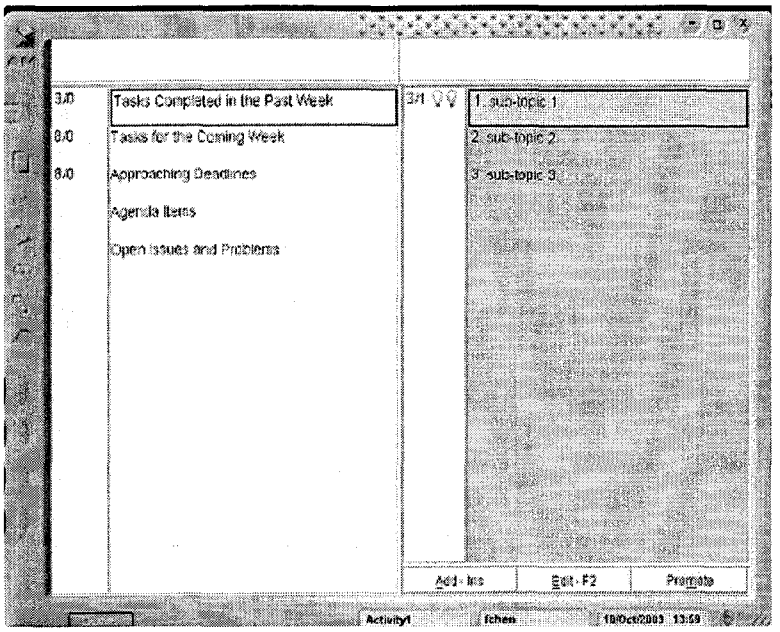

Figure 3.3 Project Process Tracking Main Window

In the first week of the course, team leaders were supposed to identify whatever topics needed to be covered on the left pane. The author found that this ad hoc process of agenda setting did not work well because some team leaders set up one or two topics for the session that actually covered more topics. Content of the session might not match a topic or be confusing to the participants. It also made it difficult for participants to locate, access, and retrieve relevant information after the interaction. The author and the Class 2 instructor consulted and decided to adopt a project process tracking session template for all team interactions. The template included five general topics: Tasks Completed in the Past Week, Tasks for this Week, Approaching Deadline, Agenda Items, and Open Issues/Questions. Open Issues/Questions referred to issues and questions that needed to be addressed, all items that were not listed under tasks, deadlines, and issues were listed under agenda items.

This session template was adopted by all teams beginning in the second week. The author created the template for each session, and the team leader logged in the session and created sub-topics for these general topics before each session. For example, to add sub-topics for Tasks Completed in the Past Week, a team leader could double click the topic title, then click the "Adds-in" button on the right pane, type the sub-topic in the pop-up window, and then click the "Submit" button on the pop-up window. Sub-topics for other topics could be created the same way. To view the sub-topics for a particular topic, the user just needed to double click the topic title. To see a detailed description and discussion for a particular sub-topic, double clicking the title of the sub-topic would bring up the discussion window, a sample of which is displayed in Figure 3.4. Session participants could add descriptions of the sub-topics under the "Specifics" tab and enter ideas and comments under the "Discussion" tab.

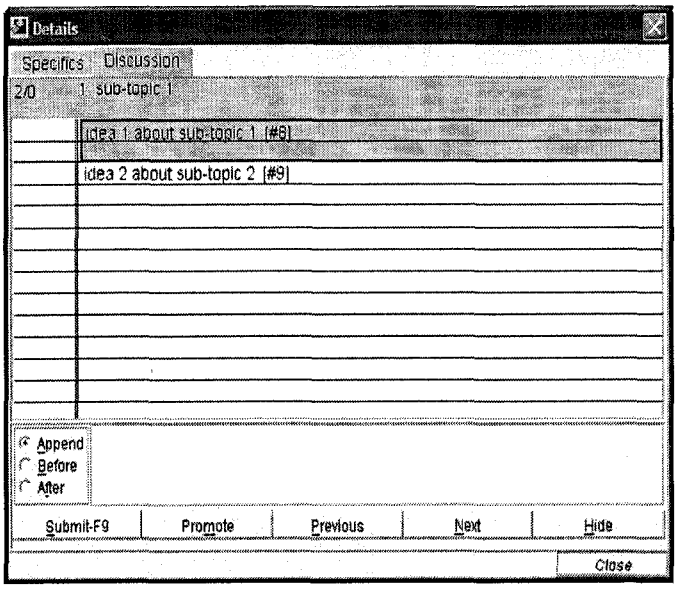

Figure 3.4 Discussion Window

One advantage of Cognito is the flexibility of its layered structure. A session facilitator (assuming he/she has full authority) can add tools within tools to create layers of communication. For example, an annotation tool can be added to the discussion window so participants can then double click on an idea and enter an annotation or comment on that idea.

3.5 Summary of Research Approach

This study adopted a multi-methodological approach. Focus Theory provided the theoretical framework. Action research was selected as a valid scientific methodology and an appropriate methodology for the study because it allowed the author to participate in group interaction, observe the interaction, intervene in the interactions, and evaluate both practice and the theory. A questionnaire was used to collect data at the individual and team levels. Quantitative data collected at the individual level were goal congruence, goal understanding, cognitive effort, distraction, session process satisfaction, and session outcome satisfaction. Goal understanding was measured to check whether participants understood the team goal. Group productivity was measured at the group level. Focus Theory defines group productivity as the degree of goal attainment and has two components: team efficiency and team effectiveness. Team efficiency for each group interaction session was not measured because the interaction modes, tasks for each session, and team sizes were so different that measuring efficiency would generate little insight into group productivity. For example, a task that might take one group 5 minutes to finish in FtF mode might take 24 hours in asynchronous mode. The efficiency measure was not comparable across the modes and session.

If team effectiveness is a measure of degree of goal attainment, the quality of final deliverables produced by each team in this study could be used to estimate goal attainment. However, the final deliverables produced by each team were different. For example, the deliverable for design team was the design of software, and the deliverable for software development team was Java code. The two were not comparable. In addition, It would be more informative to have team effectiveness measured for each interaction session so that quantitative data and qualitative data of that session could be triangulated to provide insights into group interactions through the lens of Focus Theory. A more realistic measure, the number of fully discussed sub-topics, was adopted to estimate group productivity for each session for a particular team. Before each group interaction session, the team leader listed sub-topics under five standard topics: Tasks Completed Last Week, Tasks for This Week, Approaching Deadlines, Agenda Items, and Open Issues/Problems. After the session the team leader reported which sub-topics had been fully or partially discussed, or not discussed at all. The number of fully discussed sub-topics was used to measure interaction session productivity.

Satisfaction in this study also was measured as a kind of surrogate measure of group productivity because it is "*a valanced affective arousal with respect to goal attainment*" (Briggs, Reinig, & Vreede, 2003).

Chapter 4 presents and discusses results.

CHAPTER 4 RESULTS AND DISCUSSION

Two types of data were used in this study: quantitative data and qualitative data. Quantitative data were examined by reliability test, factor analysis, repeated measure analysis, and correlation analysis. For each construct measured in the study, repeated measure analysis is reported to illustrate how these constructs were manifested during group interactions in FtF and distributed modes. Cognitive effort consumed was not estimated separately for three processes (information access, communication, and deliberation), but, this chapter reports in detail how they were manifested and facilitated or inhibited in a communication context. The chapter also discusses implications for Focus Theory and collaboration technology design.

Three Focus Theory constructs, goal congruence, distraction, and cognitive effort, were estimated from participants' perceptions as items presented in Likert format. Goal congruence refers to the extent to which the team goal is congruent with its members' individual goals. Since participants' understanding of team goals may affect how they perceive or judge goal congruence, their understanding of team goal was estimated by a three-item measure in Likert format. Group productivity refers to the degree to which the team goal is attained. It was estimated by group interaction session effectiveness, which in turn was estimated from the number of topics (or agenda items) that were fully discussed during group interaction sessions. Group interaction process satisfaction and group outcome satisfaction were measured as a kind of surrogate measure for group productivity, because satisfaction is the "*a valanced affective arousal with respect to goal*

attainment" (Briggs, et al 2003). Group interaction process satisfaction and group outcome satisfaction were respectively estimated along a 5-item scale.

Measures of group process satisfaction and outcome satisfaction had been developed and verified by Briggs and his colleagues (Briggs, et al 2003). Measures for other constructs such as goal congruence, goal understanding, distraction, and cognitive effort were developed by the author and Briggs, one of the author's dissertation committee members. All these measures were subjected to a reliability test. Factor analysis included measures of goal congruence, distraction, and cognitive effort. Because satisfaction measures had been verified by other researchers, they were not included in the factor analysis. All measures were subjected to repeated measure analysis. Correlation analysis included measures of goal congruence, distraction, cognitive effort, and effectiveness of group interaction session. All statistical analysis was conducted by using SPSS 10.0. Table 1 lists the number of items for each measure. Please refer Appendix B for items comprising constructs.

Measures/Variables	Number of items	Developed by
Goal congruence	4	Self-developed
Distraction	4	Self-developed
Cognitive effort	6	Self-developed
Process Satisfaction	5	(Briggs et al., 2003)
Outcome Satisfaction	5	(Briggs et al., 2003)
Goal understanding	3	Self-developed

Table 4.1 Table of Constructs

4.1 Reliability Test

Participants were required to fill out the same questionnaire after each interaction session. When data for six weeks were used for a reliability test, the inter-item

reliabilities may have appeared to be higher than they actually were. The reliability test therefore was conducted each week to see whether there were substantial differences. Table 2 lists the reliability for various constructs for each week. There are 46 cases (data points) for week 1 data. There are 45, 48, 42, 48, and 45 cases for week 2, 3, 4, 5, and 6, respectively. Reliabilities for all constructs were above .77, which was acceptable.

Variable	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Goal congruence	.78	.94	.89	.93	.90	.94
Distraction	.86	.93	.89	.92	.90	.88
Cognitive effort	.87	.83	.88	.91	.95	.89
Process satisfaction	.92	.97	.94	.97	.98	.97
Outcome satisfaction	.91	.96	.92	.97	.97	.97
Goal understanding	.93	.93	.81	.92	.92	.95

Table 4.2 Table of Reliability

4.2 Factor Analysis

Factor analysis was conducted for items that were intended to measure three constructs: goal congruence, distraction, and cognitive effort. A factor analysis can illustrate the number of constructs (factors) that items actually measured. Two frequently-used factor analysis methods are principal axis factoring or maximum likelihood. In this study, maximum likelihood with promax rotation was used to extract factors. Promax is an oblique rotation used when factors/constructs are supposed to be correlated, as in the cases of distraction and cognitive effort. We therefore used oblique rotation. Three important factors were extracted by examining the Eigen values, scree plots, and factor loading matrixes of the items.

Factor	Initial Eigenvalues			Rotation
	Total	% of Variance	Cumulative %	Total
1	5.084	36.315	36.315	4.080
2	2.784	19.885	56.200	3.323
3	2.374	16.957	73.158	3.009
4	.616	4.397	77.555	
5	.516	3.683	81.238	
6	.499	3.563	84.800	
7	.366	2.614	87.414	
8	.343	2.453	89.867	
9	.297	2.124	91.991	
10	.267	1.910	93.901	
11	.253	1.807	95.708	
12	.234	1.672	97.380	
13	.206	1.468	98.848	
14	.161	1.152	100.000	

Table 4.3 Eigen Value and Variance Explained by Factors

Three factors had Eigen values above 1, as illustrated by Table 4.3, and could explain 73% of the total variance. Examination of the scree plots explained three important factors and factor loading matrixes indicated all items had a pretty clear loading on three factors (see Table 4.3). All cognitive effort items were loaded nicely on Factor 1, cognitive effort with a loading correlation within the range of .52-.90. All other items were loaded very low on this factor, except for one goal congruence item that was loaded as .23. All four goal congruence items were loaded on the second factor nicely, ranging from .60 to .95. All other items were loaded very low on this factor except for one cognitive effort item that was loaded as .30. Factor 3 was distraction, for which all items were loaded at .81-.86 and all other items were loaded very low. Figure 4.2 shows the factor plot in the rotated space and also indicates that cog5 (a cognitive effort item) and goal25 (a goal congruence item) did not conform with their own clusters very well. However, because they were more loaded on their own factors than on other factors, all

original items were included when the composite scores for goal congruence, distraction, and cognitive effort were calculated. The composite score was the mean of the individual items.

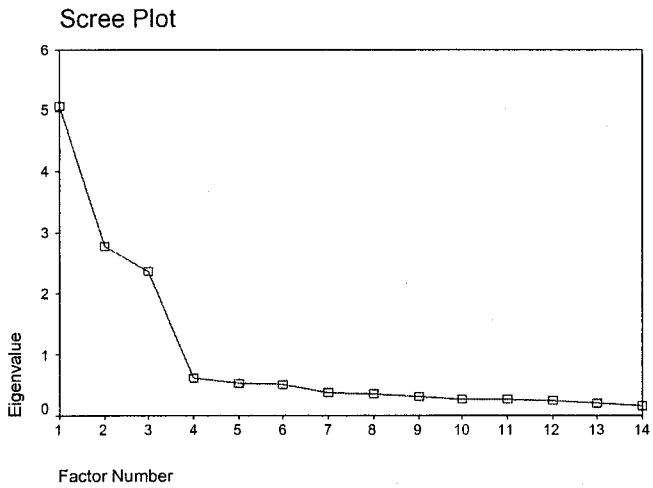

Figure 4.1 Scree Plot

	Factor		
	1	2	3
GOAL2	-.07	.87	-.03
GOAL3	-.07	.95	-.01
GOAL9	.0003	.87	.03
GOAL25	.23	.60	.03
COG5	.52	.30	-.03
COG11	.79	.02	.07
COG12	.77	.03	-.03
COG16	.73	-.0007	-.05
COG23	.90	-.1	.02
COG29	.84	-.06	-.004
DIS10	-.003	.09	.82
DIS14	-.11	.01	.83
DIS18	.13	-.09	.86
DIS26	-.03	-.003	.81

Table 4.4 Factor Loading

Factor	1	2	3
1	1.00	.32	-.23
2	.32	1.00	-.13
3	-.23	-.13	1.00

Table 4.5 Factor Correlation Matrix

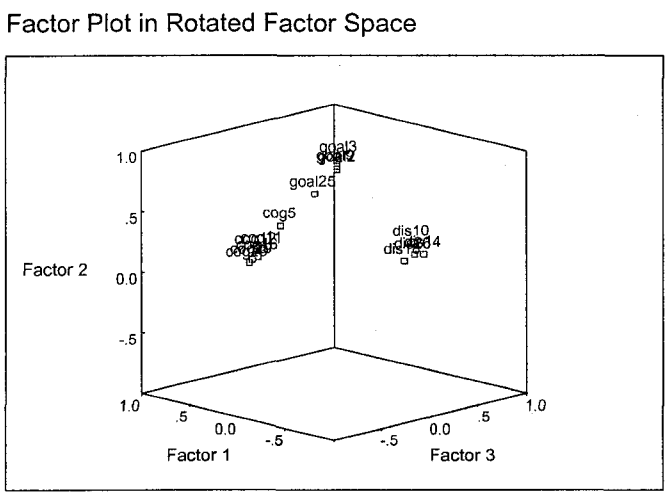

Figure 4.2 Factor Plot in Rotated Factor Space

4.3 Focus Theory Constructs Manifestations

This section addresses research question 1: How are Focus Theory constructs manifested during group interactions in FtF and distributed modes, and why. Since the study is an action research and exploratory in nature, the purpose of quantitative data analysis is not hypotheses testing, as it would be in a strictly controlled experiment. For each construct measured in the study, repeated measure analysis was conducted to see how constructs were manifested quantitatively.

Repeated measure analysis, a type of ANOVA, was conducted for measures of goal congruence, goal understanding, distraction, cognitive effort, group session effectiveness, group session process satisfaction, and group session outcome satisfaction. Between-subject factor was group. Within-subject factors were week and mode. There were three interaction modes: FtF, synchronous-distributed, and asynchronous-distributed. Two weeks were devoted to using the same interaction mode. Three groups illustrated three sequences of interaction modes. The sequence for group A was FtF, synchronous-distributed, and asynchronous-distributed; the sequence for group B was synchronous-distributed, asynchronous-distributed, and FtF; the sequence for group C was asynchronous-distributed, FtF, and synchronous-distributed. Most statistical analysis tables and some figures are presented in Appendix E. The variables were measured by Likert format scales. All items except cognitive items were recoded so that 1 indicated lower and 7 indicated higher value.

4.3.1 Goal Congruence

Goal congruence measures the degree to which team goals are congruent with individual goals. It was expected that interaction modes would not affect goal congruence. In other words, participants were anticipated to have relatively identical levels of goal congruence in all three interaction modes.

Table Appendix E-1 lists the mean and standard deviation for goal congruence over six weeks. There were 11 data points for groups A and B, eight data points for group C. As has discussed in chapter 3, some data were manually excluded from the analysis because several students participated in more than one group interaction session in a

particular week. The small number of data points in the analysis was a limitation of the study that will be discussed later and in chapter 5.

Repeated measure analysis indicated that the measure of goal congruence was different for interaction modes F (2, 54) = 3.96, p = 0.025, partial η^2 = 0.10; and week*group F(2, 27) = 4.68, p = 0.018, partial η^2 = 0.26 (see tables E-2 and E-3). A post-hoc Bonferroni test illustrated that the measure of goal congruence was higher for FtF than for synchronous-distributed (Mean Difference = 0.28, SD = 0.09, p = 0.017) mode. The measure of goal congruence was higher for FtF modes than for asynchronous mode, but the difference only approached significance (Mean Difference = 0.26, SD = 0.11, p = 0.078). There was no significant difference in the goal congruence measure between synchronous-distributed and asynchronous modes (Mean Difference = 0.02, SD = 0.13, p = 1.00) (see Table E-4 and Figure 4.3)

The interaction between week and group is illustrated by Figure 4.4, which implied that the three groups had different change patterns of goal congruence. Groups A and C had relatively constant perceived goal congruence, whereas Group B had higher goal congruence in week 2 than in week 1 (Mean Difference = .36, Standard Error = .12, p = .007) (see Table E-5).

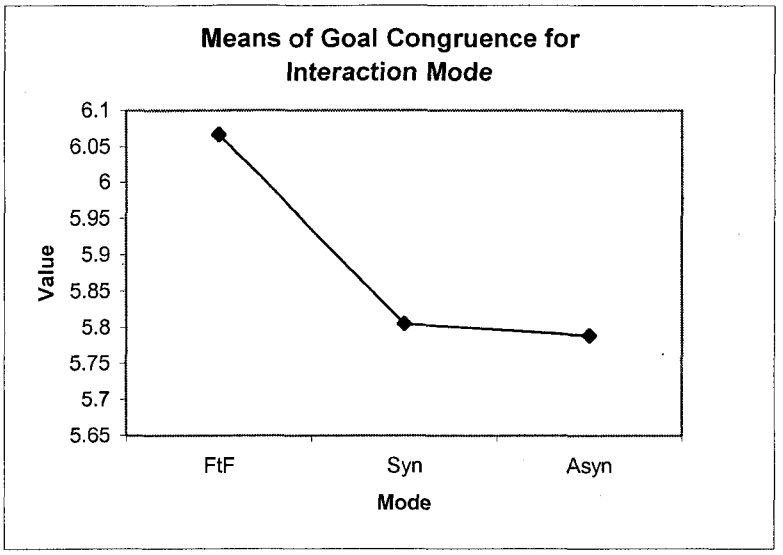

Figure 4.3 Means of Goal Congruence for Interaction Mode

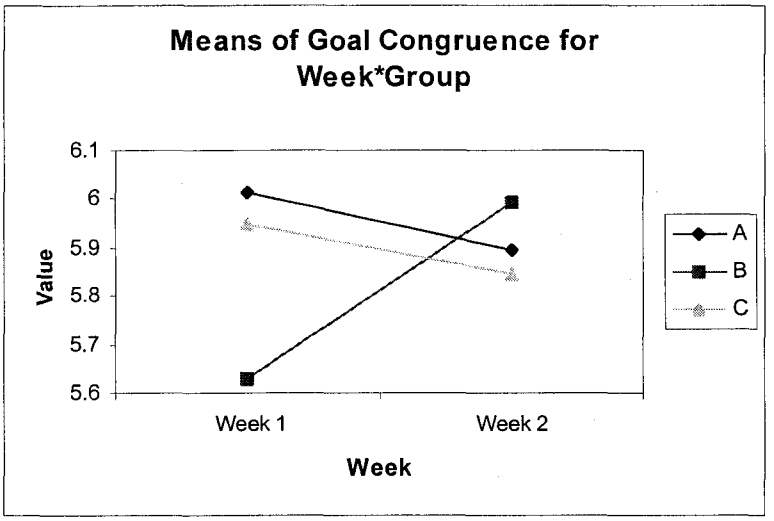

Figure 4.4 Means of Goal Congruence for Week*Group

To examine why goal congruences were different for FtF and distributed interaction modes and explore what may affect goal congruence judgment, an analysis of goal understanding was undertaken to gain some insights about goal congruence, since it was impossible to observe goal congruence directly. .

4.3.2 Goal Understanding

Team goal understanding is examined to estimate whether participants understand their team's goals. It was expected that goal understanding would be higher in FtF mode than in distributed modes, because participants might have more effective communication in FtF mode than in distributed modes.

Repeated measure analysis indicated that the measure of goal understanding was different for interaction mode F (2, 54) = 10.86, $p < 0.001$, partial $\eta^2 = 0.29$; week F(2, 27) = 4.36, p = .046, partial $\eta^2 = 0.14$, and week*group F(2, 27) = 4.38, p = 0.004, partial $\eta^2 = 0.25$ (see tables E-6, E-7 and E-8). The post-hoc Bonferroni test indicated that the measure of goal understanding was higher for FtF than for synchronous mode (Mean Difference = 0.66, SD = 0.17, p = 0.002) and asynchronous (Mean Difference = 0.68, SD = 0.13, $p < 0.001$) modes. There was no difference between the measures for synchronous and asynchronous modes (Mean Difference =0.02, SD = 0.19, p = 1.00) (see table E-9 and Figure 4.5). Participants appeared to have understood team goals better in week 2 than in week 1 (Mean Difference = .23, SD = .11, p = .046), a difference illustrated by Figure 4.6. The interaction of week and group is illustrated by Figure 4.7. The figure illustrates that participants in FtF mode did not experience much change in perceived goal understanding. However, participants in distributed mode were shown to have had better goal understanding in week 2 than in week 1 (see Figure 4.7).

The profile for goal understanding was somewhat similar to that for goal congruence, a result that seems to imply that perceived goal congruence was related to perceived goal understanding. If participants had had better understanding of team goals,

they might have perceived more goal congruence between the team goals and personal goals. The correlation analysis between these two constructs supports this statement (Pearson r = .69, p < .001).

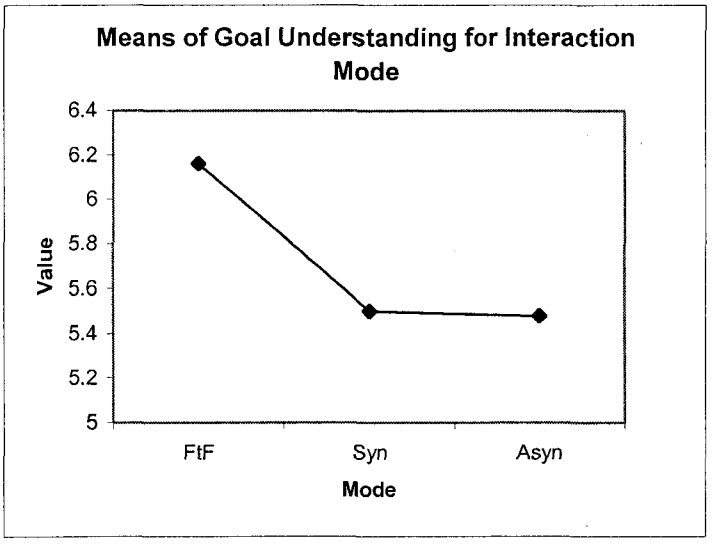

Figure 4.5 Means of Goal Understanding for Interaction Mode

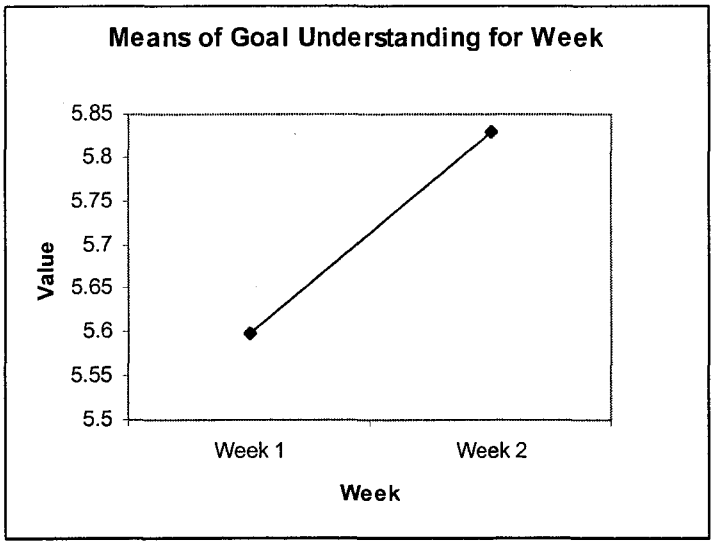

Figure 4.6 Means of Goal Understanding for Week

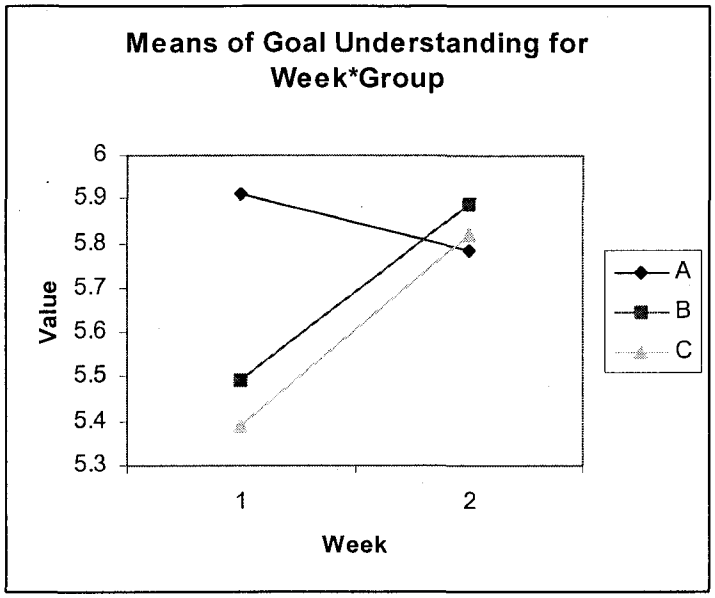

Figure 4.7 Means of Goal Understanding for Week*Group

4.3.3 Distraction

Distraction represents the degree to which participants attention resources were diverted from task-related activities. When participants interacted asynchronously, they logged on to the system, read input, and typed a response, a situation in which there should be little distraction. When participants interacted in FtF mode, they might have talked about things not relevant to group tasks and been distracted. When they interacted in synchronous-distributed mode, they have oral communication with other team members in the same room, but would have to type ideas and comments into the system. Typing and talking at the same time can be very distracting and it was predicted that synchronous-distributed interaction would be shown to be more distracting than FtF interaction, which in turn is more distracting than asynchronous interaction.

Repeated measure analysis (appendix tables E-17 and E-18) revealed no significant differences of distraction between modes, weeks, and groups. Neither were the interactions were significant. The results in this study implied that groups experienced relatively identical levels of distraction, and that distraction was not a big issue for group interactions, but the author's observations indicated that some distractions occurred, even though they were not significant statistically.

Some participants reported that using GSS for FtF interactions was distracting. One said: "*it was hard to do talking and typing at the same time, sometimes, I thought that I had an idea, then I started to type. However, after typing, I kind of did not catch up with the group conversation.*" (Quoted from the author's field notes of Class 2 SW Week 1 FtF). Some students suggested a need for specifying a person to act as a secretary to do note-taking for the team. According to their comments, the author suggested that every participant in FtF interactions log on to the system so the secretary could take the notes and all other participants could enter comments if they wanted to, allowing participants to focus on oral discussion and still keep a record of the group interaction.

The author also observed that smaller teams tended to experience less distraction than larger teams in FtF and synchronous-distributed interactions. For example, when Class 1 PP and MM team (team size was 3) conducted FtF interactions, there usually was one conversation going on at a time. However, larger teams like Class 1 project management team could be the site of three conversations going on during one FtF interaction. Some conversations may not have been related to the group tasks. Even if they were, not all participants may have been engaged in the same conversation, and

information sharing may not have been complete, which could have had a negative impact on group interaction and group task performance.

4.3.4 Cognitive Effort

Cognitive effort estimates the amount of attention resources used for communication, information access, and deliberation. When three processes are correlated, making one process easier may make the other two processes easier. Participants access task related information when they communicate with one another, and if participants do not communicate, deliberation will move to nowhere. If participants can communicate effectively, information access and deliberation may become easier, so FtF communication should provide the easiest communication because it supports all communication channels. Participants can encode messages in verbal and non-verbal channels, and message receivers can interpret messages from one or more channels. The distinction between synchronous-distributed communication and asynchronous communication is immediacy of feedback. In synchronous communication, participants can get feedback or response from team members immediately, and participants can get clarifications and responses in real time, thus reducing misunderstanding and waiting time. In contrast, participants in asynchronous mode must type ideas and comments into the system, and wait for minutes, hours or even days for a response or feedback. Delayed feedback makes it very difficult to engage in group discussion, negotiation, and consensus building. It had been predicted that participants would perceive relatively low cognitive effort for FtF mode, higher cognitive effort for synchronous-distributed mode, and highest cognitive effort in asynchronous-distributed mode.

Repeated measure analysis indicated that the measure of cognitive effort was different for interaction mode F (2, 54) = 7.03, p = 0.002, partial η^2 = 0.21, and mode*group F(2, 27) = 4.47, p = 0.003, partial η^2 = 0.25 (see Tables E-11, E-12 and E-13). The post-hoc Bonferroni test indicated that perceived cognitive effort was lower for FtF sessions than for synchronous sessions (Mean Difference = -.59, SD = 0.19, p = .012) and asynchronous sessions (Mean Difference = -0.66, SD = 0.23, p = .019), there was no difference between synchronous and asynchronous sessions (Mean Difference = 0.07, SD = 0.17, p = 1.00) (see table E-14 and Figure 4.8).

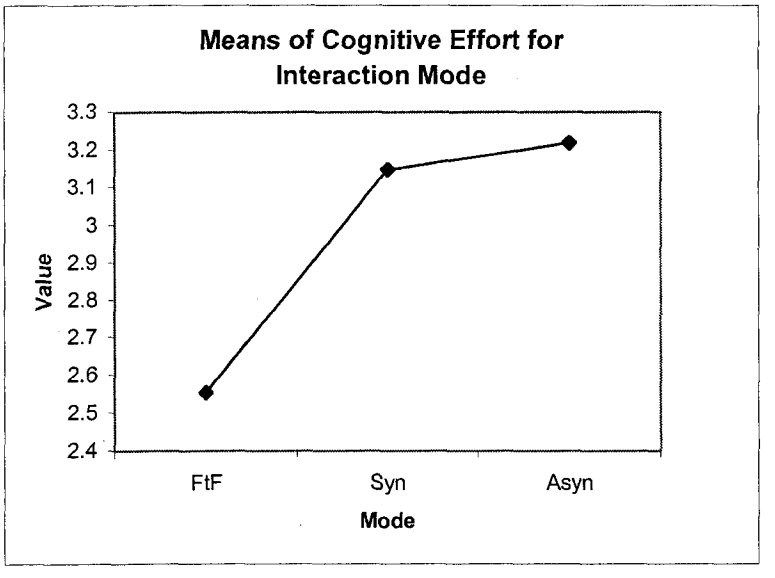

Figure 4.8 Means of Cognitive Effort for Interaction Mode

The interaction of week and group is illustrated by Figure 4.9, which indicates that participants in Groups A and C experienced different patterns of cognitive effort change than those in Group B. Group B experienced more cognitive effort in synchronous-distributed mode than Group A and C in the same mode. However, the post-

hoc Bonferroni pairwise comparison indicated that only the difference between Groups A and B in synchronous-distributed mode was significant (Mean Difference = -1.18, Standard Error = .39, p = .016) (see Table E-15). Group B experienced synchronous-distributed mode first, whereas Group A experienced FtF mode before employing synchronous-distributed mode. It was possible for Group A to have established the communication norms and familiarity with the software in FtF mode and therefore to have perceived less cognitive effort in synchronous mode than Group B, which had had no advance experience with the software.

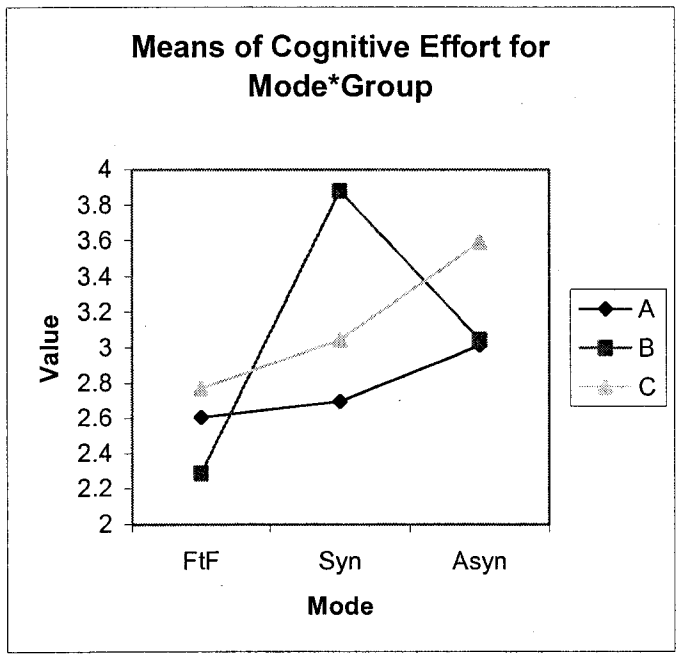

Figure 4.9 Means of Cognitive Effort for Mode*Group

It seemed that there were at least three major reasons why participants perceived synchronous-distributed interaction to be more difficult than FtF interaction. First, the system's interface did not clearly indicate who was discussing which topic, making it difficult for participants to locate the topic under discussion. In synchronous-distributed mode, team leaders set up sub-topics under five standard topics: tasks accomplished in the past week, tasks for this week, approaching deadlines, agenda items, and open issues/questions. Team members engaged in group discussion by moving from one sub-topic to the next sequentially. Participants needed to double click the sub-topic to get the discussion interface, which had two panes, a specification pane and a discussion pane. The specification pane was usually used to enter an explanation of a sub-topic. The discussion pane was used to engage in discussion. The default pane displayed was the specification pane; participants needed to click on the "discussion" tab to get the discussion pane. Since interaction did not have voice support, participants had to look around to find which topic was under discussion, which was very confusing and frustrating for participants, especially when they were engaging in synchronous-distributed interaction for the first time. The system provided a function called "match view", which can be used by the team leader to match participants' screens to the leader's screen, so that participants did not have to look around for the topic under discussion.

Team leaders had not been instructed in how to use this function, and later, the author asked one team leader to try it during synchronous-distributed interaction, and two participants complained that they had been sent to the next topic while they were typing. Therefore "match view" function was not utilized by team leaders to transit the

conversation. With a little bit of training, this function may be used effectively to reduce the communication confusion in synchronous-distributed mode.

The following comments were copied from participants' online feedback about the difficulty of locating the topic under discussion.

> *It gets a little hairy trying to keep track of where people are in the meeting sometimes...*
> (Class 1 Management Week 4 Syn Feedback)

> *Sometimes It was hard to keep track of what topic we were on*
> (Class 1 SD Week 1 Syn Feedback)

Because "match view function" was not utilized to direct participants to the topic under discussion, when the author facilitated synchronous-distributed interactions, she was very busy at the beginning of the session to go from one classroom to another to tell participants which topic was under discussion, this happened to most first-time synchronous-distributed interaction for teams. Once the team got used to the interaction procedure, it was easier for them to locate the topic under discussion. Synchronous-distributed interactions in week 2 were more smooth than in week 1 for most teams.

Second, parallel input for this study could have created more than one conversation thread at a time, and this could have caused misunderstanding or confusion. Prior GSS research had indicated that parallel input of GSS was an advantage because group productivity could be increased by allowing multiple participants to enter input at the same time (e.g., Nunamaker et al., 1991). In most of the prior GSS research, parallel input had been used for sense-making and brainstorming. Participants brainstormed ideas, and typed ideas into the system at the same time. Once brainstorming was finished, ideas were discussed and sorted. However, during brainstorming sessions, input can be

independent; it is not threaded discussion. Participants did not have to understand all other input before typing an idea. In our study, participants usually needed to engage in focused discussion, ideas typed into the system were not independent from one another, conversation was always built upon what had been said and understood. Existence of more than one conversation thread could cause misunderstanding or confusion, or at least make message interpretation more difficult.

The following messages/comments in italics illustrate this point. They were copied from interaction session minutes, and the notes inside parentheses contain information about the interaction session from which the comments were copied. For the protection of participants' identities, all name tags were replaced with "Tom" for male participants, and "Jenny" for female participants. If a particular conversation involved more than one male or female participant, the name tag designate "Tom1", "Tom2", "Jenny1", "Jenny2" and so on. The capitalization of original name tags was retained. Most messages had a line number at the end, and this number was automatically appended by the system.

1) *we are here [Tom1][#33]*
2) *Hola [Tom2][#34]*
3) *so are we [Tom3][#35]*
4) *Where? [Tom2][#36]*
5) *why aren't the names showing up [Tom4][#37]*
6) *306 [Tom1][#38]*
7) *don't know [Tom1][#39]*

- (Class 2 TST Week 3 Syn)

Statement 6 was the answer to statement 4, and statement 7 was the answer for statement 5.

1) *why not more retail as distribution channel?\ [#15]*

2) *so, we have to define those two right now? or do research? [#16]*
3) *Jenny, can you invite Tom again? [#17]*
4) *do research! [#18]*
5) *retail is defined as selling goods to consumers in small quantities and not for resale, we are doing just direst sales and wholesale. [#19]*
6) *Tom i just reinvited you, did it work? [#20]*
7) No [#21]
8) *Tom didn't get and (an) invitation again? [#22]*
9) *I'll try again [#23]*
10) *i just tried again, did it work? [#24]*
11) *so, I think wholesale and direct sale are difined (defined) as selling goods to cusomers or consumers in large quantities? [#25]*

- (Class 1 SD Week 1 Syn)

In the above example, statement 1, 2, 4, and 11 were associated with one topic; all other statements were on another topic. Existence of two conversation threads may have led to misunderstanding of the messages.

Third, synchronous-distributed group interactions in text format tended to have created information overload for several reasons: the existence of more than one topic at a time; parallel input; limited time to read input, think, and type an appropriate response. Sometimes, one participant might still have been thinking and typing a response after other participants had moved to another topic, making the response seem irrelevant to the current topic.

Participants perceived less cognitive effort in FtF mode than in distributed modes, and no difference in cognitive effort between synchronous-distributed mode and asynchronous mode was shown. It seemed that even though participants could get immediate feedback in synchronous-distributed interaction, ineffective usage of system information and possibility of having more than one conversation thread still made interaction difficult.

4.3.5 Group Interaction Session Effectiveness

As discussed in Chapter 3, group session effectiveness was used as the surrogate measure of group productivity. It was measured by the number of fully discussed agenda topics. Since FtF communication is easier and usually more effective than distributed communication, it was expected that FtF group interaction session would be more effective than distributed group interaction sessions. Being able to get immediate feedback during synchronous-distributed interactions should have facilitated discussion, negotiation, and consensus building. In contrast, delayed responses in asynchronous interactions should have made group discussion very difficult. It therefore was expected that synchronous-distributed interactions would be more effective than asynchronous interactions.

Repeated measure analysis (Appendix Tables E-20 and E-21) revealed no significant difference in session effectiveness or in interactions between modes, weeks, and groups. Using number of fully discussed items to estimate group interaction effectiveness was shown not to be accurate, as will be discussed in the discussion section of this chapter.

4.3.6 Group Session Process Satisfaction

Focus Theory defines group productivity as degree of goal attainment. Satisfaction in this study was measured as a kind of surrogate for group productivity because it is "*a valanced affective arousal with respect to goal attainment*" (Briggs, et al 2003). There are two satisfaction measures in this study: group session process satisfaction and group outcome satisfaction.

Group session process satisfaction was estimated as how satisfied participants were with the group interaction process. Because participants interacting in FtF mode have support from all communication channels (verbal, visual, and touch) whereas participants interacting in distributed mode can communicate only via text, communication in distributed format is more time-consuming and decoding and interpreting messages becomes more difficult. Therefore it was expected that participants would be more satisfied with FtF interaction process than with distributed interaction. When participants become familiar with software usage and a particular distributed interaction mode, they may be more comfortable and confident to communicate in that mode. It is expected that participants are more satisfied with the same distributed interaction mode in week 2 than in week 1.

Repeated measure analysis indicated group session process satisfaction was different for interaction mode $F(2, 54) = 15.49$, $p < 0.001$, partial $\eta^2 = 0.37$; week $F(1, 27) = 13.86$, $p = .001$, partial $\eta^2 = 0.34$; mode*week $F(2, 54) = 4.98$, $p = .010$, partial $\eta^2 = 0.16$; and mode*week*group $F(4, 54) = 6.41$, $p < 0.001$, partial $\eta^2 = 0.32$ (see Table E-23 and E-24).

The post-hoc Bonferroni contrast test indicated that session process satisfaction was higher for FtF sessions than for synchronous (Mean Difference = 0.88, SD = .20, p = .001) or for asynchronous sessions (Mean Difference = 1.25, SD = .26, $p < .001$). There was no difference between results for synchronous and for asynchronous sessions (Mean Difference = 0.38, SD = 0.22, p = .318) (see Table E-25 and Figure 4.10).

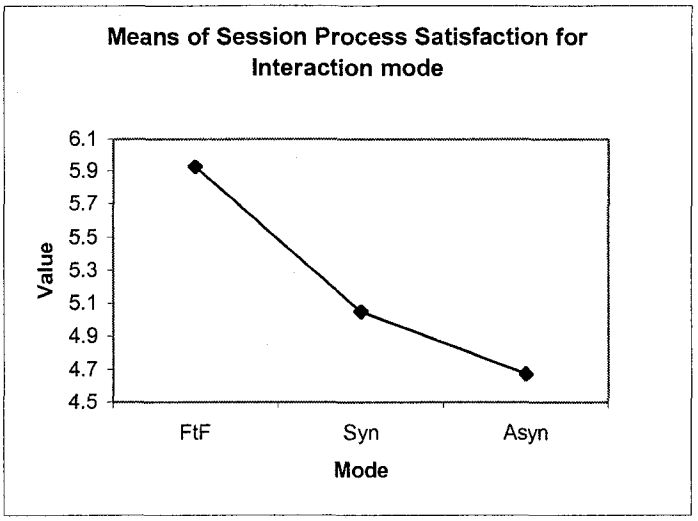

Figure 4.10 Means of Session Process Satisfaction for Mode

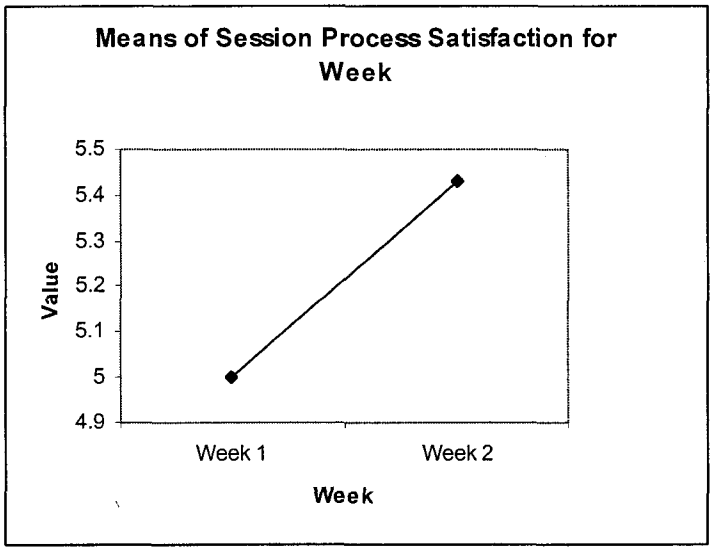

Figure 4.11 Means of Session Process Satisfaction for Week

Participants generally appeared to feel more satisfied during the second-week interaction session than during the first-week session using sessions of the same mode (Mean Difference = 0.43, SD = 0.12, p = 0.001), the difference is illustrated by Figure

4.11. The interaction of mode and week is illustrated by Figure 4.12. Participants had relatively constant process satisfaction in FtF mode, however, in distributed modes, they were more satisfied in week 2 than in week 1.

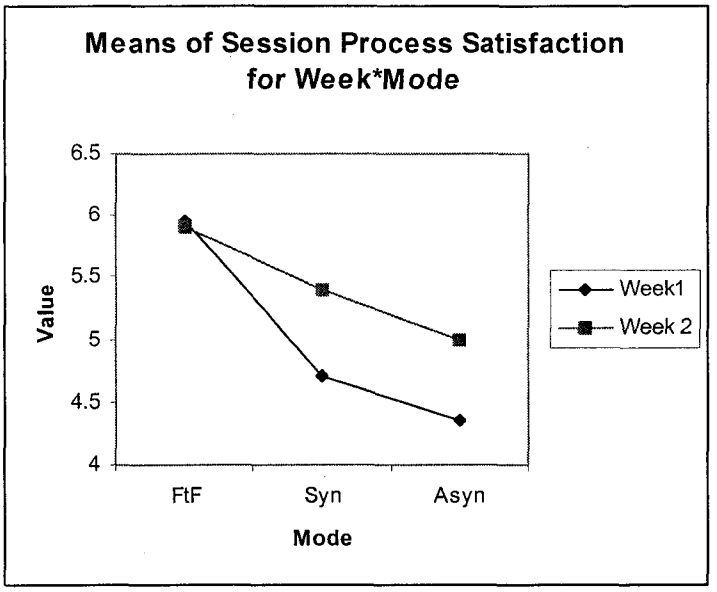

Figure 4.12 Means of Session Process Satisfaction for Week*Mode

4.3.7 Group Session Outcome Satisfaction

Group session outcome satisfaction was used to estimate how satisfied participants were with group interaction outcomes. Because group session outcome satisfaction is closely related with process satisfaction, it was predicted that FtF participants were more satisfied with interaction outcome than participants using distributed modes. Participants who were getting familiar with the software and a particular distributed interaction mode may have been able to communicate more effectively and get more done in the second week of using the same distributed mode, in

which case it was expected that participants would be more satisfied when using the same distributed format in a second week.

Repeated measure analysis indicated that group session outcome satisfaction was different for interaction mode F (2, 54) = 13.31, $p < 0.001$, partial $\eta^2 = 0.33$; week F(1, 27) = 11.34, $p < .001$, partial $\eta^2 = 0.30$; mode*week F(2, 27) = 6.51, p = .003, partial $\eta^2 = 0.19$; and mode*week*group F(4, 54) = 4.39, p = 0.004, partial $\eta^2 = 0.25$ (see Appendix Tables E-28, E-29 and E-30). The post-hoc Bonferroni test indicated that session outcome satisfaction was higher for FtF mode than for synchronous (Mean Difference = 0.98, SD = 0.20, $p < 0.001$) or asynchronous (Mean Difference = 1.19, SD = 0.27, p = 0.000) sessions. There was no difference between results for synchronous and asynchronous sessions (Mean Difference = 0.22, SD = 0.26, p = 1.00) (see Table E-31 and Figure 4.13). Participants generally felt more satisfied with the second week than with the first week using the same communication mode (Mean Difference = 0.41, SD = 0.12, p = 0.002) (see Figure 4.14). The interaction of week and mode is illustrated by Figure 4.15. Just as in group session process satisfaction, participants indicated relatively constant outcome satisfaction in FtF sessions, however, they were more satisfied with the outcome in week 2 than with that in week 1.

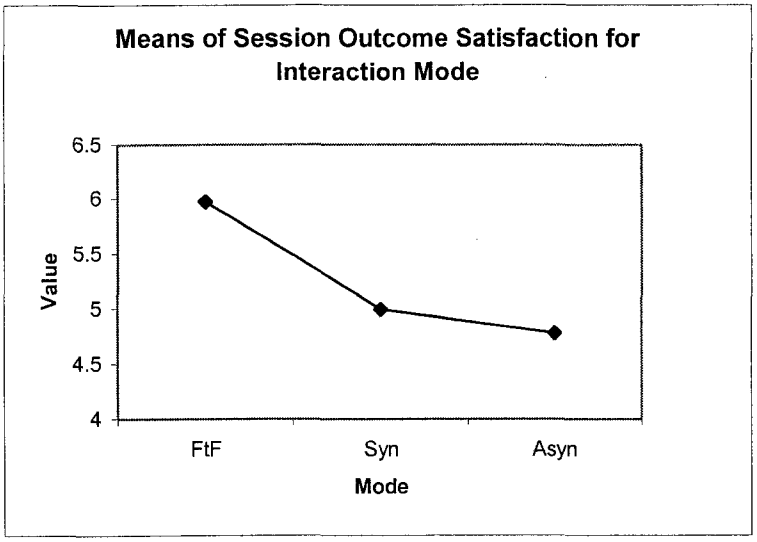

Figure 4.13 Means of Session Outcome Satisfaction for Mode

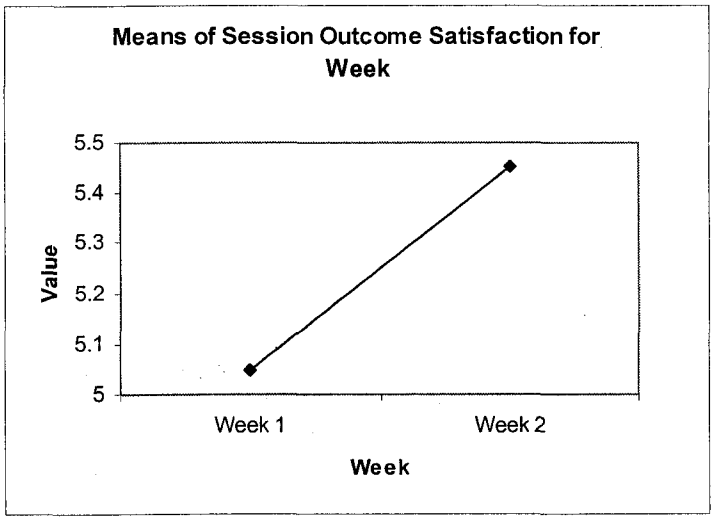

Figure 4.14 Means of Session Outcome Satisfaction for Week

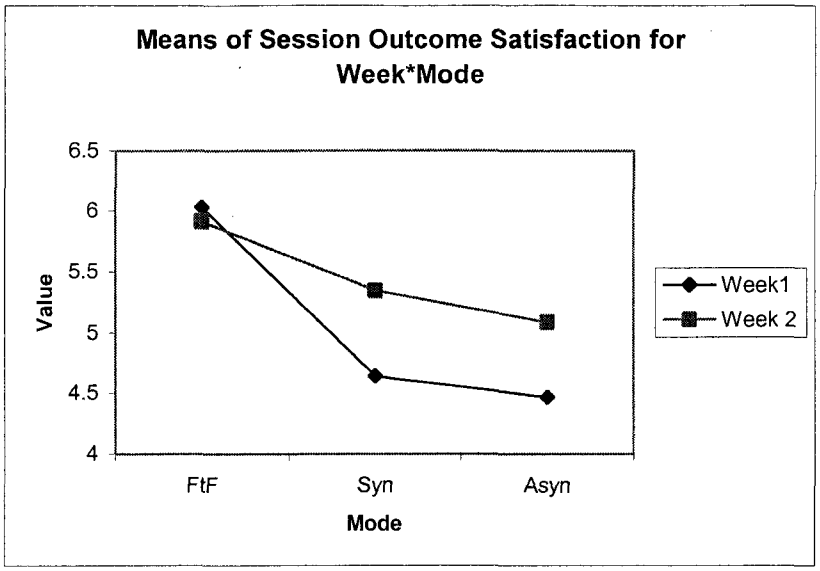

Figure 4.15 Means of Session Outcome Satisfaction for Week*Mode

4.4 Correlation Analysis

Focus Theory implies that there should be a positive correlation between the constructs of goal congruence and cognitive effort, a positive correlation between cognitive effort and group productivity, and a negative correlation between distraction and cognitive effort. Group productivity was estimated by group session effectiveness in this study, and the relationship between the constructs of cognitive effort and of group productivity was estimated as the relationship between the measures of cognitive effort and group session effectiveness. Individual scores were used to calculate the correlations among distraction, cognitive effort, and goal congruence. An aggregation at the team level of the scores for cognitive effort was used to compute the correlation between cognitive effort and group session effectiveness, because each team had only one score for group session effectiveness.

Correlation analysis (see Appendix F) indicated that there was negative correlation between goal congruence and cognitive effort (Pearson $r = -0.34$, $p < 0.001$, $N = 274$), and positive correlation between distraction and cognitive effort (Pearson $r = 0.20$, $p = 0.001$, $N = 274$). The analysis also indicated that there was no significant correlation between cognitive effort and session effectiveness (Pearson $r = 0.13$, $p = 0.13$, $N = 78$). The discussion section will discuss why the results were not consistent with the prediction implied by Focus Theory.

4.5 Discussion of Results

4.5.1 Goal Congruence and Goal Understanding

Perceived goal congruence differed by mode, and week and group were observed to interact. Goal congruence was higher in FtF mode than in distributed modes. There was no significant difference in goal congruence between synchronous and asynchronous mode. Groups A and C had relatively constant perceived goal congruence, whereas Group B had higher goal congruence in week 2 than in week 1. Possible explanations may have been that when participants communicated in FtF mode they perceived less demand for cognitive effort or that they understood the team/meeting goals better than participants working in distributed modes, which led them to judge goal congruence higher.

Participants' perception of goal understanding differed by modes and by week, and there was an interaction between week and group. FtF participants apparently understood their team goals more clearly than participants in distributed modes. There was no significant difference in goal understanding between users of synchronous and

asynchronous mode. Participants in distributed modes generally had better goal understanding in week 2 than in week 1, a result that may imply that goal understanding may also be affected by understanding of interaction procedures and familiarity with software.

In FtF mode, participants may have understood their team's goal better because of easy communication and their familiarity with the FtF interaction format. If they had problem with the system, a facilitator had always been available to resolve it. In contrast, participants interacting in a particular distributed format for the first time may not have understood how group interactions should proceed or how the system should be used. For example, in synchronous-distributed mode it was difficult for participants to locate the topic under discussion, and the facilitator had to go from one room to the other to clarify which topic was under discussion.

However, conclusions that goal understanding judgment may be affected by understanding of interaction procedures and by familiarity with software need to be verified in future studies.

4.5.2 Cognitive Effort and Cognitive Load

Perceived cognitive effort was different in different modes, and there was interaction between mode and group. Participants perceived less cognitive effort in FtF mode than in distributed modes. However, there was no significant difference between cognitive effort in synchronous and asynchronous modes. Group B experienced more cognitive effort in synchronous-distributed mode than Group A did in the same mode. The sequence of use of interaction mode for Group B was synchronous, asynchronous,

and FtF. The order of interaction for Group A was FtF, synchronous, and asynchronous. It was possible that Group A had established group norms and familiarity with the software in FtF mode, so its members perceived less cognitive effort in synchronous mode than Group B, which had less experience with the group and with software.

The correlation analysis indicated a negative correlation between perceived cognitive effort and goal congruence, and a positive correlation between perceived cognitive effort and distraction. This result contradicted propositions of Focus Theory, which implies that there is a positive correlation between the constructs of cognitive effort and goal congruence, and a negative correlation between the constructs of cognitive effort and distraction.

A closer examination at Focus Theory and group interactions showed that the study measured cognitive load instead of cognitive effort. Cognitive load refers to all the attention resources used for a task and includes attention resources used for irrelevant diversions taking place during the time allocated to accomplish a task. Cognitive effort refers only to attention resources that are used for task-related thinking or activities. For example, in a very noisy and crowded environment, it would be very difficult for a person to concentrate on reading a serious book, cognitive load may be high because some of attention resources must be used to overcome distraction. Cognitive load for the same person to read the same book in a quiet environment might be lower, although cognitive effort used for reading the book might be the same. In other words, cognitive load includes cognitive effort and distraction. The difference between cognitive effort and cognitive load is illustrated by Figure 4.16.

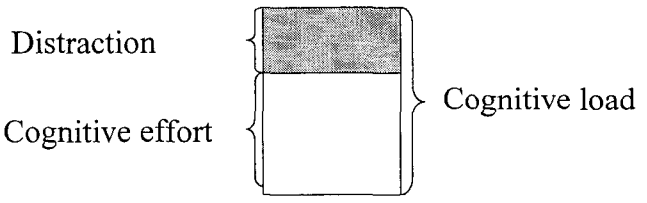

Figure 4.16 Distraction, Cognitive Effort, and Cognitive Load

Since cognitive load includes distraction, there should be a positive correlation between cognitive load and distraction, a relationship supported by correlation analysis. The term cognitive load will be used later to designate the cognitive effort measured in this study. Differentiation between cognitive load and cognitive effort also explains the negative correlation between cognitive load and goal congruence. When Participants perceive team goals are congruent with their personal goals, they are willing to invest cognitive effort for the task, and they evaluate cognitive load against cognitive effort that need to be invested. The higher the goal congruence, the more cognitive effort they were willing to invest and the smaller a cognitive load was, perceived to be, given a constant cognitive load. Focus Theory posits that there is positive relationship between the constructs of cognitive effort and group productivity, but such a relationship could not be tested by the correlation between perceived cognitive load and group session effectiveness.

4.5.3 Cognitive Load and Communication

It seemed that communication was the key process to affect the perceived cognitive load in group interaction sessions. It seemed that communication had affected both perceptions of the group process and outcomes. It was possible that, with easy

communication, perceptions of goal congruence, goal understanding and satisfaction were more favorable.

In FtF mode, participants could communicate easily with all supported communication channels (verbal and non-verbal). In distributed interaction modes, communication was more difficult because delayed feedback in an asynchronous mode made it very difficult to engage in serious discussion, negotiation, or consensus building. However, cognitive demand may have been lower in asynchronous sessions than in synchronous-distributed sessions, since participants had time to read input, think about it, and respond at a self-controlled pace. In synchronous-distributed sessions, immediacy of feedback facilitated communication, but several things complicated synchronous-distributed interactions: 1) It was difficult for communicators to locate who was at which topic, and which topic was under discussion. 2) Parallel input might have caused confusion or misunderstanding by creating more than one conversation thread at a time. 3) There was limited time for participants to read input, deliberate, and type comments. The fast pace of group interaction might have created information overload for participants, especially those not familiar with the collaboration software or the interaction procedures. However, as participants became familiar with the software and the interaction procedures, these issues may have become less serious or pronounced. This may explain why participants in distributed modes generally had better goal understanding, higher goal congruence, and less cognitive load in week 2 than in week 1 in the same mode. It also may imply that cognitive load for synchronous-distributed

mode may be reduced by first establishing communication norms and software familiarity in FtF modes.

4.5.4 Distraction and Group Session Effectiveness

Repeated measure analysis revealed no significant difference in distraction in different communication modes, weeks or groups, so distraction may not importantly affect cognitive effort availability for group processes. The repeated measure analysis revealed no differences in project session effectiveness across three modes, and there were several explanations for this result.

First, the session sample size was small, 39 sessions altogether. It was difficult for such a small sample size to detect a session-effectiveness difference even if there had been one. Second, there may actually have been no difference in session effectiveness across three modes. Participants had felt it to be easier to have FtF interactions but the group tasks might generally be so easy that and participants could have effective distributed interactions even if they were not as satisfied with distributed interactions as with FtF interactions. (Field observations and participants' feedback did not support this explanation and the interactions notes indicated that synchronous discussion tended to be more extensive and thorough than asynchronous discussion.)

Third, the session effectiveness measure may not have been accurate. Group interaction session effectiveness was estimated from the number of fully discussed agenda items, but some agenda items may have been more complex than others and taken more time and effort to thoroughly discuss. In addition, discussion thoroughness and extensiveness should be an aspect of group productivity. In previous GSS research, group

interaction effectiveness was usually measured by the quality of the final decision/report, the completeness of the information sharing, and the number of ideas/solutions generated. Although these measures were not applicable to this study, counting the number of discussed agenda items cannot have been an accurate measure for group session effectiveness or group productivity. Future study that develops more accurate measures for effectiveness and group productivity clearly is needed.

4.5.5 Satisfaction

Satisfaction (both process satisfaction and outcome satisfaction) differed for mode and week in this study, and there was interaction between them. Participants were more satisfied with the process and outcome in FtF sessions than participants in distributed sessions. The repeated measure analysis revealed no significant difference of satisfaction between synchronous and asynchronous sessions. Participants experienced relatively constant satisfaction in FtF mode, but in distributed modes they were more satisfied in week 2 than in week 1.

As mentioned, satisfaction may be closely related to ease of communication. It was easier for participants to communicate in FtF sessions than in distributed sessions, and they were more satisfied with FtF sessions than with distributed sessions. When participants in distributed interactions they had become more familiar with the group process in the second session of the same mode, they perceived communication to be easier in the second session than in the first session, and they were more satisfied with the second session than the first session.

4.5.6 Discussion Summary

Correlation analysis did not support some correlations specified by Focus Theory, specifically that there is positive correlation between the constructs of goal congruence and cognitive effort and negative correlation between cognitive effort and distraction. The results displayed the opposite effect attributable to a measurement problem with cognitive effort. The study measured cognitive load instead of cognitive effort.

Focus theory also implies a positive correlation between cognitive effort and group productivity. This correlation was estimated as the correlation between perceived cognitive effort and group session effectiveness, which had not been an accurate measure for group productivity. Also, because the study measured cognitive load instead of cognitive effort, the correlation between cognitive load and group session effectiveness did not reflect the real relationship between cognitive effort and group productivity.

These analysis results should not invalidate the relationships among the constructs of goal congruence, cognitive effort, distraction, and group productivity, but more studies have to be done to understand their relationships.

4.6 Reflection about Focus Theory

This section addresses research question 2, which investigated the ways in which Focus Theory is useful and in what ways it is limited in terms of explaining observed phenomena, and suggesting how can it be improved. The next section will first discuss individual constructs and then summarize Focus Theory's usefulness and limitations.

4.6.1 Goal Congruence

There is a difference between goal congruence and the goal congruence mechanism described in Briggs's paper (Briggs, 1994). However, that difference is not illustrated by the diagram of Focus Theory model, which could be confusing or misleading. Goal congruence is a complex construct in the Briggs model, the goal congruence mechanism (Briggs, 1994) is illustrated by Figure 4-17. Goal congruence construct determines how much effort a participant is willing to invest in a task. Several factors affect how much effort a participant would like to invest in a task: perceived effort required, perceived task difficulty, perceived effort available, desired certainty of success, self efficacy, and desire for goals. Two of the factors are very important: perceived effort required and desire for goals. If a participant does not have the desire to obtain the task goal, it is likely that he/she won't put much effort into the task, so desire for goal achievement is a prerequisite for effort investment. If the participant has the desire to reach the goals, he/she then evaluates how much effort is required to do so. The more perceived effort required, the more effort will be put into the task, everything else being equal. Desired certainty of success and perceived task difficulty also affect perceived effort required. Increased desired certainty of success will likely increase perceived task difficulty. Increasing perceived effort required will reduce perceived self efficacy, whereas increased perceived effort available will likely increased self efficacy. And self efficacy moderates how much effort is likely to be invested.

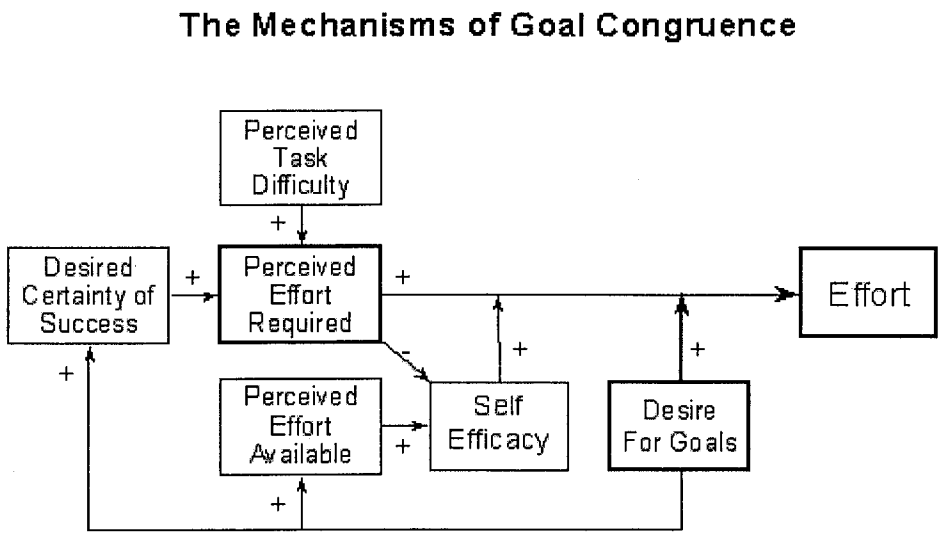

Figure 4.17 The Mechanisms of Goal Congruence

From (Briggs, 1994)

The preceding explanation of a goal congruence mechanism indicates how the label and the mechanism of goal congruence are not congruent. The label of goal congruence refers to the extent to which an individual perceives his/her personal goals to be congruent with the team's goals, whereas the goal congruence mechanism involves several additional constructs. The output of the mechanism is not goal congruence, it is the amount of cognitive effort that the participant would like to invest in a task. Motivation may be a better label for this mechanism because measuring goal congruence is far from sufficient to determine how much effort a participant is willing to invest into the task. Instead of measuring goal congruence, a future study to test Focus Theory may need to manipulate goal congruence level and measure cognitive effort and group productivity at different congruence levels to test the relationships among goal congruence, cognitive effort, and group productivity.

4.6.2 Three Cognitive Processes

The issues mentioned below are not necessarily flaws of Focus Theory, although they need to be addressed when testing the validity of Focus Theory in empirical settings.

The first issue is how to measure the amounts of attention resources consumed by three processes respectively. Focus theory specifies that the three processes involved in group activities, communication, information access, and deliberation and they are tightly interwoven. Communicators can access task-relevant information when they communicate with their team members, and if they do not communicate, deliberation won't move to anywhere. As the theory proposes that three processes are correlated, it is very difficult to separate them. For example, when participants communicate very successfully, it is likely that they will access more relevant information and can deliberate or think about the task more effectively. When participants cannot communicate well, they may not have enough information to think about. Allocating more cognitive effort to communication may improve communication effectiveness, and make information access and deliberation much easier, permitting participants to allocate less cognitive effort to information access and deliberation and still be able to increase group productivity.

Not all three processes can be easily observed. In the study, the process of communication could be observed, and so could some formats of information access. The deliberation process was very difficult to observe. Information access was manifested as reading agenda items and notes during and after group interactions, reading documents related to the group task, conducting online searches for task-related information, and requesting information from team members and instructors. Requesting information from

others always involved communication, and it was very difficult to differentiate between communication and information access. It was impossible to observe deliberation directly, we could observe only some manifestations or effects of the group deliberation process. For example, structured problem solving (understanding the problem, brainstorming solutions, discussing and ranking solutions, and selecting one of the solutions) usually facilitate a group deliberation process, letting researchers observe whether a problem solving structure makes the group deliberation process more efficient/effective or less so. The fact that three processes may tightly interwoven and that some processes are difficult to observe gives rise to a measurement issue: how can one respectively measure cognitive effort that is consumed by three processes?

The second issue is that Focus Theory does not explicitly differentiate between cognitive effort and cognitive load, which also is a measurement issue. Whenever perceived cognitive effort is measured, it seems that we in fact are measuring cognitive load. Without being able to measure cognitive effort accurately, investigation of the relationship between cognitive effort and productivity cannot proceed

The third issue is that the proposition that allocation of attention resources to three processes interferes with one another may not be valid. Focus Theory proposes that allocation of attention resources to three processes interfere with one another. For example, allocating more attention to communication makes less attention available for information access and deliberation. However, a closer examination of daily-life communication reveals that three cognitive processes may not interfere with one another if the threshold of cognitive load has not been reached. For example, allocating more

cognitive effort to communication does not necessarily reduce cognitive effort available for deliberation, if the cognitive load threshold or ceiling has not been reached. Since this study did not collect empirical data about attention resources allocation to three processes, future study of this issue is needed.

The fourth issue is that the weights of three cognitive processes are not specified by the theory. The author's observations and student feedback in this study indicated that information access and deliberation were not as important as communication. In most cases, when participants communicated very clearly, the interaction was more effective and/or efficient, and participants were more satisfied. What should be the weights of cognitive processes in terms of their impact on group productivity? Which process is most important when considering group productivity? In other words, which process may be a bottleneck for group productivity for a particular interaction scenario? For a simple group activity such as deciding a meeting date and time, participants who communicate well can easily get results without any other information access, and with very little deliberation. In this scenario, communication may be the only process that is important.

4.7 Three Processes and Collaboration Technology

Research question 3 investigated how the three processes were facilitated and/or inhibited during group interactions in different modes, given the theoretical foundation and observed findings, how should collaboration technology be designed and deployed to enhance performance of people engaged in distributed interactions?

The first part of this section addresses how the three processes were facilitated and/or inhibited during group interactions in different modes, the second part of the

section addresses how collaboration technology could be designed and deployed to enhance distributed interactions.

4.7.1 Communication

When distributed groups communicated via text, they lost nonverbal cues to identify who said what, and in asynchronous distributed interactions they might not be able to tell the exact date and time a message was posted, unless it had been specified. Having the system add a name tag to a message, appending a date and time stamp, and adding line numbers to messages helped disambiguate a communication. It was important for team leaders to set up clear agenda items and interaction procedures and to communicate these to participants interacting in distributed format.

When distributed group communicated only in text, content and process support were communicated together, which could interfere with message interpretation. It would be better if the system could provide a separate communication channel for group process support and technical support. Participants felt synchronous-distributed interactions were more difficult than FtF interactions because it was difficult for participants to locate which topic is under discussion, and parallel input may create confusion.

Synchronicity seemed to be the key communication feature for group discussions and consensus building and immediacy of feedback mattered. When participants needed to engage in group discussion rather than simply share information, asynchronous communication was very difficult because of delayed feedback.

For co-located groups, asynchronous interactions could efficiently and effectively augment FtF interactions for information sharing. Participation in asynchronous mode

could be improved by adding to the system an automatic feature to remind participants to log on to the system and engage in discussion. The above mentioned points will be explained in more details in the following section.

Identified communication vs. anonymous communication

Participants in distributed modes used identified communication more often than anonymous communication. System feature of adding name tags automatically can reduce participants' time of manual typing name tag, thus increase task efficiency and effectiveness. Prior GSS research indicated that for FtF group interactions, anonymous communication reduced evaluation apprehension and facilitated open and creative communication (e.g., Fjermestad & Hiltz, 1999-2000). Romano et al. (Romano et al., 1999) indicated that anonymity may not be as important in virtual sessions as in FtF sessions, but in this study , it seemed that participants in FtF interactions did not much care about whether communication was anonymous or not. The interesting observation was that once the group became distributed, participants used identified communication more often and wanted to see name tags for messages posted. It seemed that name tags helped them interpret the message more accurately by identifying who said what.

For synchronous interactions, the system could be configured to add name tags automatically, but participants in asynchronous interactions had to add name tags for each message posted. Table 5.1 and Table 5.2 displays respective name tag usage for each synchronous and asynchronous interaction session. For asynchronous interaction, the number of messages with name tags was counted and used to illustrate that participants would exert extra effort to show who was talking about what. However,

counting the number of name tags used for synchronous-distributed interactions may not be a good measure if name tags are automatically added at the beginning of an interaction.

Table 4.5 indicates that only two of 26 synchronous-distributed interaction sessions (MGN teams) did not use name tags at all. With only three members, the MGN team might have not needed name tags to tell who had said what in most of the discussion. The team members had clear assignments of responsibilities, and the interaction agenda was set up to indicate who was the major talker for a particular agenda item. In other interaction sessions during which not everyone used name tags, at least some participants used name tags for all or part of their interaction.

Team	Group	Team size	Week	Name tags usage
PMT	A	7	3	yes
PMT	A	7	4	yes
DOC	A	4	3	yes
DOC	A	4	4	yes
SW	A	6	3	yes
SW	A	6	4	yes
TEST	A	4	3	yes
TEST	A	4	4	yes
FI	B	4	1	partially
FI	B	4	2	yes
SD	B	6	1	partially
SD	B	6	2	yes
DES	B	5	1	partially
DES	B	5	2	yes
MGN	B	3	1	no
MGN	B	3	2	no
QA	B	5	1	partially
QA	B	5	2	yes
MM	C	3	5	yes
MM	C	3	6	yes
PP	C	3	5	yes

PP	C	3	6	yes
DB	C	5	5	partially
DB	C	5	6	partially
IMP	C	5	5	yes
IMP	C	5	6	yes

Table 4.5 Name Tag Usage in Synchronous-Distributed Interactions

Clearly, participants in synchronous-distributed interactions used source-identified communication more often than anonymous communication. Table 4.6 lists usage of name tags for asynchronous interactions and indicates that for 26 asynchronous interactions, 19 had messages with name tags.

Team	Team size	Week	Total No. of messages	No. of tagged messages	No. of non-tagged messages	Tagged percentage	Non-tagged percentage
PMT	7	5	65	55	10	84.62%	15.38%
PMT	7	6	62	40	21	64.52%	33.87%
DOC	4	5	37	33	4	89.19%	10.81%
DOC	4	6	49	42	7	85.71%	14.29%
SW	6	5	75	62	13	82.67%	17.33%
SW	6	6	89	48	41	53.93%	46.07%
TEST	4	5	127	105	22	82.68%	17.32%
TEST	4	6	119	108	11	90.76%	9.24%
FI	4	3	46	38	8	82.61%	17.39%
FI	4	4	50	40	10	80.00%	20.00%
SD	6	3	39	31	8	79.49%	20.51%
SD	6	4	91	70	21	76.92%	23.08%
DES	5	3	60	52	8	86.67%	13.33%
DES	5	4	90	38	48	42.22%	53.33%
MGN	3	1	55	2	53	3.64%	96.36%
MGN	3	2	34	1	32	2.94%	94.12%
QA	5	3	78	54	22	69.23%	28.21%
QA	5	4	50	35	14	70.00%	28.00%
MM	3	1	7	3	4	42.86%	57.14%
MM	3	2	31	7	24	22.58%	77.42%
PP	3	1	51	35	16	68.63%	31.37%
PP	3	2	32	6	26	18.75%	81.25%

DB	5	1	7	0	7	0.00%	100.00%
DB	5	2	31	16	15	51.61%	48.39%
IMP	5	1	70	15	55	21.43%	78.57%
IMP	5	2	34	24	10	70.59%	29.41%

Table 4.6 Name tags usage in asynchronous-distributed interactions

Some reasons teams did not add name tags manually apparently were that smaller teams could engage in anonymous communication if the agenda items were structured in a way that participants could tell who was the major talker for a particular agenda item. This was the case for three-member MGN teams. During two MM asynchronous interactions, the team leader posted most of the messages, along with detailed instructions about their upcoming presentation. Two team members could easily tell the ownership of the message and a similar situation existed for PP team's second asynchronous interactions. DB team had only seven messages posted during the first-time asynchronous interaction due to an incorrect set up of the interaction. For so limited a number of messages, identification of message owner may not be very important.

One reason for the wide usage of name tag in asynchronous mode may have been that participants were required to add their name tags manually beginning with the second week, a requirement derived from participants' preferences and requests. Fourteen participants asked other team members in 16 synchronous-distributed interaction sessions to attach their names to certain messages that had no name tags. Four online feedback comments mentioned name tags, all indicating that name tags should be added automatically and in a straightforward way. Some examples of requests for and comments about name tags were:

we need name tags [#632]
- (Class 1 FI Week2 Syn)

note: please enter a manual name tag...ie (Tom) [#1252]
- (Class 1 FI Week 3 Asyn)

put your name tag, so we know who is saying what [Tom1][#130]
- (Class 1 PMT Week 3 Syn)

I wish we used nametags more often
- (Class 2 QA Week 6 FtF feedback)

Name tags should be automatically assigned, with an option to turn them off if wanted.
- (Class 2 QA Week 6 FtF Feedback)

need name tag in each comment
- (Class 1 SD Week 1 Syn Feedback)

Some participants forgot to enter a name tag when they posted messages and added the name tag right after the message. There were 54 such cases from 26 asynchronous interaction sessions. Some examples are:

I think that we are light years ahead of the rest of the class [#1262]
- Tom [#1263]
- (Class 1 FI Week 3 Asyn)

I may get back by sunday afternoon [#1816]
oh that was me -Tom [#1817]
- (Class 1 FI Week 3 Asyn)

The next deadline, as best as I can remember, is the first Wed. of Dec, you will be giving your presentation on your actual business processes that you completed. [#884]
Sorry, #884 was posted by Tom. [#885]
- (Class 1 PMT Week 5 Asyn)

I think the test plan is ready. I emailed it to Jenny and it should be on the web now. [#1081]
from Tom [#1082]
(Class 2 TST Week 5 Asyn)

do you all know the parts you'll be talking about [#1085]

from Tom (sorry I keep forgeting) [#1086]
(Class 2 TST Week 5 Asyn)

Name tags have another purpose, They can be used for topic transition in synchronous-distributed mode. When participants moved from one topic to another in synchronous-distributed, they often used name tags to check on who had moved to the correct topic, there were 19 cases in 26 synchronous-distributed interaction sessions. If the system's "match view" feature had been used for topic transition, participants might not have had to use name tags to check whether a colleague had moved to the correct topic. It seemed that once the teams established the communication norm of moving from the first sub-topic sequentially to the last subtopics, they did not check other participants' presence under every sub-topic. The following are two examples of using name tags for topic transition. This type of communication scenario usually takes place at the beginning of discussion of an agenda item.

im here [Tom1][#474]
I'm here [Tom2][#475]
i'm here [Jenny1][#476]
I'm already here [Jenny2][#477]
- (Class 1 PMT Week 4 Syn)

I'm here [Tom1][#127]
Are you both at this step yet? [Tom1][#128]
i'm in [tom2][#129]
Im here! [Jenny][#130]
- (Class 1 MM Week 5 Syn)

Jenny1's here [Jenny1][06:41 PM][#644]
Here [Jenny2][06:41 PM][#645]
here [Jenny3][06:42 PM][#646]
here [Tom][06:42 PM][#647]
- (Class 1 DOC Week 4 Syn)

Implicit communication vs. explicit communication

When participants interacted via text in distributed modes they had explicitly to refer to an object, time and place for non-ambiguous communication. For example, rather

than typing "you" and "today", it was better actually to specify name, date, or day of the week to avoid confusion. The following examples illustrate appropriate explicit specification of date, day of the week, or message target.

We have meeting tonight at 9 pm in glnn106.....today is Tuesday [#531]
- (Class 1 SD Week 3 Asyn)

I would like to mention that I want give us a week to fix problems in configuration [Tom1&Tom2][#457]
i mean a week from dec 12 [Tom1&Tom2][#458]
...
- (Class 2 TST Week 6 Asyn)
Jenny, will you be in lab early before class today (wednesday)? [#548]
- (Class 1 SD Week 3 Asyn)

The following comment illustrates how a system feature of adding date and time stamp should help with asynchronous communication in text format.

but (asynchronous was) still difficult in the sense that the messages need to be time stamped, dated, and or threaded [#56]
- (Class 2 TST Week 6 Asyn Feedback.)

The system feature of adding line numbers also facilitated communication because participants could use the line number for reference.

I would like to mention that I want give us a week to fix problems in configuration [Tom1&Tom2][#457]
i mean a week from dec 12 [Tom1&Tom2][#458]
...
In response to #457: yes, that is a very good point...[Jenny][#461]
(Class 1 PP Week 5 Syn, #457 was the message number)

Communication in synchronous-distributed format

Communication via distributed text in synchronous format was more difficult than FtF communication. During synchronous-distributed interactions it had been difficult for participants to locate the topic under discussion, and parallel input could have created

confusion by allowing more than one conversation thread at a particular time. This has been discussed in details in section 4.3.4 (about cognitive effort), and won't be repeated here.

Communication in asynchronous modes

When participants mainly needed to share information during their interaction, asynchronous communication could be effective. For example, when the Class 1 MM team (with three members) had an asynchronous interaction session for week 2, they prepared, via asynchronous interaction, a group presentation about their task. The team leader posted detailed instructions and an outline for the presentation in the system, and clearly assigned each team member his/her responsibilities. The session notes indicated that participants understood the team leader very well, and they asked very few questions for clarification. Participants did not meet FtF before their presentation, but the presentation was well-organized, smoothly transitioned, and easy-to-follow. On the other hand, if participants had needed to engage in sense-making and had to ask for a lot of clarification of their responsibilities, asynchronous interaction session might not have worked as well.

Delayed feedback was an issue with asynchronous communication.

It takes too long to get responses and solicit feedback.
- (Class 2 Management Week 4 Asyn)

It may take you a while to get an answer you may need
- (Class 2 Test Week 5 Asyn)

cant have a quick conversation with someone to resolve a problem
- (Class 2 Test Week 5 Asyn)

Asynchronous interaction could be a very good communication format for a co-located team that needed to share information frequently but did not have time to meet FtF. Asynchronous interactions for the Class 2 Software and Testing teams were good examples. Individual team members had his/her own tasks and also needed frequently to report his/her work progress and to learn others' progress. They logged into the asynchronous session often to exchange information. Their interaction went well, delayed response was reduced, and information exchange was timely. This observation suggested that, instead of being a substitute of FtF interactions, asynchronous interactions could be a very useful communication format to augment FtF interaction for co-located teams.

Interaction coordination

Interaction preparation, fast feedback, and understanding of interaction process were very important in distributed modes. It seemed that participants did not clearly understand their interaction process very well when the group communicated in the distributed format, especially the first time. The researcher had to go from one room to another to help participants to locate topics under discussion, especially during most teams' first-time synchronous interactions. For asynchronous interactions, participants usually did not know when they should log into the system and where they should post comments and ideas.

The following comment indicated that the team leader's clear laying-out of interaction and fast feedback were appreciated by participants.

> *Today's meeting was very well thought out thanks to our team lead (leader) the tasks were laid out and thorough we all knew what was upcoming and needed to be worked on.*
> - (Class 2 DOC Week 1 FtF Feedback)

I appreciated the fact that one of the project managers was so active in their participation
- (Class 2 MGN Week 5 Asyn)

Tom, a team leader in Class 1 was not satisfied with two project managers because they did not log in the asynchronous meetings. He told Fang, they were managers, they gave a bad example for meeting participants, team leaders need to get feedback from them, and they did not even login to see what team leaders were talking about.
- (Class 1 PMT Week 5 Asyn – from the author's field notes)

Participation in asynchronous sessions

Participation level in asynchronous sessions was an issue. In this study, asynchronous interactions were simulated interactions because participants could see one another FtF. Most participants logged into the system and participated in discussions. Some participants did not log in as frequently as expected or as they needed to. They cited three reasons: they forgot, they were too busy, or they had not installed the system on a home computer and therefore did not have easy access to the system. Infrequency of logins contributed to delayed feedback, and could be very frustrating for participants who logged in more frequently. The feel of being left alone and frustrated by inactive participation of other team members was illustrated by the following messages copied from interaction notes.

I feel like Im(I'm) having a meeting with myself. -Tom [#1438]
-(Class 1 FI Week 4 Asyn)

Tom. . .Tom. . . oh Tom, where art thou Tom? [#932]
-(Class 1 PMT Week 5 Asyn)

hello, hello, hello - anyone out there?
-(Class 1 PMT Week 5 Asyn)

okay, where is everybody??? Hellooooo out there! Am I the only one left on the planet? Jenny [#1175]
-(Class 1 PMT Week 5 Asyn)

Where are you guys? The presentation is getitng (getting) prepared? -tom [#1124]

-(Class 2 TST Week 5 Syn)

In this study, the author regularly sent two or three emails to teams engaging in asynchronous interactions to remind them about the ongoing session. These emails also indicated how many times each individual had logged into the system. This reminding method worked well, since students were repeatedly informed that they could earn credits for participation in GSS-facilitated interactions. A system's capability to send a login reminder automatically and/or alert participants to new inputs into the system might increase participant login frequency.

Participants in this study were required to log comments into the asynchronous session four times during a 24-hour period. Some, when they had nothing to say, simply typed "I am here," to indicate their participation. While this may not be important for co-located teams, it could be very important for real distributed teams, for which awareness of the availability and active participation of remote team members should provide motivation to actively participate the group session. This statement needs to be verified in future studies.

4.7.2 Information Access

The study indicated that information access was necessary for group interactions. In FtF interactions, participants engaged in oral discussion while entering ideas and

comments into the system, they felt it to be distracting to type while talking. Teams usually elected one member as a secretary to take notes for the entire team. Participants often looked at their computer screens to read these notes. The observation indicated that the effect of information access was confounded with the effect of communication. If participants could communicate more effectively and efficiently, they should have been able to access, and understand more information about their tasks. It was seen that in asynchronous interactions delayed feedback made some information unavailable and prevented participants' continuation of their discussion tasks.

When participants were asked what they liked about GSS-facilitated interactions, and what system features they liked, some reported that they liked being able to take notes by using the system. All comments that mentioned recorded interaction notes (11 in number) indicated that recorded notes were useful to track what had been said and decided. These comments did not state that information access was important for group interactions, only that the recording feature of notes was useful. The comments implied that keeping interaction notes was important. The underlying implication was that participants read the notes during and/or after group interactions and considered note reading a form of information access.

The following comments stated that the system's note-recording feature was useful.

> *Question: What features do you like about Cognito?*
> *Answer: Best feature is a written record.*
> - (Class 1 PP Week 6 Syn Feedback)

> *Question: What do you like about the Cognito meeting?*

Answer: It is a good way to keep track of comments given during the meeting...
- (Class 1 Management Week 2 FtF Feedback)

Question: What do you like about the Cognito meeting?
Answer: I liked being able to jot down the main points of a meeting especially (especially) with the face to face meetings.
- (Class 2 DOC Week 6 Asyn Feedback)

Question: What features do you like about Cognito?
Answer: The best thing about Cognito is the written record of meetings and topics.
- (Class 1 Management Week 6 Asyn Feedback)

The author copied interaction notes saved in the Cognito server and posted them online after each interaction session, and when asked whether they read the online notes, all participants who answered this question indicated that they had. There were 10 such comments on online notes, like:

Question: Did you read the online Cognito meeting notes that have been posted each week? Briefly explain please.

Answer: Yes, so that I could see what we discussed in prior meetings.

(Class 2 DOC Week 6 Asyn Feedback)

Answer: I read them so I can stay up to speed w/ what's going on.

(Class 2 Management Week 4 Asyn Feedback)

Answer: I read most of the notes. It is good if you are unclear about something that happened at the meeting.
(Class 2 QA Week 6 FtF Feedback)

Answer: I read the first or second session's notes, but then didn't refer to the notes after that.
(Class 2 Software Week 6 Asyn Feedback)

Answer: Not every meeting, but some meetings. I plan to go back and copy the meeting notes for all of our meetings in the next week.

(Class 1 Management week 6 asyn)

Answer: yeah, sometimes i read it
(Class 1 SD Week 6 Asyn)

It seemed that Information access during an interaction session was tightly interwoven with communication, and sometimes it was difficult to differentiate effort to gain information access from effort to communicate.

4.7.3 Deliberation

Although deliberation is a process that it is nearly impossible to observe with the naked eye, group process structure was supposed to facilitate group deliberation. Many prior GSS studies had used a structured process for decision making: understand the problem – brainstorm the solutions – organize solutions – vote on the solutions – discuss and select the optimal solution. This process structure allows a group to experience both divergent thinking and convergent thinking in an organized procedure. Divergent thinking (brainstorm activity) allows participants to explore as large a solution space as possible, calling upon organization and voting tools help participants narrow down the number of solutions and evaluate and select solutions according to certain criteria. In this study, a project process tracking template was used instead of this structure. The session template listed five standard agenda topics: tasks completed in the past week, tasks in this week, approaching deadlines, agenda items, and open issues/questions. Team leaders created sub-topics for these standard topics, and groups usually started with the first sub-

topic and moved through all sub-topics sequentially. This template provided structural support for all three interaction modes. The support seemed more important for distributed modes than for FtF mode because of the explicit communication requirements in distributed modes. The template clearly listed all items that need to be discussed in a particular session, and it helped focus participants' attention on one small topic at a time. When participants were asked what they liked about Cognito meetings, eight mentioned that the structure and outline of the meeting were helpful. The following comments were copied from the participants' feedback about their interactions and the author's field notes. These comments and notes did not specify that deliberation was an important process in group activity, nor did they imply that group structure have facilitated deliberation. Focus Theory specifies that group deliberation could be a structured process (understand the problem – brainstorm the solutions – organize solutions – vote on the solutions – discuss and select the optimal solutions) or a chaotic process (understand the problem, get one solution, and use this solution). Consequently, it is reasonable to argue that, if participants like the organization or structure of an interaction, the structure is a useful feature and may facilitate a group deliberation process.

The following comments and notes indicate that participants liked the structure support.

Question: What do you like about the meeting?

Answer: I like the organization or structure imposed on the discussion.
- (Class 2 Management Week 4 Asyn Feedback)

Answer: Was able to organize discussion topics nicely
- (Class 1 MM Week 3 FtF Feedback)

Answer: Good outline of what needed to be done in the meeting
- (Class 2 Test Week 2 FtF Feedback)

Answer: The ability to have a structured meeting makes the meeting go faster and smoother
- (Class 2 Test Week 2 FtF Feedback)

When the author asked them whether the meeting was better than week 1 meeting, one participant said, "definitely". One participant said, "it is a lot smoothier", another participant said, "the structure of the meeting did help".
- (Class 1 SD Week 2 FtF – From the author's field notes)

When the meeting has a clear agenda with specific sub-topics, the meeting is more organized, more focused, and the meeting flow is better
- (Class 2 SW Week 2 FtF - From the author's field notes)

4.8 Implications for Collaboration Technology

The study indicated that some features of the system were good for collaboration and others needed to be improved. Participants generally reported that the system was easy to use, and that they liked the layered structure of the communication interface. However, some technical issues arose and some improvements should be made to facilitate distributed group interactions.

Technical issues with the current system

There was an installation problem with the current system. The system had a server-client architecture, the server was hosted in the University of Arizona, users needed only to download and install the client. Some users were unable to install the system correctly at their home PCs, and therefore could not access the system from home. These participants were unable to participate asynchronous interactions as frequently was wanted or expected. The client was not very stable either. It sometimes crashed and could

not be used after for a while. Collaboration technology should be easy to install and free of maintenance problems.

Another problem with the current system was that the system was slow. It took more than one minute to launch a session, frustrating participants, who posted 11 comments on its lack of response speed.

it takes a long time to load
- (Class 1 Management Week 6 Asyn Feedback)

function is ok. but the system is little slow.
- (Class 1 SD Week 6 Asyn Feedback)

it is extremely slow
- (Class 1 SD Week 1 Syn Feedback)

It takes a long time to log in
- (Class 2 QA Week 6 FtF Feedback)

Good features of the current system

Several features of the current system facilitate distributed group interactions, of which structural support seemed the most important. Some students asked what difference there is between Cognito and other communication media such as online chat room, electronic message board, and instant messenger. They were told that a major difference is that Cognito provides group interaction structure support while others do not. In this study, the system interface was configured to support hierarchical arrangement of topics so that it was easy for groups to have focused discussions guided by agendas. After participants had experienced use of the system, some who had asked the difference between Cognito and other online communication media agreed that structure support was an important feature for group collaboration. Structure support also

made it easy for participants to locate and retrieve information when a session has ended. Structural support should be even more important for large-group performance when there are multiple agenda items for one group interaction session.

Another feature that facilitates distributed group interaction is the ability to grant different levels of authority to different roles. The system supports two roles: team leader and participants. Team leaders have the authority to create interaction sessions, add new sessions, invite participants into the session, send participants to a particular session, and change participant's authority. Participants usually can only log on to a particular session, and input ideas for that particular session. Limitation of access and writing authority helped prevent accidental deletion of important contents or changing of settings. For example, in class 1 PP's first asynchronous interaction session for which all project managers had been invited as team leaders for the session, a project manager had deleted agenda items created by the team leader. Frustrated, the team leader asked the researcher to invite project managers only to be participants, so that they would not have the authority to delete agenda items.

Granting different information access authority also helped reduce information load by allowing participants to see and do only what they were supposed to see and do.

The current system is very flexible and can support identified communication or anonymous communication. The default setting supports anonymous communication, which maybe preferred when participants wants creative ideas and honest feedback from participants. For example, when the researcher needed to get participants' honest feedback about their group interactions, anonymous communication was used. The

system can also be configured to add name tags. When participants interacted in distributed format, they would have liked to have name tags added automatically.

The system usually adds a line number for discussion reference at the end of each message posted on the discussion pane. The system can also be configured to add a date and time stamp for each message posted. As was discussed in the first part of this chapter, name tags and date & time stamp helped participants interpret messages more accurately by identifying who said what at what time.

System features need to be improved or incorporated

The study suggested that there should be a separate communication channel to provide group process and technical support for distributed interactions, especially for synchronous-distributed modes. The web-based GSS used in this study supports chat room, which can act as process and online support. However, a mechanism to ensure that only one chat room can be opened during an interaction session is needed so participants will not become get confused about which chat room to enter. Whenever new content enters the chat room, the chat room will be flagged, and everyone can read that new content before continuing discussion. The current GSS version automatically saved all content in the server except that in the chat room, which could be valuable if participants wanted to review it.

The current system did not allow participants to add name tags in asynchronous modes. They could only add name tags manually to each message in asynchronous interactions, and it was suggested that name tags should be automatically appended to each message once the feature was turned on at the beginning of a session.

The current interface does not indicate who is at which topic. Participants suggested that there should be an icon or sign to show who was at which topic, the system should also email the participants when new input has arrived at an asynchronous session.

It would be very useful for GSS to provide a group calendaring function to help project members more easily figure out a date and a time for FtF or synchronous group activities.

There should be a function to export session minutes to a text file. Participants would like being able to keep a permanent record of session minutes. The current GSS version did not make it possible to export session minutes. The team leader or facilitator had to copy and paste the session minutes to a text file. It would be much more efficient if GSS could export minutes to a text file.

The current system does not have the attachment function. If a participant wanted others to view a particular document, he/she had to email it or post it online for access. However, there are disadvantages with this practice. Members maybe overwhelmed by email attachments if they need to exchange documents frequently. Posting the document online greatly compromises the security of a document. For a class project, this may not be important, but real organizations may find it unacceptable. No organization will expose critical information online without protection. It would be very useful for collaboration technology to have the attachment function so that team members could attach a document to the interface, have other participants view it, download and edit it, and upload it to the interface again.

Despite all the system's technical issues and design flaws, participants learned to use it and started to think about its potential use by real distributed teams. Some participants also reported that there should be more training in use of the software so when teams started to use the software in actual group interactions they would not have to learn how to use the system while solving problems.

4.9 Summary of the Chapter

Research question 1 investigates how Focus Theory constructs are manifested during group interactions in different modes, and why. Three constructs were measured by participant perceptions: goal congruence, distraction, and cognitive effort. Group productivity was estimated by group session effectiveness, which in turn was estimated by the number of fully discussed items. The data analysis results indicated that the study measured cognitive load instead of cognitive effort. Whereas cognitive load refers to attention resources that are used during the process of accomplishing a task, cognitive effort refers to attention resources that are used only for task-related activities or thinking. Cognitive load therefore includes cognitive effort and distraction. Group session effectiveness measure has not been accurate for estimating group productivity, so future research needs to find a better productivity variable. Due to these measurement issues, relationships among various constructs cannot be tested. Focus Theory implies a positive correlation between the construct of goal congruence and cognitive effort, a negative correlation between distraction and cognitive effort, and a positive correlation between group productivity and cognitive effort, but these relationships could not be estimated by the current study.

Research question 2 investigated the ways in which Focus Theory is useful and in what ways it is limited in terms of providing explanations for the observed phenomena, as well as how it can be improved. The study indicated that Focus Theory had been useful in specifying three processes, and that facilitating one or all of the processes would likely increase group productivity. When the need for identified and explicit communication was supported in distributed interaction, it was easier for participants to interpret the messages by identifying who said what and when. Information access was supported by saving the interaction session notes into the server for reference during and after interactions. Group deliberation process was supported by structuring interactions into layers of topics. Participants reported that recorded interaction notes helped them keep track of what had been done and what needed to be done, and that group interaction structure support led to easier interaction and more focused discussion.

Focus Theory has its flaws and measurement issues. 1) Its proposition that allocations of attention resources to three processes interfere with one another may not be valid, and may only come into play when a cognitive threshold is reached. This creates another issue: How can we know whether a cognitive threshold has been reached? Individuals may have different cognitive thresholds for different group activities. How can we establish a cognitive threshold? However, since this study did not collect data to estimate allocation of attention resources to three processes, the assertion that allocations of attention resources interfere with one another may not be valid needs to be examined in future study.

2) Measuring the respective attention resources consumed by three processes also is an issue. Without being able to measure attention resources consumed by processes respectively, how the proposition that allocations of attention resources interfere with one another be tested?

3) Focus theory does not explicitly differentiate between cognitive effort and cognitive load. Without being able to differentiate cognitive effort and cognitive load, how can we test the relationship between cognitive effort and group productivity specified by Focus Theory?

4) Focus Theory does not specify the weights of the three processes. It does not specify whether and one process is more important than the others under particular conditions, but in some group interaction scenarios that may be the case. For example, communication may be the most important process in one task while in another task information access may be the most important process.

Research question 3 investigates how three processes are facilitated and/or inhibited during group interactions. Given a theoretical foundation and observed findings, how could collaboration technology be designed and deployed to enhance the performances of people engaged in distributed interactions.

Due to the loss of non-verbal cues, distributed communication in text format is likely to be more vague and ambiguous than FtF communication, so it was expected that distributed interactions would impose a higher demand for explicit communication. As a result, name tags, date stamp, time stamp and line numbers were added to help with distributed communication in text. Interaction coordination, interaction facilitation, and

group process structures were more important in distributed modes than in FtF mode. It appeared that it would be helpful to have a separate communication channel for group process and technical support in the distributed modes. The system interface should also indicate the identities of participants, and the topic under discussion, which would increase awareness of the communication context.

GSS can be used to reduce distraction by providing a common user interface to focus participants' attention on a certain topic at a particular time. Information access and deliberation were found to be tightly interwoven with communication process. Communication was the key process among all three processes. It seemed that when communication was more effective/efficient, group interactions were more effective/efficient. It seemed that information access and deliberation did not affect group productivity very much. However, this does not mean Focus Theory is invalid, or that it does not have explanatory power for group productivity in other situations. For example, when the group size is medium (8 – 12) or large (more than 12 participants), group tasks are complex and complicated to resolve, support for information access and deliberation may greatly increase the performance of group interaction. This needs to be examined in future study.

In this study, asynchronous interactions could be as effective as synchronous-distributed and FtF interactions if the only purpose of the interaction was to share information. In fact, in this situation, asynchronous mode could be much more efficient than synchronous-distributed or FtF mode. However, when groups needed to engage in

discussion, negotiation, and build consensus, asynchronous mode was not as effective as synchronous-distributed and FtF modes.

Accordingly, collaboration technology should be designed and configured to support distributed group interaction in text. GSS can enhance distributed interactions by facilitating explicit communication (e.g., persistent name tags, automatic line numbering, date and time stamp), providing group process structure, separating communication channels for content communication and process communication, indicating interaction progress, allowing group calendaring, and granting different use roles different authorizations to access information and different feature access qualifications.

Chapter 5 discusses the study's contributions, study limitations, and suggestions for future study.

CHAPTER 5 CONCLUSION

This chapter presents limitations of the study; describes implications for further development of the theory, insights for researchers of collaboration, guidelines for collaboration technology designers, and everyday tips for practitioners; and discusses directions for future study.

5.1 Study Limitations

There were two major limitations of the study. The first was that the study used students as subjects. Since students may have had little working experience, it may be difficult to generalize the study results to personnel in a working environment. However, the students in this study were juniors and seniors whose average number of full-time working years was approximately four. Many had had some working experience.

Student subjects also may have lacked motivation to participate the study and failed to put serious effort into project tasks (Class 1 engaged in a contrived project and Class 2 engaged a real project for their business school). Both projects were non-trivial in terms of project complexity, required skills, time, and effort and subjects from both classes spent an entire semester (two-and-a-half months) to accomplish their respective projects. Individual students' final grades were partially determined by group project (nearly 20% of their final grades were determined by project participation and deliverables). The author observed that students were motivated to do a good job on their projects in general and on the GSS-facilitated project process tracking session in particular. She noticed that participants who were not active in either their project or in GSS-facilitated group interactions did not belong to a particular group or class. As a

group, students participation was serious and did not vary between classes or across groups.

A second limitation was that the project teams were not working in a real distributed environment and the simulation of asynchronous interactions may not have been sufficiently realistic. In a real distributed environment, team members would be expected to communicate only via the system. In the study, because participants were on the same campus, they had opportunities to engage in discussions outside the classroom. This may have affected the validity of results summarized from asynchronous interactions. However, co-location of team members should not invalidate the results as a whole, because the study was more interested in how Focus Theory constructs are manifested, and how three processes are facilitated or inhibited during group interactions, than in the outcomes of group interactions. Co-location of team members should not invalidate the results summarized from FtF and synchronous-distributed interaction modes.

5.2 Study Contributions

Guided by Focus Theory, this study adopted an action research approach to investigate efficacy of Focus Theory, a general theory of group productivity, in the context of GSS-facilitated group interactions in FtF as well as distributed interaction modes. Understanding the mechanism of group productivity should prove useful to team leaders and participants in a distributed environment because they might be helped to select and configure appropriate collaboration technology, and improve group interaction efficiency and/or effectiveness. It also should assist collaboration technology designers in

determining what system features need to be implemented and improved to support more productive group interactions. The phenomenon of group productivity for group interactions supported by collaboration technology had not previously been fully addressed, even though studies in GSS and CMC had examined group productivity to a certain degree. This study added knowledge about this topic.

Much prior GSS research implicitly or explicitly adopted an input-process-output model to investigate how different types of input factors (groups, technology, context, and tasks) affected group processes, which in turn affected group outcome. Group outcome includes group productivity. The input-process-outcome model is a descriptive model rather than a causal model. Studies guided by it have testified the effects of different input factors on group outcome, but have not explained why certain input factors affected group outcome in a particular way. It could not be used to predict group productivity given a particular combination of input factors. In addition, it treats group process as a black box; nothing is specified for group process and how group process affects group outcome.

CMC studies have investigated how communication context affected communication outcome, with a focus on the communication process of group interaction. Although communication may be a part of group productivity, it may not fully explain group productivity.

In response to a lack of a theoretical model to explain group productivity, Briggs developed Focus Theory (Briggs, 1994), an understanding of which may reveal some insights into group productivity. But because Focus Theory has been little examined in

empirical settings, this study investigated group productivity using an action research approach.

The study has made contributions in theoretical and practical aspects of information technology, discussion of which has implications for researchers, collaboration technology designers, and distributed teamwork practitioners.

5.2.1 Implications for Researchers

Focus Theory suggests that goal congruence and distraction determine the amount of cognitive effort that is available for group interactions that involve the three processes of communication, information access, and deliberation. The allocation of cognitive effort for three processes interferes with one another and logical reasoning implies that technology can enhance group productivity if the technology can reduce distraction, increase goal congruence, or facilitate any of the three processes.

This study suggested that Focus Theory has some explanatory power for the observed phenomena, indicating that facilitating any of the three processes involved in group interactions was likely to increase interaction efficiency and/or effectiveness.

GSS System features such as adding name tags, date stamps, time stamps, and line numbers facilitated unambiguous distributed communication by identifying who said what and when. GSS supported information access by displaying comments and ideas on the computer screen promptly and by saving these comments and ideas for future access. GSS supported the group deliberation process by allowing the building of a hierarchical structure of interaction topics, which facilitated better organized and smoother interaction.

The study also suggested that Focus Theory has its limitations and issues. First, the study suggested that it was difficult to separate the three processes and to measure attention resources allocated to these processes respectively. Future study is needed to determine how to manipulate and measure the respective allocations of attention resources to each of them.

Second, Focus Theory does not differentiate between cognitive effort and cognitive load. The differentiation is necessary to test the relationship between cognitive effort and group productivity. As discussed in chapter 4, cognitive load refers to total attention resources consumed during a task, cognitive effort includes attention resources consumed only by task-related thinking or activities. Cognitive load therefore incorporates cognitive effort and distraction. A researcher attempting to measure perceived cognitive effort, as the author did in this study, would end up measuring cognitive load instead of cognitive effort. Future studies are needed to find a way to measure cognitive effort empirically.

Third, Focus Theory does not specify the weights of the three processes. It does not specify whether and one process is more important than the others under particular conditions, but in some group interaction scenarios that may be the case. For example, communication may be more constrained than information access and deliberation, in one task while in another task information access may be the most constrained process. Future study may be needed to investigate which processes are more important than others for what types of interaction conditions or task types, as well as how much the more important process should be supported by using collaboration technology.

These flaws need to be addressed before empirical tests of Focus Theory can be designed and conducted. There are two implications of this study for researchers. The first is that communication is not the sole process that needs to be investigated when studying distributed group interaction. Examining the roles of the other two is also essential to understanding group interactions supported by collaboration technology. Future study needs to investigate how support for group-process structure, and for information access can be provided for distributed groups.

Just as this study investigated the use of collaboration technology to facilitate project process tracking session in FtF and distributed mode, future research can investigate how collaboration technology can be configured to support day-by-day distributed project/team interactions, not just track the process. Distributed group activities can be useful for co-located teams as well. Collaboration technology can act as an online information center, which can augment FtF interactions. Co-located team members can continuously exchange information online, reserving FtF interactions for activities that require serious discussion, negotiation, and problem solving. Future research can investigate how co-located teams can utilize distributed interactions more effectively and efficiently.

5.2.2 Implications for System Designers

The study has several implications for GSS or for designers of other collaboration technology.

Process structure support

It is very important that collaboration technology provide process structure support for distributed group interactions. The system used in this study allowed users to configure the interface by embedding one tool in another to create a layered structure for group interactions, thereby facilitating divergent thinking, convergent thinking, and information retrieval. This may be even more important when a) the group size is large (more than five members), b) a variety of issues and problems need to be discussed and resolved, c) the issues and problems are complex. Further studies are required to verify this.

Communication support

Collaboration technology should provide flexibility for users to choose anonymous communication or identified communication (e.g., adding name tags to message); it should support explicit communication (e.g., adding line numbers, date stamps, and time stamps). Anonymous communication facilitates generation of creative ideas, expression of honest comments on ideas, and encouragement of judgment of ideas based on ideas instead of the person who expresses them. Source-identified and explicit communication were preferred and were used more often than anonymous communication in distributed mode in this study. Participants had better understanding of a message when they knew who sent it and at what time it was sent. Collaboration technology should allow users to select or configure a system so that different communication formats (e.g., anonymous and identified) can be supported.

Group process support

The current system supports communication only in text. Team leaders usually set up session topics before the session, and group members engaged in discussion by moving from one topic to the next. The system needs to support the group process by indicating who is at which topic and providing a separate channel for group process and technical support. This channel should always be open and participants should always be able to enter questions about the group process and technical issues, and it should always be possible for the team leader to be alerted about a new entry in the channel.

Information access control support

The current system provides different information access privileges for team leaders and participants, enforcing tight information access control and reducing information overload and confusion. The study indicated that differentiation of user roles was effective and could be incorporated in other collaboration technologies.

Other collaboration function support

A system may be made more useful by supporting document attachment for easy access to and sharing of text, providing a group calendar for group activity coordination, and exporting session notes to a text file for archival and reporting convenience. The system also needs to provide options to send email alerts to other participants when new information is entered in an asynchronous session. Online chat in the current system is not persistent when participants log off. All chat contents disappear. It would be helpful to have the online chat room persist so that participants could keep a permanent record for future reference.

5.2.3 Implications for Practitioners

The study had several implications for project practitioners and distributed teamwork practitioners. Group interaction preparation, interaction facilitation, and interaction structures were important for all interaction modes, and they were more important for distributed interactions.

Before-group interaction

Adequate software training should be provided, participants need to have enough hands-on experience using the collaboration software before actually participating in distributed interactions by using the software. They should not have to figure out how to use the system and solve a problem at the same time.

Leaders/facilitators need to make sure participants have an interest in group interaction outcomes, otherwise is was likely that participants will not put serious effort into a group interaction. Before each group interaction, leaders/facilitators need to make careful preparations: clearly defining group goals, setting up a session agenda, asking participants to make necessary preparations and do research, and communicating interaction procedure clearly and explicitly.

During-group interaction

Leaders/facilitators need to lead discussions and provide feedback and technical support for interaction. For asynchronous interaction, a login schedule and a frequent email reminder may increase the number of times that participants log onto the system and participate in discussion.

After-group interaction

Leaders/facilitators need to make sure to follow up on assigned tasks and unresolved issues after each group interaction. Group interaction notes or summaries need to be posted on the Internet and easy access by all team members should be provided.

Other implications for practitioners

The template of the project process tracking session in this study was very useful for structuring the discussion into topics so that leaders could create their own sub-topics. The template approach may be applicable for other project activities and group interactions.

Asynchronous interaction can be a very useful and convenient communication format that augments FtF interactions for co-located teams. When team members need to exchange information in a timely manner, asynchronous interaction can be a more efficient and/or effective communication format than FtF interaction.

5.3 Future Study

The study results suggest that no empirical test of Focus Theory can be done until its flaws and measurement issues have been addressed. The study also suggests that the following questions need to be addressed, even if they may not be related to Focus Theory.

The study investigated text communication in the synchronous-distributed mode, and team sizes are from three to seven. The author observed that synchronous-distributed interaction was more effective for smaller teams (e.g., two or three members) than larger

teams (e.g., six or seven members). When a team had two or three members, it was easier for team members to maintain one conversation thread and to focus discussion.

Questions requiring additional research are: If participants use only text communication for synchronous-distributed interaction, what is the maximum team size for effective interaction? Which synchronous-distributed team will perform better, one using only text communication, one using only voice communication, or one using both text and voice communication?

The study suggested that having a permanent group memory increased participants' awareness of group team activities: what had been discussed and achieved, and what needed to be done. Its group memory feature implies that GSS may function as a knowledge management tool in organizations, and future research may study how GSS can be used to facilitate knowledge management for distributed projects and organizations.

The study suggests that future study can design experiments to test whether a hierarchical structure of group interaction topics, subtopics, and content support group deliberation process and enhance group performance.

Group productivity is a very important phenomenon that so far has been studied only from certain aspects or to a certain degree. Prior GSS and CMC theoretical models have not addressed group productivity per se, even though they had implications for it. Focus Theory is a model that can be used to explain group productivity per se, but it has limitations and issues. Until these have been addressed or another theoretical model has

been developed, examination of group productivity may have to continue to be investigated from certain aspects, as has been done in prior GSS and CMC studies.

APPENDIX A

TABLE OF DISTRIBUTED GSS EMPIRICAL STUDIES

Abbreviation	Meaning
FtF	face-to-face
Manual-FtF	FtF meetings without computer support
Facilitated-FtF	FtF meetings with computer support
Syn	synchronous-distributed
Asyn	asynchronous-distributed
s	hypothesis was supported
ns	hypothesis was not supported
ps	partially supported
comm.	communication

Author, Year	Study Description	Hypotheses & Conclusions
(Anderson & Hiltz, 2001)	2 x 2 (culturally heterogeneous & culturally homogeneous) x (manual FtF & Asyn) Name of the system WEB-EIES Type of task Conflict	H1a. level of influence equality: Asyn > FtF (ns) H1b. level of influence equality: heterogeneous > homogeneous (ns) H2a. post meeting consensus: Asyn < FtF (ns) H2b. post meeting consensus: heterogeneous < homogeneous (ns) H3a. level of consensus change: Asyn < FtF (s) H3b. level of consensus change: heterogeneous > homogeneous (ns)
(Burke &	Facilitated-FtF, Syn, Asyn	H1. cohesiveness differ across treatments overtime (ns)

Chidambaram, 1994), (Burke & Chidambaram, 1995)	(longitudinal) Name of the system GroupSystems Type of task Creating & planning	H2. leadership effectiveness differ across treatments overtime (s) H2a. leadership effectiveness: FtF > Syn&Asyn initially (ns) H2b. leadership effectiveness increase: Syn&Asyn > FtF (ns) H3. coordination competence differ across treatments overtime (s) H3a. coordination competence: FtF > Syn&Asyn initially (ns) H3b. coordination competence increase: Syn&Asyn > FtF (ns) H4. social presence differ across treatments overtime (ns) H5. equality of participation differ across treatments overtime (ns) H6. task performance do not differ across treatments (s)
(Burke, Chidambaram & Locke, 1995)	Facilitated-FtF, Syn, Asyn (longitudinal) Name of the system GroupSystems Type of task Creating & planning	H1. cohesiveness differ across treatments overtime (ns) H1a. cohesiveness: FtF > Syn&Asyn initially (ns) H1b. cohesiveness increasing: Syn&Asyn > FtF (ns) H2. perceived conflict management differ across treatments overtime (ns) H2a. perceived conflict management: FtF > Syn&Asyn initially (ns) H2b. perceived conflict management increasing Syn&Asyn > FtF (ps) H3. process satisfaction differ across treatments overtime (ns) H3a. process satisfaction: FtF > Syn&Asyn initially (ns) H3b. process satisfaction increasing: Syn&Asyn > FtF (ns)
(Burke & Chidambaram, 1996)	Facilitated-FtF, Syn, Asyn (longitudinal) Name of the system GroupSystems Type of task Creating & planning	H1. social presence differ across treatments overtime (ns) H2. profile comm. effectiveness differ across treatments overtime (ns) H3. profile perceived comm. interface differ across treatments overtime (ns) H4. task performance: FtF > Syn & Asyn (ns)
(Burke & Aytes,	Facilitated-FtF, Video,	H1a. cohesion will increase for all media (s)

1998)	video&audio, Audio, CMC_Syn, CMC_Asyn, (longitudinal) Name of the system for CMC: GroupSystems Type of task Creating & planning	H1b. cohesion: richer media > leaner media initially (ns) H1c. cohesion increase: richer media < leaner media (ns) H2a. process satisfaction increase for all media (s) H2b. process satisfaction: richer media > leaner media initially (ns) H2c. process satisfaction increase: richer media < leaner media (ns)
(Burke & Chidambaram, 1999)	Facilitated-FtF, Syn, Asyn (longitudinal) Name of the system GroupSystems Type of task Creating & planning	H1. social presence differ across treatments initially (s) H1a. social presence: FtF > Syn initially (s) H1b. social presence: Syn > Asyn initially (ns) H2. social presence do not differ across treatments eventually (ns) H2a. social presence: FtF do not differ from Syn eventually (ns) H2b. social presence: Syn do not differ from Asyn eventually (s) H3. perception of comm. interface differ across treatments initially (s) H3a. perception of comm. interface: FtF > Syn initially (s) H3b. perception of comm. interface: Syn > Asyn initially (ns) H4. perception of comm. interface do not differ across treatments eventually (s) H4a. perception of comm. interface: FtF do not differ from Syn eventually (s) H4b. perception of comm. interface: Syn do not differ from Asyn eventually (s) H5. perception of comm. effectiveness differ across treatments initially (s) H5a. perception of comm. effectiveness: FtF > Syn initially (s)

		H5b. perception of comm. effectiveness: Syn > Asyn initially (ns) H6. perception of comm. effectiveness do not differ across treatments eventually (ns) H6a. perception of comm. effectiveness: FtF do not differ from Syn eventually (s) H6b. perception of comm. effectiveness: Syn do not differ from Asyn eventually (ns) H7. task performance differ across treatments (ns) H7a. task performance: FtF > Syn (ns) H7b. task performance: Syn > Asyn (ns)
(Burke & Chidambaram, 1999)	Facilitated-FtF, Syn, Asyn (longitudinal) Name of the system GroupSystems Type of task Creating & planning	Social attitude: cohesion, conflict, process satisfaction Technical attitude: social presence, comm. effectiveness, comm. interface H1. social attitude and technical attitude will change over time (s) H2. social attitude change profile is different from technical attitude change profile over time (s) H2a. social attitude increase sooner than technical attitude (s) H2b. social attitude change > technical attitude change (s)
(Burke & Aytes, 2001)	Partially-distributed-syn Three modes: video,Audio, Combined video& audio (repeated) Name of the system Collaborative writing tool (name not specified) Type of task	High preference for procedural order (HPO) Low preference for procedural order (LPO) H1. quantity of procedural comments: HPO > LPO (ns) H2. perceived procedural ordering: HPO > LPO (ns) H3. satisfaction with the group process: HPO > LPO (ns)

	Creating & planning	
(Burke & Aytes, 2001)	The same as (Burke & Aytes, 2001)	H1. quantity of procedural comments: audio > video (ns) H2. quantity of procedural comments: HPO > LPO (ns) H3. perceived procedural ordering: audio > video (ns) H4a. perceived procedural ordering: HPO > LPO (ns) H4b. satisfaction with the group process: HPO > LPO (ns)
(Burke, Aytes & Chidambaram, 2001)	Report studies from (Burke et al., 1995), and (Burke & Aytes, 2001) Name of the system The same as (Burke et al., 1995), and (Burke & Aytes, 2001) Type of task Creating & planning	H1. cohesion: richer media > leaner media initially (ns) H2. satisfaction: richer media > leaner media initially (ns) H3. cohesion increase overtime regardless media richness (s) H4. satisfaction increase overtime regardless media richness (s)
(Burke, Chidambaram & Aytes, 2002)	Report two studies, one design is similar to (Burke & Chidambaram, 1999), the other design is similar to (Burke & Aytes, 2001)	Social perceptions: cohesion & satisfaction technical perceptions: social presence & communication effectiveness H1. Perceptions about social and technical structures will both increase over time (s) H2. Social perceptions will differ from technical perceptions (s) H2a. Social perceptions will increase sooner than technical perceptions (s) H2b. Social perceptions will increase more than technical perceptions (s)
(Cass, Heintz & Kaiser, 1991)	2 x 2 incomplete (GSS & non-GSS) vs. (FtF & Syn)	F_GDSS (FG) F_non-GDSS (FN) - unpopulated Syn-GDSS (DG), Syn-non-GDSS (DN)

	Name of the system SAMM Type of task Preference	H1: meeting process satisfaction: DG > GN (ns) H2: meeting outcome satisfaction: DG > GN (ns) H3: dispersed groups do not differ in meeting process satisfaction from FtF groups (s) H4: dispersed groups do not differ in meeting outcome satisfaction from FtF groups (s)
(Cass, Heintz & Kaiser, 1992)	The same as (Cass et al., 1991)	H1. meeting process satisfaction: GDSS = non-GDSS (ns) H2. meeting outcome satisfaction: GDSS = non-GDSS (ns) H3. meeting process satisfaction: dispersed = FtF (s) H4. meeting outcome satisfaction: dispersed = FtF (s) H5. effects of GDSS on meeting process satisfaction do not differ with meeting proximity (s) H6. effects of GDSS on meeting outcome satisfaction do not differ with meeting proximity (ns)
(Chidambaram & Jones, 1993)	2 x 2 (repeated) (GSS & non-GSS) vs. (FtF & Syn) Name of the System GroupSystems Type of task Decision making	H1a. social presence: non-GSS > GSS (supported for FtF only) H1b. social presence: FtF > dispersed (supported for all groups) H2a. perception of comm. effectiveness: GSS > non-GSS (supported for dispersed groups only) H2b. perception of comm. effectiveness: FtF > dispersed (supported for non-GSS groups only) H3a. perceptions of comm. interface: non-GSS > GSS (ns) H3b. perceptions of comm. interface: FtF > dispersed (supported for non-GSS groups only) H4a. quality of final decision: GSS > non-GSS (ns) H4b. quality of final decision: FtF > dispersed (ns) H5a. quality of decision process: GSS > non-GSS (s) H5b. quality of decision process: FtF > dispersed (s) H6a. number of alternatives: GSS > non-GSS (s)

		H6b. number of alternatives: FtF > dispersed (ns)
(Cho et al., 2003)	2 x 2 all Asyn team size x comm. structure team size: small (5-6), medium (10-12) comm. structure: Delphi & unstructured Name of the System Webboard Type of task Creativity & decision making	H1a. number of unique ideas: Delphi groups > unstructured groups (s) H1b. number of unique ideas per person: Delphi groups > unstructured groups (s) H2a. number of unique ideas: medium-sized groups > small-sized groups (s) H2b. number of unique ideas per person: medium-sized groups < small-sized groups (ns) H3a. number of unique ideas: medium-sized Delphi group > small sized Delphi group disproportionately (ns) H3b. number of unique ideas per person: medium-sized Delphi groups > small sized Delphi group disproportionately (ns)
(Dufner, Hiltz & Turoff, 1994)	2 x 2 Asyn (GSS voting, listing tools & no tools) x (sequenced & non-sequenced procedure) Name of the system EIES 2 Type of task Preference	Overall, GSS with tools (listing and voting) were perceived to be more useful than GSS without tools. Groups following the sequenced procedure felt distracted by the mechanics of the system significantly more often than groups not instructed to follow the sequenced procedure
(Dufner, Hiltz, Johnson & Czech, 1995)	The same as (Dufner et al., 1994)	There are consistent differences in favor of the use of GSS TOOL (List and Vote TOOL) in terms of perceptions of the richness of the medium: TOOLS groups saw it as significantly more personal, more flexible, more convenient, more dependable, more wide-ranging, more rich, and as

		providing more feedback and more immediate feedback.
(Fjermestad et al., 1995)	2 x 2 Asyn (repeated) decision approach x group history decision approach: DI (dialectical inquiry), CC (constructive consensus) Name of the system EIES 2 Type of task Decision making	Asyn meeting time: DI groups > CC groups, no difference for group experience, no interaction between decision approach and experience Number of comments: DI groups > CC groups, no difference for group experience, DI decrease between tasks Decision effectiveness & depth of evaluation: no main effect for decision approach and experience, no interaction between decision approach and experience
(Gallupe & McKeen, 1990)	2 x 2 mode x GDSS (FtF & Asyn) x (GSS & non-GDSS) Name of the system DECAID1 Type of task Choice	H1a. decision quality FtF: GDSS > non-GDSS (ns) H1b. decision quality remote: GDSS > non-GDSS (ns) H2a. decision time FtF: GDSS = non-GDSS (ns, GDSS took longer) H2b. decision time remote: GDSS > non-GDSS (s) H3a. choice shift FtF: GDSS = non-GDSS ((ns) H3b. choice shift remote: GDSS > non-GDSS (ns) H4a. decision confidence FtF: GDSS < non-GDSS (ns) H4b. decision confidence remote: GDSS = non-GDSS (s) H5a. process satisfaction FtF: GDSS < non-GDSS (ns) H5b. process satisfaction remote: GDSS = non-GDSS (ns)
(Hiltz, Johnson & Turoff, 1986)	2 x 2 (repeated) task types x dispersion task types: information exchange & social-emotional dispersion: Manual-FtF &	H1. comm exchange in the same amount of time: FtF > Syn (s) H2. social-emotional comm exchange: FtF > Syn (s) H3. differences in comm. process will be related to differences in comm. outcome, with social-emotional comm. aiding agreement and task-oriented comm. aiding quality of decision (s)

	Syn Name of the system EIES	H4. quality of decision: FtF < Syn (ns) reaching agreement: FtF > Syn (s) H5. equality of participation: FtF < Syn (s) H6. differences between modes in interaction process and outcomes are somewhat task dependent. In particular, effectiveness of reaching agreement on the human relations task: FtF > Syn (s)
(Hollingshead, McGrath & O'Conner, 1993)	Manual-FtF & Syn Name of the system OIM Type of task negotiation, discussion & intellective see (McGrath, 1993)	H1a. for generation tasks (ns) Performance: FtF < Syn Process difficulty: FtF > Syn Satisfaction: FtF < Syn H1b. for negotiation tasks (s) Performance: FtF > Syn Process difficulty: FtF < Syn Satisfaction: FtF > Syn H1c. for intellective & decision-making tasks (ns) Performance: FtF >= Syn Process difficulty: FtF < Syn Satisfaction: FtF > Syn H1d. difference of task performance between media for any given type of task will decrease over time (partially supported) H2a. initially, task performance for all task types: Syn < FtF (s) H2b. difference between FtF and Syn will decrease over time (s) H2c. change in media and membership will cause perturbations in group performance (s) H2d. for first few weeks, all groups will have relatively unstable process; during later weeks, group will show more table pattern of process (s) H2e: initially, satisfaction: FtF > Syn (s) Eventually, satisfaction: FtF = Syn (s)
(Kim, Hiltz &	2 x 2 Asyn	H1a. actual decision quality: parallel groups > sequential groups (ns)

Turoff, 1998)	leadership x coordination structure coordination structure: sequential & parallel Name of the system EIES 2 Type of task Choice	H1b. actual decision quality: groups with a leader > groups without a leader(ps) H2a. perceived decision quality: parallel groups > sequential groups (s) H2b. perceived decision quality: groups with a leader > groups without a leader (ns) H3a. decision satisfaction: parallel groups > sequential groups (ns) H3b. decision satisfaction: groups with a leader > groups without a leader (ns) H4a. process satisfaction: parallel groups > sequential groups (s) H4b. process satisfaction: groups with a leader > groups without a leader (s)
(Kim et al., 2002)	The same as (Kim et al., 1998)	Included all hypotheses in (Kim et al., 1998), two additional hypotheses: Additional H1a. lines per comment: parallel groups > sequential groups (ns) Additional H1b. lines per comment: groups with a leader > groups without a leader (s) Additional H2a. improved understanding of the task: parallel groups > sequential groups (s) Additional H2b. improved understanding of the task: groups with a leader > groups without a leader (ns)
(Ocker, Hiltz, Turoff & Fjermestad, 1995)	2 x 2 mode x process structure (Manual-FtF & Asyn) x (structured & non-structured) Name of the system EIES 2	H1. solution quality: GSS > FtF (ns) H2. solution creativity: GSS > FtF (s) H3. solution quality: structured GSS and unstructured FtF > non-structured GSS & structured FtF (ns)

	Type of task Planning, creativity, decision making & cognitive conflict	
(Ocker et al., 1996)	The same as (Ocker et al., 1995)	H1. solution quality: GSS > FtF (ns) H2. solution creativity: GSS > FtF (s) H3. solution quality: structured > non-structured (ns) H4. solution creativity: structured > non-structured (ns) H5. solution quality: structured GSS & unstructured FtF > non-structured GSS & structured FtF (ns) H6. solution creativity: structured GSS & unstructured FtF > non-structured GSS & structured FtF (ns)
(Ocker, Fjermestad, Hiltz & Turoff, 1997), (Ocker et al., 1998)	Manual-FtF, Asyn, Syn Combined (Asyn& Manual-FtF) Name of the system EIES 2 Type of task The same as (Ocker et al., 1995)	H1.1-1.3. solution creativity: combined > Asyn & Syn & FtF (s) H1.4 & 1.5. solution creativity: Asyn > Syn & FtF (ns) H2.1-2.3. solution quality: combined > Asyn & Syn & FtF (s) H2.4 & 2.5. solution quality: Asyn > Syn & FtF (ns) H3.1 - 3.3. solution satisfaction: combined > Asyn & Syn & FtF (s) H4.1 – 4.3. process satisfaction: combined > Asyn & Syn & FtF (ns)
(Ocker & Fjermestad, 1998)	Manual-FtF, Asyn, Combined (Manual-FtF & Asyn& Manual-FtF) Name of the system	H1.1. solution quality: Combined > Asyn (ns) H1.2. solution quality: Combined > FtF (s) H2.1. solution creativity: Asyn > FtF (s) H2.2. solution creativity: Combined > FtF (ns) H2.3. solution creativity: Combined > Asyn (ns)

	Web-EIES Type of task The same as (Ocker et al., 1995)	
(Ocker & Fjermestad, 2000)	The same as (Ocker & Fjermestad, 1998)	Total number of comments: no difference between high performance and low performance team Total number of comment lines: high team > low team Contents of comm. are coded into four categories: design activity, summary activity, coordination activity, and other activity Design activity: low performance teams spent a higher portion of their comments discussing design aspects than high performance teams; high teams communicated more regarding interface design and implementation than low teams; Summary activity: high teams spent more time summarizing their work and communicated more regarding the write up of the report than low teams Coordination activity: there were no differences between high teams and low teams in terms of actual number of comment lines and percentage of comm. Other activity: low teams spent a larger percentage of time on this category than high teams, no differences between high teams and low teams in terms of actual comment lines
(Ocker, 2001)	Asyn, Combined (Asyn & Manual-FtF) Name of the system FirstClass	H1. combined (teams) will be more highly developed compared to virtual groups (s) H1a. group cohesiveness: Combined > Asyn (s) H1b. conflict management: Combined > Asyn (s) H1c. socio-emotional needs support: Combined > Asyn (s)

	Type of task The same as (Ocker et al., 1995)	H1d. comm. effectiveness: Combined > Asyn (s) H1e. participation equality: Asyn > Combined (ns) H2. solution quality: more developed teams > less developed teams (s) H3a. process satisfaction: more developed teams > less developed teams (s) H3b. solution satisfaction: more developed teams > less developed teams (s) H4. creativity : more developed teams < less developed teams (s) H5. solution quality: Combined > virtual (ns) H6a. process satisfaction: Combined > Asyn (s) H6b. solution satisfaction: Combined > Asyn (s) H7. solution creativity: Combined < Asyn (s)
(Ocker, 2002)	The same as (Ocker, 2001)	All hypotheses were supported H1. satisfaction: Combined > Asyn H1a, 1b, 1c, 1d, 1e. solution satisfaction, solution confidence, process satisfaction, satisfaction of discussion quality, perceived level of teamwork: Combined > Asyn H2. perceived group development: Combined > Asyn H2a & 2b. group cohesiveness & conflict management: Combined > Asyn H3. satisfaction: more highly developed > less developed H3a-1 & 3b-1. solution satisfaction & solution confidence, : cohesive groups > less cohesive groups H3a-3, 3a-4 & H3a-5. process satisfaction, satisfaction of discussion quality & perceived level of teamwork: cohesive groups > less cohesive groups H3b-1, 3b-2, 3b-3, 3b-4 & 3b-5 . solution satisfaction, solution confidence, process satisfaction, satisfaction of discussion quality, perceived level of teamwork: effective conflict management

		groups> less effective groups
(Siegel, Dubrovsky, Kiesler & McGuire, 1986)	3 x 3 (repeated latin squares) comm. mode x task modes: Manual FtF, Syn-anonymous, Syn-nonanonymous Name of the system CONVERSE Type of task Choice	Computer-supported groups made fewer remarks than FtF groups and took longer to make their group decisions. Computer-supported groups exhibited more equal participation and more uninhibited behaviors than FtF groups. Decisions of computer-supported group shifted further away from the members' initial individual choices than group decisions which followed FtF discussions
(Smith & Vanacek, 1989)	Manual-FtF & Asyn Name of the system EIES Type of task Intellective	H1. there will be difference for FtF and Asyn modes in amount and comprehensiveness of the shared information, perception of progress toward goal, perception of freedom to participate, and deviation from the correct answer (s) H2. shared information: FtF > Asyn (s) H3. comprehensiveness of discussion: FtF > Asyn (s) H4. perception of progress toward the goal: FtF > Asyn (s) H5. perception of freedom to participate: FtF > Asyn (ns) H6. deviation from the correct answer: FtF < Asyn (ns)
(Valacich, Nunamaker Jr. & Vogel, 1994)	Facilitated-FtF, Syn Electronic Brainstorming tool Type of task Idea generation	H1. idea generation: Syn outperform FtF (s) H2. idea generation: performance of distributed groups will increase with group size at a faster rate than FtF groups (ns)

APPENDIX B

GROUP ACTIVITY EVALUATION QUESTIOINNAIRE

Your class: _____ Your team: _____ Date:_____

Meeting mode: □ FtF □ Synchronous-Distributed □ Asynchronous-Distributed

Your Date of Birth (Month_Date_Year) _____ (e.g if your birth date is Aug. 5, 1967, your code is 08_05_1967)

Thank you for choosing to participate in this study. Your participation is optional. There are no correct or wrong answers for the questions. Please be forthright and candid with your answer. Please do not write your full name on the questionnaire. Please email questions to Fang Chen at fchen@email.arizona.edu.

I. Questions about Team Activity

1 = Strongly Agree
2 = Moderately Agree
3 = Slightly Agree
4 = Neither Agree nor Disagree (Neutral)
5 = Slightly Disagree
6 = Moderately Disagree
7 = Strongly Disagree

Circle one of the responses for each question.

	1=Strongly Agree			4=Neutral			7=Strongly Disagree
1. I have lots of experience with computers.	1	2	3	4	5	6	7
2. Reaching the team goal gets me closer to something I value.	1	2	3	4	5	6	7
3. It may help me personally if the team succeeds.	1	2	3	4	5	6	7
4. I consider myself to be a power-user of computers.	1	2	3	4	5	6	7
5. It was easy to work out solutions for team tasks.	1	2	3	4	5	6	7
6. I am happy with the results of today's meeting.	1	2	3	4	5	6	7
7. I understood the team goal.	1	2	3	4	5	6	7
8. I understood what the group was supposed to accomplish.	1	2	3	4	5	6	7
9. Accomplishing the team purpose helps me attain personal aim(s).	1	2	3	4	5	6	7
10. Other things took my attention away from team activities.	1	2	3	4	5	6	7
11. Our task-related problems were not hard to solve.	1	2	3	4	5	6	7
12. It took very little effort to accomplish our tasks.	1	2	3	4	5	6	7
13. I feel satisfied with the way in which today's meeting was conducted.	1	2	3	4	5	6	7
14. Distractions interfered with my efforts for the team.	1	2	3	4	5	6	7
15. I feel good about today's meeting process.	1	2	3	4	5	6	7
16. It did not demand much cognitive effort to get the team task done.	1	2	3	4	5	6	7

17. I liked the way the meeting progressed today.	1	2	3	4	5	6	7
18. Outside influences kept me from paying attention to team efforts.	1	2	3	4	5	6	7
19. The team goal was clear to me.	1	2	3	4	5	6	7
20. I feel satisfied with the procedures used in today's meeting.	1	2	3	4	5	6	7
21. I feel satisfied about the way we carried out the activities in today's meeting.	1	2	3	4	5	6	7
22. I liked the outcome of today's meeting.	1	2	3	4	5	6	7
23. The team task was easy to solve.	1	2	3	4	5	6	7
24. I feel satisfied with the things we achieved in today's meeting.	1	2	3	4	5	6	7
25. If the team achieves its goal, it moves me toward an outcome I want.	1	2	3	4	5	6	7
26. I experienced distractions when working on team tasks.	1	2	3	4	5	6	7
27. When the meeting was finally over, I felt satisfied with the results.	1	2	3	4	5	6	7
28. Our accomplishments today give me a feeling of satisfaction.	1	2	3	4	5	6	7
29. It did not require hard thinking to accomplish team tasks.	1	2	3	4	5	6	7
30. I am highly computer literate.	1	2	3	4	5	6	7

Please answer the following questions

31. How many times (excluding this one) have you used Group Support Systems (e.g. Cognito)? _____.

II. Demographic Questions

32. How many years of full-time work experience do you have? _____

33. How old are you? _____

34. Sex: Male Female

35. For how many years have you used computers _____.

Goal congruence: 2, 3, 9, 25
Distraction: 10, 14, 18, 26
Cognitive load: 5, 11, 12, 16, 23, 29
Process Satisfaction: 13, 15, 17, 20, 21
Outcome satisfaction: 6, 22, 24, 27, 28
Goal understanding: 7, 8, 19
Computer literacy: 1, 4, 30

APPENDIX C

HUMAN SUBJECTS DISCLAIMER

Title of Project: Virtual Project Management by Using Group Support Systems (Virtual Project Charter Development/Activity)

Principal Investigator: Fang Chen (a Ph.D. candidate in the Department of Management Information Systems at the University of Arizona)

Purpose/Selection Criteria: You are being invited to participate in the above-titled research study because you are 18 years of age or older. Approximately 500 students will be invited to participate. The purpose of the study is to investigate the group dynamics in GSS-facilitated meetings for different meeting modes.

Procedure: If you agree to participate, your participation will involve participating several GSS-facilitated project meetings, filling out the same questionnaire about the meeting each time after the meeting, and possibly an individual interview about the meeting, some meetings may be observed. Notes will be taken for individual interviews and observations. The meeting will take approximately 60 – 90 minutes each time. Filling out the questionnaire will take approximately 10-15 minutes. Individual interview may take approximately 15-20 minutes. Your responses to the questionnaires will be identified for data analysis purpose, they are confidential. Observation notes, and individual interviews will be completely anonymous and confidential. The results of the study may be presented at academic conferences or published in academic journals. But you will not be identified in any publication and presentation.

Risks: There are no known risks associated with participation in this study.

Benefits: There are no guaranteed direct benefits, but the information you give may contribute to the research on GSS-facilitated project meeting, or virtual team meeting.

Participation costs and subject compensation: You may receive course extra credit for finishing the whole study process. There is no cost to you except your time.

Contacts: If you have any questions regarding your participation or rights as a research subject, you may contact Fang Chen, the Principal Investigator, at fchen@email.arizona.edu or the Human Subjects Committee at 520-626-6721.

Consent: By agreeing to participate in this research, you are granting permission for use of your data to be used for research and instructional purposes.

APPENDIX D

MEETING AGENDA FORM

A. Instructions

Purpose of the form: help team leaders and project managers prepare agenda before each meeting and check to see whether the meeting has achieved its meeting purpose.

Who should use and fill out the form: meeting leaders (team leader or project managers)

When to fill out the form: before each meeting and after each meeting. Sub-topics should be listed before each meeting, and status needs to be filled out after each meeting

When to hand in the form: after each meeting

Where to get the blank form: from Fang or print from the web: http://bpa.arizona.edu/~fangch/MeetingForm.doc

B. Form

Class _____ Team _____ Date_____
Your name: _____
Meeting Mode (check one):
__FtF __Synchronous-distributed __Asynchronous - distributed

If you need to list more sub-topics for each of the five topics listed below, please list them on the back of page 2, and clearly mark which topic it belongs with.
There are three statuses for each sub-topics. Please mark the number in ***status*** column for sub-topics, if the status is 2 or 3, please briefly list the reason in ***note*** column (e.g., no time, not possible to do this in this meeting mode, don't have necessary information or tool to do this, team members agree to do this for next meeting time…)

1. Fully discussed the sub-topic
2. Did not fully discuss the sub-topic
3. Did not discuss the sub-topic at all

status	topics and sub-topics	note
	Tasks Completed in the Past Week	
	1)	

	2)	
	3)	
	4)	
	5)	
	Tasks for the Coming Week	
	1)	
	2)	
	3)	
	4)	
	5)	
	Approaching Deadlines	
	1)	
	2)	
	3)	
	4)	
	5)	
	Agenda Items	
	1)	
	2)	
	3)	
	4)	
	5)	
	Open Issues/Problems	
	1)	
	2)	
	3)	
	4)	
	5)	

APPENDIX E

REPEATED MEASURE ANALYSIS TABLES AND FIGURES.

This appendix lists tables and figures about repeated measure analysis and correlation analysis. For repeated measure analysis, tables include descriptive statistics, within-subjects test, and between-subjects test. The within-subject factors are week and mode, and the between-subject factor is group. If the analysis results indicated significant difference of a particular variable for week, mode, group, or interactions, tables of Bonferroni pairwise comparison and figures are presented as well.

Goal Congruence

	Group	Mean	Std. Deviation	N
Goal Congruence Week 1 FtF	A	6.11	.75	11
	B	6.02	.96	11
	C	6.09	1.03	8
	Total	6.08	.88	30
Goal Congruence Week 1 FtF	A	6.05	1.01	11
	B	6.16	.85	11
	C	5.97	.76	8
	Total	6.07	.86	30
Goal Congruence Week 1 Syn	A	6.05	.96	11
	B	5.23	1.22	11
	C	5.91	.82	8
	Total	5.71	1.07	30
Goal Congruence Week 2 Syn	A	5.89	.80	11
	B	5.8	1.06	11
	C	5.97	.73	8
	Total	5.88	.86	30
Goal Congruence Week 1 Asyn	A	5.89	.78	11
	B	5.64	1.00	11
	C	5.84	.87	8
	Total	5.78	.87	30
Goal Congruence Week 2 Asyn	A	5.75	.81	11
	B	6.02	.93	11
	C	5.59	1.24	8
	Total	5.81	.96	30

Table E-1 Descriptive Statistics of Goal Congruence

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partical Eta Squared
Mode	2.87	2	1.43	3.96	.025	.13
Mode * Group	2.21	4	.55	1.53	.207	.10
Error (Mode)	19.57	54	.36			
Week	.09	1	.09	.37	.55	.01
Week * Group	2.39	2	1.20	4.68	.018	.26
Error (Week)	6.88	27	.26			
Mode * Week	.27	2	.14	.46	.631	.02
Mode*Week*Group	.48	4	.12	.41	.803	.03
Error (Mode * Week)	15.95	54	.30			

Table E-2 Tests of Within-subjects Effects of Goal Congruence

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Intercept	130.97	1	130.97	214.05	.000	.89
Group	.12	2	.06	.09	.91	.01
Error (Week)	16.52	27	.612			

Table E-3 Tests of Between-Groups Effects of Goal Congruence

Contrast	Mean Difference	Std. Error	Sig (a)
FtF vs. Syn	.26*	.11	.078
FtF vs. Asyn	.28*	.09	.017
Syn vs. Asyn	.02	.13	1.000

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-4 Pairwise Comparison of Goal Congruence for Mode

Group	(I) Week	(J) Week	Mean Difference (I-J)	Std. Error	Sig (a)
A	1	2	.12	.12	.338
	2	1	-.12	.12	.338
B	1	2	-.36*	.12	.007
	2	1	.36*	.12	.007
C	1	2	.10	.15	.481
	2	1	-.10	.15	.481

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-5 Pairwise Comparison of Goal Congruence for Week*Group

Goal Understanding

	Group	Mean	Std. Deviation	N
Goal Understanding Week 1 FtF	A	6.03	.95	11
	B	6.12	.87	11
	C	6	1.13	8
	Total	6.06	.94	30
Goal Understanding Week 1 FtF	A	6.15	.91	11
	B	6.55	.52	11
	C	6.12	.78	8
	Total	6.29	.75	30
Goal Understanding Week 1 Syn	A	5.67	1.37	11
	B	4.42	1.86	11
	C	5.83	1.05	8
	Total	5.26	1.59	30
Goal Understanding Week 2 Syn	A	5.89	.93	11
	B	5.52	1.09	11
	C	5.67	.69	8
	Total	5.69	.92	30
Goal Understanding Week 1 Asyn	A	6.03	.88	11
	B	5.94	.61	11
	C	4.33	1.49	8
	Total	5.54	1.22	30
Goal Understanding Week 2 Asyn	A	5.3	1.68	11
	B	5.61	1.07	11
	C	5.67	1.26	8
	Total	5.51	1.34	30

Table E-6 Descriptive Statistics of Goal Understanding

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partical Eta Squared
Mode	17.69	2	8.85	10.86	.000	.29
Mode * Group	14.23	4	3.56	4.38	.004	.25
Error (Mode)	43.97	54	.81			
Week	2.38	1	2.38	4.36	.046	.14
Week * Group	3.01	2	1.50	2.75	.08	.17
Error (Week)	14.75	27	.55			
Mode * Week (1)	.63	1.35	.47	.39	.60	.01
Mode*Week*Group	11.98	4	2.99	3.73	.009	.22
Error (Mode * Week)	43.40	54	.80			

*(Note 1: Because sphericity for mode*week was violated, Greenhouse-Geisser value was reported for mode*week. All other values were reported as sphericity was assumed.)*

Table E-7 Tests of Within-subjects Effects of Goal Understanding

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Intercept	153.29	1	153.29	245.14	.000	.90
Group	.29	2	.15	.23	.80	.02
Error (Week)	16.88	27	.63			

Table E-8 Tests of Between-Groups Effects of Goal Understanding

Contrast	Mean Difference	Std. Error	Sig (a)
FtF vs. Syn	.66*	.17	.002
FtF vs. Asyn	.68*	.13	.000
Syn vs. Asyn	.02	.19	1.000

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-9 Pairwise Comparison of Goal Understanding for Mode and Week

Group	(I) Week	(J) Week	Mean Difference (I-J)	Std. Error	Sig (a)
A	1	2	.13	.18	.494
	2	1	-.13	.18	.494
B	1	2	-.39*	.18	.039
	2	1	.39*	.18	.039
C	1	2	-.43	.21	.054
	2	1	.43	.21	.054

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-10 Pairwise Comparison of Goal Understanding for Week*Group

Cognitive Effort

	Group	Mean	Std. Deviation	N
Cognitive Effort Week 1 FtF	A	2.65	.78	11
	B	2.32	1.04	11
	C	2.79	1.10	8
	Total	2.57	.96	30
Cognitive Effort Week 1 FtF	A	2.56	.95	11
	B	2.26	.98	11
	C	2.75	.84	8
	Total	2.50	.92	30
Cognitive Effort Week 1 Syn	A	2.88	1.29	11
	B	4.36	1.23	11
	C	2.73	.58	8
	Total	3.38	1.33	30
Cognitive Effort Week 2 Syn	A	2.52	.90	11
	B	3.39	1.03	11
	C	3.00	1.03	8
	Total	2.97	1.02	30
Cognitive Effort Week 1 Asyn	A	3.12	1.60	11
	B	3.14	1.24	11
	C	3.60	.82	8
	Total	3.26	1.27	30
Cognitive Effort Week 2 Asyn	A	2.91	1.41	11
	B	2.95	1.53	11
	C	3.58	.76	8
	Total	3.11	1.31	30

Table E-11 Descriptive Statistics of Cognitive Effort

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partical Eta Squared
Mode	15.55	2	7.78	7.03	.002	.21
Mode * Group	19.77	4	4.94	4.47	.003	.25
Error (Mode)	59.72	54	1.11			
Week	1.52	1	1.52	2.93	.10	.10
Week * Group	1.56	2	.78	1.51	.24	.10
Error (Week)	13.98	27	.52			
Mode * Week (1)	.67	2	.33	.90	.41	.03
Mode*Week*Group	2.13	4	.53	1.42	.24	.10
Error (Mode * Week)	19.99	54	.37			

Table E-12 Tests of Within-subjects Effects of Cognitive Effort

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Intercept	259.32	1	259.32	387.62	.000	.94
Group	.63	2	.31	.47	.630	.03
Error (Week)	18.06	27	.67			

Table E-13 Tests of Between-Groups Effects of Cognitive Effort

Contrast	Mean Difference	Std. Error	Sig (a)
FtF vs. Syn	-.59*	.19	.012
FtF vs. Asyn	-.66*	.23	.019
Syn vs. Asyn	.07	.17	1.000

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-14 Pairwise Comparisons of Cognitive Effort for Interaction Mode

Mode	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig (a)
FtF	A	B	.32	.37	1.00
		C	-.17	.40	1.00
	B	A	-.32	.37	1.00
		C	-.48	.40	.705
	C	A	.17	.40	1.00
		B	.48	.40	.705
Syn	A	B	-1.18*	.39	.016
		C	-.168	.43	1.00
	B	A	1.18*	.39	.016
		C	1.01	.43	.073
	C	A	.168	.43	1.00
		B	-1.01	.43	.073
Asyn	A	B	-.03	.53	1.00
		C	-.58	.58	.976
	B	A	.03	.53	1.00
		C	-.55	.58	1.00
	C	A	.58	.58	.976
		B	.55	.58	1.00

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-15 Pairwise Comparisons of Cognitive Effort for Mode*Group

Distraction

	Group	Mean	Std. Deviation	N
Distraction Week 1 FtF	A	3.3	1.75	11
	B	3.41	1.79	11
	C	3.41	1.41	8
	Total	3.37	1.63	30
Distraction Week 2 FtF	A	3.16	1.82	11
	B	3.41	1.47	11
	C	3.87	1.70	8
	Total	3.44	1.63	30
Distraction Week 1 Syn	A	4.55	1.64	11
	B	4.39	1.23	11
	C	3.72	1.94	8
	Total	4.27	1.57	30
Distraction Week 2 Syn	A	3.91	1.62	11
	B	3.73	1.66	11
	C	3.12	1.52	8
	Total	3.63	1.59	30
Distraction Week 1 Asyn	A	4.43	1.88	11
	B	3.7	1.72	11
	C	3.62	1.34	8
	Total	3.95	1.68	30
Distraction Week 2 Asyn	A	4.85	1.66	11
	B	3.39	2.00	11
	C	3.31	1.31	8
	Total	3.9	1.81	30

Table E-16 Descriptive Statistics of Distraction

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partical Eta Squared
Mode	8.57	2	4.28	2.32	.108	.08
Mode * Group	17.35	4	4.34	2.34	.066	.15
Error (Mode)	99.75	54	1.85			
Week	1.70	1	1.70	1.35	.26	.05
Week * Group	.41	2	.20	.16	.85	.01
Error (Week)	34.00	27	1.26			
Mode * Week (1)	4.37	2	2.18	1.80	.18	.06
Mode*Week*Group	2.37	4	.59	.49	.74	.04
Error (Mode * Week)	65.44	54	1.21			

Table E-17 Tests of Within-subjects Effects of Distraction

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Intercept	532.96	1	532.96	348.02	.000	.93
Group	1.40	2	.70	.46	.638	.03
Error (Week)	41.35	27	1.53			

Table E-18 Tests of Between-Groups Effects of Distraction

Group Interaction Session Effectiveness

	Group	Mean	Std. Deviation	N
Number of Fully Discussed Topics Week 1 FtF	A	9.00	2.00	4
	B	6.40	5.03	5
	C	8.00	2.58	4
	Total	7.69	3.52	13
Number of Fully Discussed Topics Week 2 FtF	A	10.25	4.50	4
	B	6.80	4.09	5
	C	5.25	1.71	4
	Total	7.38	3.97	13
Number of Fully Discussed Topics Week 1 Syn	A	8.25	3.59	4
	B	6.20	3.56	5
	C	4.25	.50	4
	Total	6.23	3.19	13
Number of Fully Discussed Topics Week 2 Syn	A	7.50	4.20	4
	B	8.00	3.39	5
	C	6.00	.82	4
	Total	7.23	3.03	13
Number of Fully Discussed Topics Week 1 Asyn	A	8.00	2.16	4
	B	10.60	5.50	5
	C	3.50	3.51	4
	Total	7.62	4.87	13
Number of Fully Discussed Topics Week 2 Asyn	A	8.00	2.83	4
	B	8.40	4.39	5
	C	4.50	1.91	4
	Total	7.08	3.55	13

Table E-19 Descriptive Statistics of Session Effectiveness

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Sqaured
Mode	10.81	2	5.40	.58	.570	.06
Mode * Group	81.81	4	20.45	2.19	.107	.31
Error (Mode)	186.60	20	9.33			
Week	.06	1	.06	.02	.882	.00
Week * Group	.12	2	.06	.02	.978	.01
Error (Week)	25.50	10	2.55			
Mode * Week	7.43	2	3.72	1.03	.376	.09
Mode*Week*Group	38.99	4	9.75	2.69	.061	.35
Error (Mode * Week)	72.40	20	3.62			

Table E-20 Tests of Within-subjects Effects of Session Effectiveness

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Sqaured
Intercept	659.33	1	659.33	85.87	.000	.90
Group	23.39	2	11.70	1.52	.265	.23
Error	76.78	10	7.68			

Table E-21 Tests of Between-Groups Effects of Session Effectiveness

Session Process Satisfaction

	Group	Mean	Std. Deviation	N
Process Satisfaction Week 1 FtF	A	5.73	.87	11
	B	6.09	.82	11
	C	6.02	1.01	8
	Total	5.94	.87	30
Process Satisfaction Week 2 FtF	A	5.51	1.21	11
	B	6.25	.50	11
	C	5.95	.68	8
	Total	5.9	.90	30
Process Satisfaction Week 1 Syn	A	4.91	1.55	11
	B	4	1.49	11
	C	5.2	1.49	8
	Total	4.65	1.55	30
Process Satisfaction Week 2 Syn	A	5.51	.86	11
	B	5.22	1.17	11
	C	5.45	.95	8
	Total	5.39	.98	30
Process Satisfaction Week 1 Asyn	A	4.33	1.65	11
	B	5.11	1.67	11
	C	3.6	.64	8
	Total	4.42	1.54	30
Process Satisfaction Week 2 Asyn	A	5	1.69	11
	B	4.67	1.90	11
	C	5.32	1.19	8
	Total	4.97	1.63	30

Table E-22 Descriptive Statistics of Session Process Satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Mode	48.59	2	24.29	15.49	.000	.37
Mode * Group	10.94	4	2.73	1.74	.154	.15
Error (Mode)	84.68	54	1.57			
Week	8.26	1	8.26	13.86	.001	.34
Week * Group	.80	2	.40	.67	.52	.05
Error (Week)	16.10	27	.60			
Mode * Week	5.01	2	2.50	4.98	.010	.16
Mode*Week*Group	12.89	4	3.22	6.41	.000	.32
Error (Mode * Week)	27.12	54	.50			

Table E-23 Tests of Within-subjects Effects for Session Process Satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Intercept	227.45	1	227.45	270.87	.000	.91
Group	.04	2	.02	.03	.97	.00
Error (Week)	22.67	27	.84			

Table E-24 Tests of Between-Groups Effects for Session Process Satisfaction

Contrast	Mean Difference	Std. Error	Sig (a)
FtF vs. Syn	.88*	.20	.001
FtF vs. Asyn	1.25*	.26	.000
Syn vs. Asyn	.38	.22	.318

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-25 Pairwise Comparison of Process Satisfaction for Mode and Week

Week	(I) Mode	(J) Mode	Mean Difference (I-J)	Std. Error	Sig (a)
1	*FtF*	Syn	1.25*	.27	.000
		Asyn	1.60*	.28	.000
	Syn	FtF	-1.25*	.27	.000
		Asyn	.36	.29	.674
	Asyn	FtF	-1.60*	.28	.000
		Syn	-.36	.29	.225
2	*FtF*	Syn	.51*	.19	.033
		Asyn	.91*	.31	.019
	Syn	FtF	-.51*	.19	.033
		Asyn	.39	.25	.381
	Asyn	FtF	-.91*	.31	.019
		Syn	-.39	.25	.381

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-26 Pairwise Comparison of Process Satisfaction for Mode* Week

Mode	Group	(I) Week	(J) Week	Mean Difference (I-J)	Std. Error	Sig (a)
FtF	A	1	2	.22	.26	.400
		2	1	-.22	.26	.400
	B	1	2	-.16	.26	.526
		2	1	.16	.26	.526
	C	1	2	.08	.30	.804
		2	1	-.08	.30	.804
Syn	A	1	2	-.60	.35	.094
		2	1	.60	.35	.094
	B	1	2	-1.22*	.35	.002
		2	1	1.22*	.35	.002
	C	1	2	-.25	.41	.542
		2	1	.25	.41	.542
Asyn	A	1	2	-.67	.33	.049
		2	1	.67	.33	.049
	B	1	2	.44	.33	.193
		2	1	-.44	.33	.193
	C	1	2	-1.73*	.38	.000
		2	1	1.73*	.38	.000

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-27 Pairwise Comparison of Process Satisfaction for Mode*Week*Group

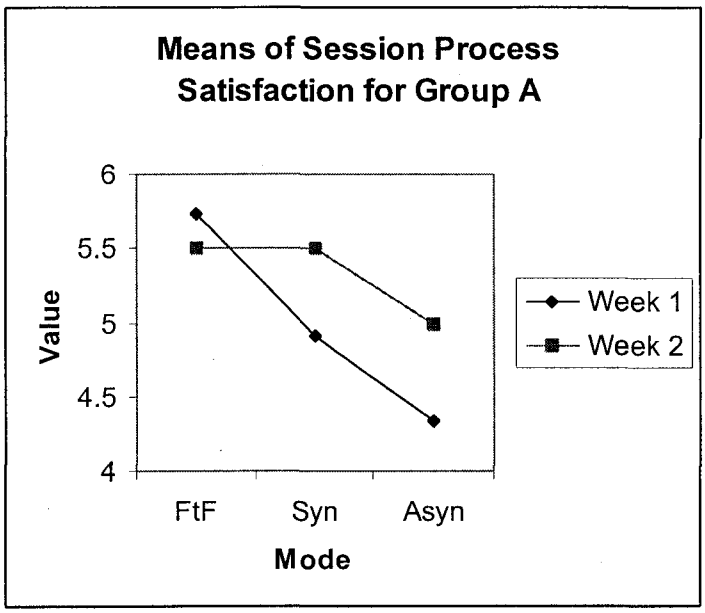

Figure E- 1 Means of Session Process Satisfaction for Group A

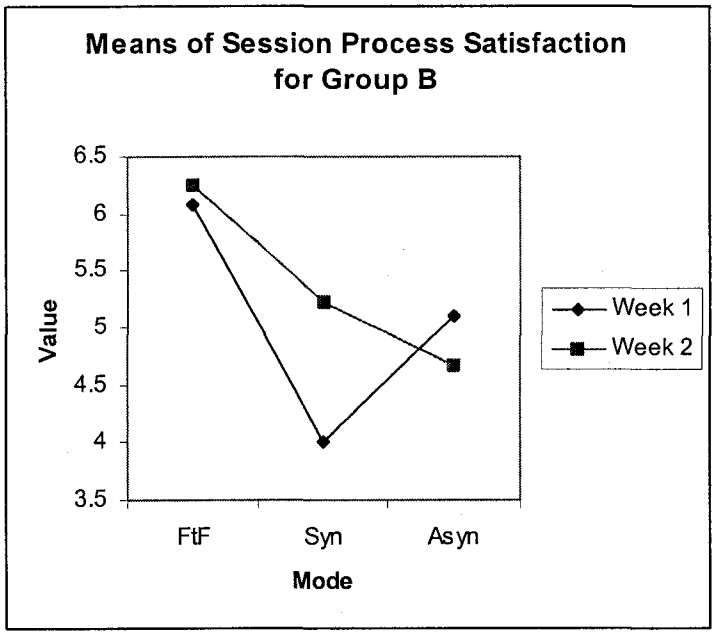

Figure E-2 Means of Session Process Satisfaction for Group B

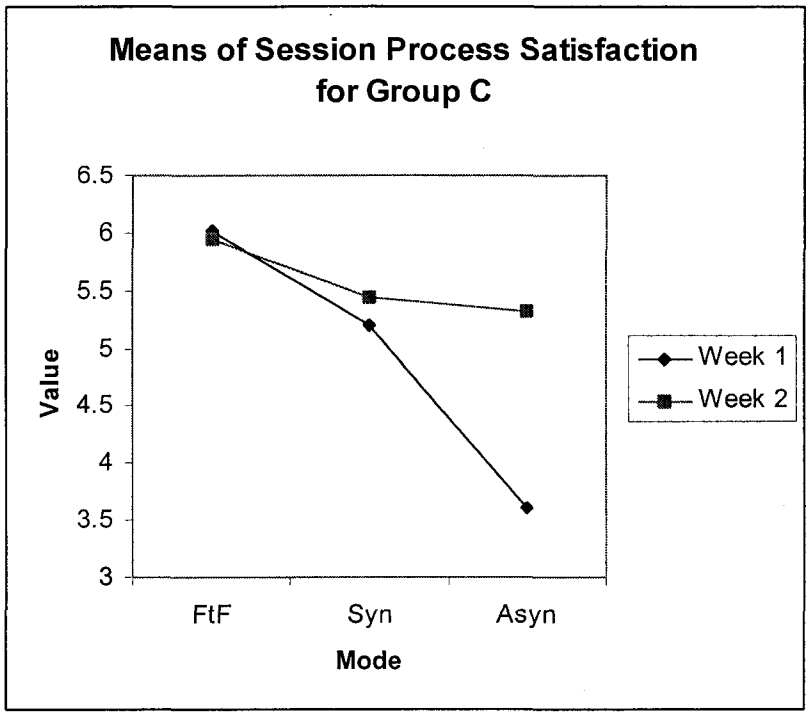

Figure E-3 Means of Session Process Satisfaction for Group C

Session Outcome Satisfaction

	Order	Mean	Std. Deviation	N
Outcome Satisfaction Week 1 FtF	A	5.89	.77	11
	B	6.09	.80	11
	C	6.1	.82	8
	Total	6.02	.77	30
Outcome Satisfaction Week 2 FtF	A	5.55	1.00	11
	B	6.25	.64	11
	C	5.95	.67	8
	Total	5.91	.83	30
Outcome Satisfaction Week 1 Syn	A	4.76	1.33	11
	B	4.07	1.59	11
	C	5.1	1.55	8
	Total	4.6	1.50	30
Outcome Satisfaction Week 2 Syn	A	5.58	.94	11
	B	5.04	1.28	11
	C	5.42	.87	8
	Total	5.34	1.05	30
Outcome Satisfaction Week 1 Asyn	A	4.65	1.64	11
	B	4.94	1.68	11
	C	3.8	.63	8
	Total	4.53	1.49	30
Outcome Satisfaction Week 2 Asyn	A	5.15	1.54	11
	B	4.78	1.86	11
	C	5.35	1.30	8
	Total	5.07	1.57	30

Table E-28 Descriptive Statistics of Session Outcome Satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Mode	47.33	2	23.67	13.31	.000	.33
Mode * Group	9.28	4	2.32	1.30	.28	.09
Error (Mode)	96.00	54	1.78			
Week	7.25	1	7.25	11.34	.002	.30
Week * Group	.57	2	.28	.44	.65	.03
Error (Week)	17.25	27	.64			
Mode * Week	5.91	2	2.96	6.51	.003	.19
Mode*Week*Group	7.97	4	1.99	4.39	.004	.25
Error (Mode * Week)	24.50	54	.45			

Table E-29 Tests of Within-subjects Effects for Session Outcome Satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig	Partial Eta Sqaured
Intercept	221.94	1	221.94	314.47	.000	.92
Group	.04	2	.02	.03	.970	.006
Error (Week)	19.06	27	.71			

Table E-30 Tests of Between-Groups Effects for Session Outcome Satisfaction

Contrast	Mean Differences	Std. Error	Sig
FtF vs. Syn	.98*	.20	.000
FtF vs. Asyn	1.19*	.27	.000
Syn vs. Asyn	.22	.26	1.000

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-31 Pairwise Comparisons of Outcome Satisfaction for Mode and Week

Week	(I) Mode	(J) Mode	Mean Difference (I-J)	Std. Error	Sig
1	FtF	Syn	1.38*	.28	.000
		Asyn	1.56*	.30	.000
	Syn	FtF	-1.38	.28	.000
		Asyn	.18	.31	1.000
	Asyn	FtF	-1.56*	.30	.000
		Syn	-.18	.31	1.000
2	FtF	Syn	.57*	.18	.012
		Asyn	.82*	.30	.031
	Syn	FtF	-.57*	.18	.012
		Asyn	.26	.27	1.000
	Asyn	FtF	-.82*	.30	.031
		Syn	-.26	.27	1.000

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-32 Pairwise Comparisons of Outcome Satisfaction for Mode*Week

Mode	Group	(I) Week	(J) Week	Mean Difference (I-J)	Std. Error	Sig (a)
FtF	A	1	2	.35	.19	.076
		2	1	-.35	.19	.076
	B	1	2	-.16	.19	.389
		2	1	.16	.19	.389
	C	1	2	.15	.22	.499
		2	1	-.15	.22	.499
Syn	A	1	2	-.82	.37	.037
		2	1	.82	.37	.037
	B	1	2	-.96	.37	.016
		2	1	.96	.37	.016
	C	1	2	-.33	.44	.464
		2	1	.33	.44	.464
Asyn	A	1	2	-.49	.33	.145
		2	1	.49	.33	.145
	B	1	2	.16	.33	.621
		2	1	-.16	.33	.621
	C	1	2	-1.55*	.38	.000
		2	1	1.55*	.38	.000

**:The mean difference is significant at the 0.05 level.*
a. Adjustment for multiple comparisons: Bonferroni

Table E-33 Pairwise Comparisons of Outcome Satisfaction for Mode*Week*Group

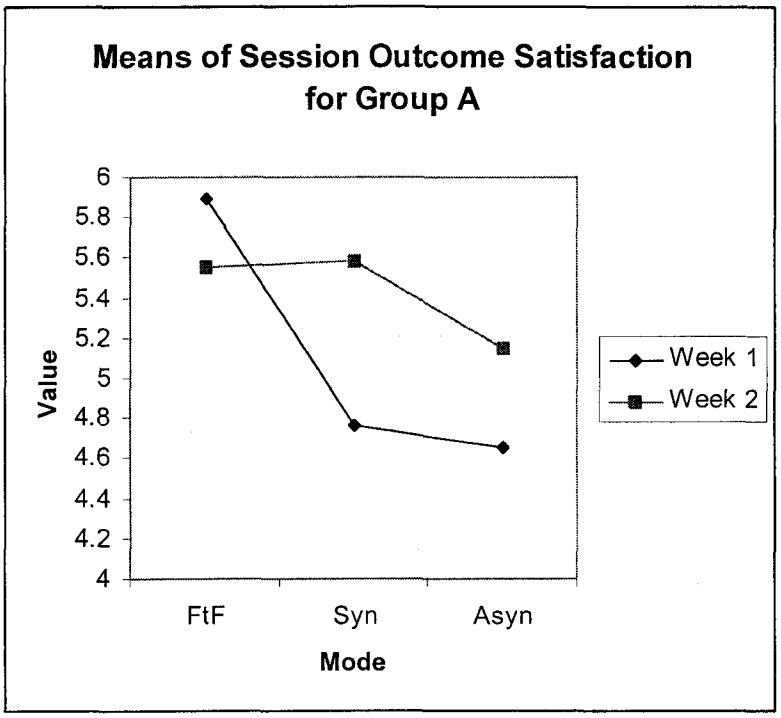

Figure E-4 Means of Session Outcome Satisfaction for Group A

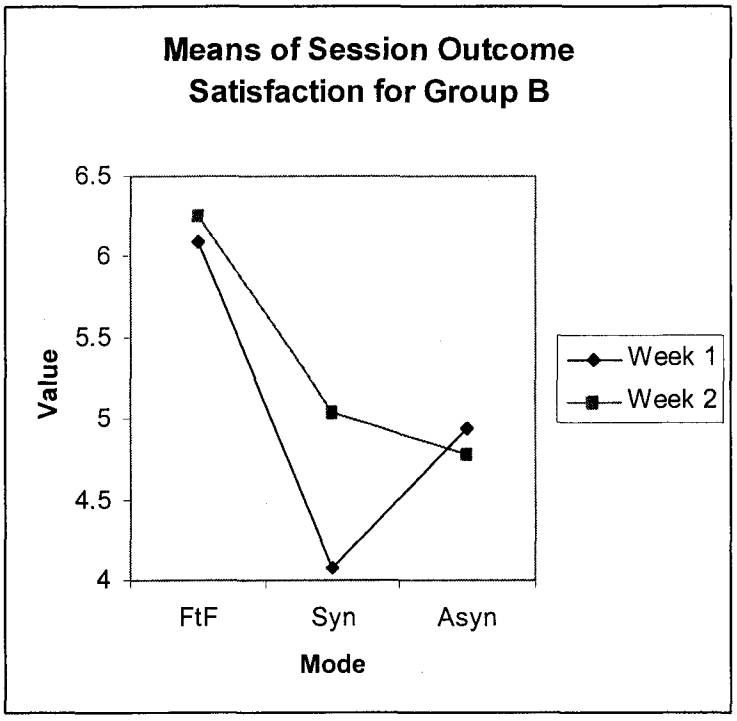

Figure E-5 Means of Session Outcome Satisfaction for Group B

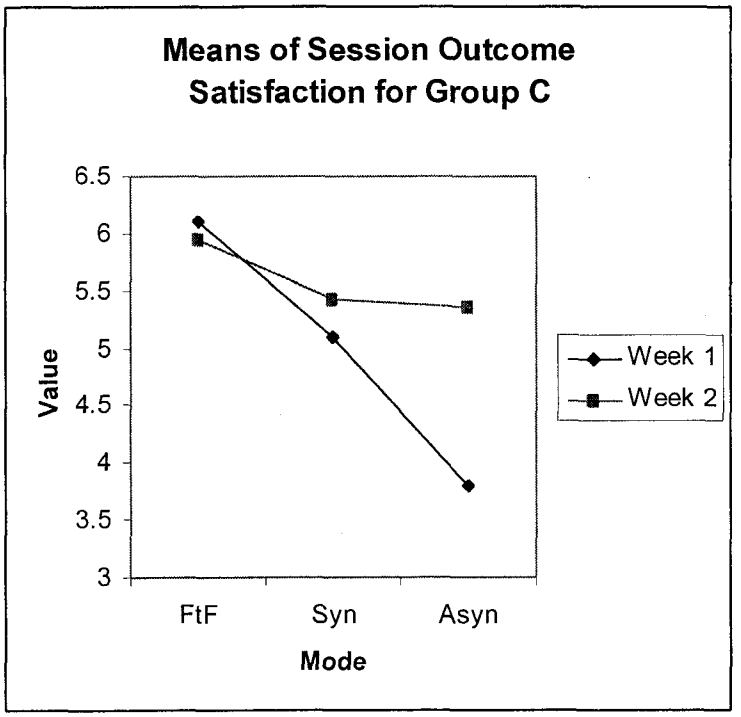

Figure E-6 Means of Session Outcome Satisfaction for Group C

APPENDIX F CORRELATION TABLE

		Goal Congruence	Cognitive Effort	Distraction	Process Satisfaction	Outcome Satisfaction	Session Effectiveness
Goal Congruence	Pearson r	1.00					
	Sig	.					
	N	78					
Cognitive Effort	Pearson r	.446**	1.00				
	Sig	.000	.				
	N	78	78				
Distraction	Pearson r	.063	.281**	1.00			
	Sig	.291	.006	.			
	N	78	78	78			
Process Satisfaction	Pearson r	.470**	.763**	.300**	1.00		
	Sig	.000	.000	.004	.		
	N	78	78	78	78		
Outcome Satisfaction	Pearson r	.478**	.742**	.323**	.960**	1.00	
	Sig	.000	.000	.002	.000	.	
	N	78	78	78	78	78	
Session Effectiveness	Pearson r	.159	-.111	-.221*	-.091	-.044	1.00
	Sig	.083	.168	.026	.214	.351	.
	N	78	78	78	78	78	78

**: correlation is significant at the 0.01 level (one-tailed)

*: correlation is significant at the 0.05 level (one-tailed)

All scores that are used to calculate correlation is the average mean score for the entire team, for example, one group session has only one average mean score of goal congruence, which is the average of all individual scores for the construct in that particular session.

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