COMPUTER-SUPPORTED COLLABORATIVE WORK AND ITS APPLICATION TO SOFTWARE ENGINEERING IN A CASE ENVIRONMENT

DISSERTATION

Presented to the Graduate Council of the

University of North Texas in Partial

Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Janet L. Bailey, B.B.A.

Denton, Texas

May 1997

Major Prof.: Dr. Michael Vanecek

COMPUTER-SUPPORTED COLLABORATIVE WORK AND ITS APPLICATION TO SOFTWARE ENGINEERING IN A CASE ENVIRONMENT

DISSERTATION

Presented to the Graduate Council of the

University of North Texas in Partial

Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Janet L. Bailey, B.B.A.

Denton, Texas

May 1997

Major Prof.: Dr. Michael Vanecek

Bailey, Janet L., Computer-supported collaborative work and its application to software engineering in a case environment. Doctor of Philosophy (Business Computer Information Systems), May 1997, 193 pp., 27 tables, 4 illustrations, references, 88 titles.

Rapidly changing organizational and technological environments present a major challenge to computer professionals. Systems development by individual programmers is increasingly less feasible. It is necessary to make a conscious paradigm shift from developers primarily working independently to produce modular system components to cross-functional teams comprised of various system experts working jointly to produce a solution to a mutually defined user-problem set.

The complexity of the dialogue and poor communication between users, developers, and managers have been cited as major factors in the failure of information system projects. In contrast, computer-supported collaborative work (CSCW) systems enhance communication by providing process and task support in the form of group memory, anonymity, parallel communication, and collaboration tools. They further provide both task and process structure.

This study investigated, in the context of a field-based case study, possibilities for formation of a synergistic union between CSCW and CASE tools. A major dimension of today's software challenge is in gearing up for large-scale system development necessitating large teams of systems engineers. The principal goal of this research was to advance the body of knowledge regarding the nature of collaborative technological

support in the software development process. Specifically, the study was designed to evaluate the potential for using a CSCW tool as an effective front-end to a CASE tool in the furtherance of SDLC goals.

The findings suggest that CSCW support had the greatest positive effect on satisfaction levels with the communication process and the task progress, as well as confidence in the quality of the results. Positive results were also seen in satisfaction levels with resulting system quality, team productivity, communication process, communication technology, CASE technology benefits, system development methodology, project management methodology, group process, and task results. A slight decline in satisfaction with the system development technology occurred. Additionally, a significant increase was seen in the volume of descriptive information available to the development team. However, despite these positive results, CSCW support was abandoned after nine months because of training and political.

ACKNOWLEDGMENTS

I am appreciative for the guidance, support, and dedication of my dissertation committee: Dr. Michael Vanecek, Dr. Al Kvanli, Dr. Kathleen Swigger, and Dr. Richard Yellen. I am especially indebted to my chairperson, Dr. Michael Vanecek who, in addition to being expert at idea stimulation, always knew when to encourage, push, pull, and prod. Additionally, I am immeasurably grateful for Dr. John Windsor who, from inception to completion of my doctoral career, consistently and repeatedly provided invaluable moral support and for Dr. Leon Kappelman who provided cheerleading that helped me through the final stages of the dissertation process.

TABLE OF CONTENTS

Page

ACKNOWLEDGMENT iii

LIST OF TABLES vi

LIST OF ILLUSTRATIONS vii

Chapter

1. INTRODUCTION 1

    Purpose of the Study
    Problem of the Study
    Significance of the Study
    Definitional Overview
        Computer-Supported Collaborative Work
        CSCW Group Process Support Features
        Collaborative SDLC Support

2. REVIEW OF THE LITERATURE 19

    Anonymity
    Idea Generation
    Group Memory
    Productivity and Quality
    Effects of Environment and Tool Selection
    Collaborative CASE
    Groupware Failure
    Team Room
    Information System Failure and Abandonment
    Summary

3. THEORETICAL FRAMEWORK 28

    Systems Development Model
    Computer-supported Group Task Framework

Page

3. THEORETICAL FRAMEWORK (cont.) 28

Technological Meeting Support Framework
Research Framework
Research Questions
Constructs
Hypotheses

4. METHODOLOGY 45

Research Design
Project Overview
Setting
Subjects and Population
Tool Selection
Project Description
Instrument Development
Measurements
Data Collection Techniques
Pre- and Post-Questionnaires
Notes Database
Structured Interviews
Effectiveness and Viability Measures
Data Analysis
Validity and Reliability
Construct Validity
Internal Validity
External Validity
Reliability
Summary

5. DATA COLLECTION AND ANALYSIS 68

Implementation of Data Collection and Analysis
Chain of Evidence for Question 1
Chain of Evidence for Question 2
Chain of Evidence for Question 3

Page

5. DATA ANALYSIS (cont) 68

Questionnaire Data
Quality
Productivity
Satisfaction
Notes Database
Structured Interviews
Summary

6. FINDINGS, IMPLICATIONS, AND FOCUS OF FUTURE RESEARCH 96
Brief Review of Methodology
Overview of Findings
Findings for Research Question 1
Hypothesis $_{11}$
Conclusions Drawn by the Researcher
Chain of Evidence Supporting the Conclusion
Hypothesis $_{12}$
Conclusions Drawn by the Researcher
Chain of Evidence Supporting the Conclusion
Hypothesis $_{13}$
Conclusions Drawn by the Researcher
Chain of Evidence Supporting the Conclusion
Findings for Research Question 2
Hypothesis $_{21}$
Conclusions Drawn by the Researcher
Chain of Evidence Supporting the Conclusion
Hypothesis $_{22}$
Conclusions Drawn by the Researcher
Chain of Evidence Supporting the Conclusion
Findings for Research Question 3
Hypothesis $_{31}$
Conclusions Drawn by the Researcher
Chain of Evidence Supporting the Conclusion
Additional Findings
Implication of the Findings
Limitations and Key Assumptions
Focus of Future Research
Summary

Page

APPENDIX

A. Pre-Implementation Instruments 134

B. Post-Implementation Instruments 142

C. Sample Lotus Notes Database for BOSS Project 149

D. Structured Interview Questions Addressed to Participants 158

E. Structured Interview Questions Addressed to Industry Expert Panel Members 161

F. Case Description Outline 164

G. QSR NUD.IST 168

H. Case Study Protocol 173

I. Sample QSR NUD.IST Node Investigation Report 178

REFERENCES 184

LIST OF TABLES

Table Page

1. Reasons for Group Process Gains 11
2. Causes of Group Process Losses 13
3. Table of Constructs 40
4. Process of Building Theory from Case Study Research 47
5. Constructs and Measures 59
6. Matrix of Communication Process Results 60
7. Quantity of Interactions 60
8. Depth of Interactions 61
9. Breadth of Interactions 61
10. Matrix of Quality Results 77
11. Matrix of Productivity Results 78
12. Matrix of Communication Process Results 80
13. Matrix of Communication Technology Results 80
14. Matrix of System Development Technology Results 81
15. Matrix of System Development Methodology Results 82
16. Matrix of Project Management Methodology Results 82
17. Matrix of CASE Technology Benefit Results 83
18. Matrix of Attitudes Towards the Group Process 84

Page

19. Matrix of Attitudes Towards the Task Results 85

20. Matrix of Technology Assessment 86

21. Matrix of Attitudinal Shifts Past Midpoint 87

22. Matrix of Greatest Shifts in Satisfaction Ratings 88

23. Matrix of Issues 89

24. Matrix of Descriptive Lines 89

25. Matrix of Interaction Breadth 91

26. QSR Nodes 92

27. Summary of Findings 98

LIST OF ILLUSTRATIONS

Figure Page

1. Systems development model 29

2. Framework for analyzing the impacts of GDSS support 31

3. Model of variables to study technological support of meetings 33

4. Framework for analyzing the impacts of GDSS support in a CASE environment 35

CHAPTER 1

INTRODUCTION

During the course of its life cycle, a system is likely to be nurtured by a group of software engineers and users working collaboratively on planning, analysis, design, development, testing, implementation, and maintenance. The larger the system, the more numerous the engineers and, consequently, the more cumbersome the coordination and communication processes. Additionally, the more complex the system, the more critical effective coordination and communication are to resulting system quality. Unfortunately, as Dewan and Riedl (1993) point out, traditional software engineering environments are geared toward individual rather than collective support of these processes.

Purpose of the Study

This study explores the possibilities for formation of a synergistic union between computer-supported collaborative work (CSCW) and computer-aided software engineering (CASE) tools. Definitions for these two terms are provided later in this chapter. A major dimension of today's software challenge is in gearing up for large-scale system development necessitating large teams of systems engineers (Forte and Norman 1991). The results of this research serve to advance the body of knowledge regarding the nature of technological collaborative support in the software development process.

The current environment has dictated a need for organizations to downsize. This trend has resulted in efforts to produce more, in less time, with fewer participants, without sacrificing quality. However, this trend is not unique to those organizations that are in the downsizing cycle. Most going-concern organizations are also striving to do more with less as they attempt to reduce development backlogs. Based on promising results of computer support for group tasks, which are inherent to the system development life cycle (SDLC), a symbiotic relationship could potentially be formed by combining a CSCW tool with a CASE environment (Henderson and Cooprider 1990; Liou and Chen 1993-94). Specifically, this study evaluates the use of a CSCW tool as a front-end to a CASE tool in the furtherance of SDLC goals.

Problem of the Study

Modern organizations are increasingly faced with challenges that did not exist twenty years ago. Globalization, distributed work environments, and increased competition have all complicated the system development process. Opportunistic organizations are constantly looking for ways to increase system quality while simultaneously reducing the demands on scarce resources of time, money, personnel, and equipment. In short, organizations are looking for ways to do more with less. Three techniques being examined in the furtherance of this goal are teamwork, computer-supported cooperative work (CSCW), and computer-assisted software engineering (CASE). Through the utilization of each technique, the potential exists for improving productivity, quality, and the firm's competitive position. Collectively, the combination

of the three appears extremely promising, and yet little has been known about the effects of their integration.

The system development realm continuously becomes more complex and dynamic. Rapidly changing organizational and technological environments present a major challenge to computer professionals. System development by individual programmers is becoming increasingly less feasible. Zahniser (1993) makes the point that it is necessary to make a conscious paradigm shift from developers primarily working independently to produce modular system components to cross-functional teams comprised of various system experts working jointly to produce a solution to a mutually defined user-problem set. By their very nature, large software projects necessitate the collaboration of a team of software designers/developers. The collaborative creation of systems requires an interactive environment, which fosters the collective harvesting and coordination of each member's knowledge, skills, and expertise (Alavi 1993a).

The complexity of the dialogue and poor communication among users, developers, and managers have been cited as major factors in the failure of information system projects (Chen, Nunamaker, and Konsynski 1987). In contrast, CSCW systems enhance communication by providing process and task support in the form of group memory, anonymity, parallel communication, and collaboration tools. Furthermore, they provide both task and process structure (Nunamaker et al. 1991).

Significance of the Study

Christakis (1987) notes that "interdisciplinary teams cannot work productively and efficiently in designing complex systems unless their work is supported and argued

by methodologies that have been invented specifically for this task" (53). Consistent with this argument, collaborative software engineering tools are being developed and researched for process effects. However, relatively little research has been done concerning the integration of CSCW tools into the computer-aided software engineering (CASE) environment. Furthermore, no major move is yet in the offing to include collaborative tools in many CASE products despite the common underlying goals of increased productivity, reduced costs, and higher profitability by both sets of tools. At best, a limited number of CASE tools allows users to have concurrent access to the same project dictionary, but lack a form of communication support for user interactions (Chen and Nunamaker 1991).

This study provides evidence as to the process effects of CSCW support on CASE-supported SDLC phases of planning, analysis, and design. By introducing a CSCW tool into the working environment of CASE developers, the researcher captured data on CSCW strengths and weaknesses as related to productivity, system quality, and participant satisfaction with the group process and the technology.

Although he cites no studies, Zahniser (1993) states research indicates that a superior product can be developed in six weeks in a collaborative environment as opposed to six months in a traditional setting. If development time can be significantly reduced through the utilization of a CSCW tool, organizational resources of time, money, personnel, and equipment can be redirected in a more efficient and cost-effective manner.

Additionally, this research extends the body of knowledge in software-development quality research. Other studies have found significant increases in software

development quality as a result of collaborative electronic support (Ellis, Rein, and Jarvenpaa 1989-90; Olson et al. 1992). These studies were not conducted in a CASE environment, and so the question remains as to whether the findings resulted from the group process support or whether the collaborative tool simply acted as a surrogate for a CASE tool repository. This study provides evidence regarding whether or not improvements in quality will be seen in a CASE environment.

Liou and Chen's research (1993-94) suggests that the introduction of group support systems (GSS) tools improve participant satisfaction in a CASE environment. This research sheds light on the reasons for and effects of the changes in satisfaction. Through the collection of this data from experienced personnel working on live systems, the results prove valuable in determining the direction for future research in this area.

Henderson and Cooprider (1990) discovered in open-ended interviews with leading CASE designers that cooperative functionality is considered desirable in a CASE environment. To date, however, group communication support is seriously lacking in commercially available CASE products (Forte and Norman 1991; Vessey and Sravanapudi 1995). The results of this study provide an indication of the value of electronic group process support for CASE developers. The primary contribution of this research is the knowledge gained from studying the incorporation of CSCW into a field setting of established teams of professionals using a CASE product.

Definitional Overview

The utilization of business teams to improve productivity and competitive position has become a growing trend (Drucker 1988; Johnson and Johnson 1991;

Mohrman and Cummings 1989). The potential exists for organizations to evolve to the point where virtually all managerial and service-level work will be performed by teams (Applegate, Cash, and Mills 1988; Drucker 1988). This trend, combined with the propensity of organizations to utilize information technology (IT) to enhance their competitive position, results in an environment that demands electronic meeting support. Opportunistic organizations can enhance the productivity of teams through the effective use of IT.

System development by individual programmers is becoming increasingly less feasible. Zahniser (1993) vividly portrays the necessary shift in the way organizations and individuals characteristically view the realm of programming.

> People traditionally think of programmers as being cut from the hacker pattern, brilliant but idiosyncratic loners who drink a six-pack of Jolt cola and turn out thousands of lines of code a night, or techies buried in the basement with listings, like accountants of old. Certainly these computing icons exist, but most software today is built by loosely organized groups of workers who have had little if any training in software teamwork. It is necessary to make a conscious paradigm shift from expert knowledge workers performing fairly independently to produce modular system components, to cross-functional teams of various system experts working together to produce a consensus system solution to a jointly defined user-problem set (115).

By their very nature, large software projects necessitate the collaboration of a team of software designers/developers. Intuitively, the level of success at all stages of the system life cycle is likely to be affected by the underlying group processes of the responsible team. Collaborative creation of systems requires an interaction environment which fosters the collective harvesting and coordination of each member's knowledge, skills, and expertise (Alavi 1993b). Succinctly stated, coordination technology is

"functionality that enables or supports the interactions of multiple agents in the execution of a planning or design task" (Henderson and Cooprider 1990). Software teams are more than a collection of individuals who have come together for the purpose of making a limited number of decisions. These teams consist of a group of individuals who will function together over an extended period of time throughout the course of the SDLC.

The paradigm shift to cross-functional teams in a SDLC environment as suggested by Zahniser (1993) necessitates the integration of CSCW tools designed to support the team's communication needs in both traditional and CASE environments. Historically, we have seen that the lack of integrated tools and methodologies invented specifically to support cross-functional team SDLC and communication tasks will adversely affect the productivity and efficiency of the team (Christakis 1987).

Computer-Supported Collaborative Work

Information technology can play a role in SDLC group communications in the form of electronic mail, audio conferencing, video conferencing, and/or a range of computer conferencing techniques known as groupware. Groupware, often referred to as electronic meeting systems (EMS), is defined as tools that provide support to groups of individuals working on a common task. EMS provide an interface into a shared decision-making environment (Collaborative Technologies 1991). These systems are designed to support communication, provide structure to the process, and serve as a repository for the contents of the group processes.

Several motivating factors are responsible for the development of groupware (Collaborative Technologies 1991). Evaluation reveals that these factors are

characteristic of information system environments as well as overall organizational structures. First, organizations are focusing on becoming more flexible and innovative. Adoption of self-managed teams as an alternative to the traditional hierarchy of the past is resulting. Second, organizations are faced with increasingly complex economic forces such as globalization, increased competition, the quality movement, and greater demand for consumer satisfaction. Third, the necessary supporting technology is in place. Computers have become smaller, more powerful, and less expensive. Powerful and accessible local area networks can provide the necessary connection between members. Consequently, groupware is designed to support the needs of organizations operating in this new and evolving environment.

Computer-supported collaborative work (CSCW), also referred to as computer-supported cooperative work, is a special type of groupware. The CSCW definition adopted by this study is as follows: CSCW tools provide an electronic support mechanism for multiple individuals to work collectively on a joint project.

One of the strengths of CSCW is that it facilitates the communication of a team of individuals, which is fundamental to the existence of a group. The exchange of information is crucial to the team performance (Johnson and Johnson 1991). Groups develop through five stages: forming, storming, norming, performing, and adjourning (Tuckman 1965; Tuckman and Jensen 1977). The team becomes productive during the performing stage as it works collectively to achieve the group's goals. Software manufacturers of groupware products contend that their systems have the capability to take a team directly to the performing stage (Collaborative Technologies 1991). CSCW

tools are designed to support teams in the simultaneous creation, modification, and maintenance of manuscripts, engineering designs, spreadsheet development, software engineering, and other team activities.

During the course of its life cycle, a system is likely to be nurtured by a group of software engineers working collaboratively on planning, analysis, design, development, and maintenance. In corollary, the larger the system, the more numerous the engineers and, consequently, the more cumbersome the coordination and communication processes become. Additionally, the more complex the system, the more critical effective coordination and communication are to resulting system quality. Unfortunately, as Dewan and Riedl (1993) point out, traditional software engineering environments are geared toward individual rather than collective support of these processes.

In contrast, CSCW systems provide process and task support in the form of group memory, anonymity, parallel communication, and collaboration tools. Furthermore, they provide structure to both the process and the task (Nunamaker et al. 1991).

Group memory consists of a repository for the group processes. It provides electronic logging and storage of all electronic session communications. This repository allows the group to remember and manipulate ideas. Anonymity is a system feature that allows each member to contribute to the process without being identified as the contributor. Parallel communication capabilities provide the mechanism through which each member can contribute to the process simultaneously, if so desired. Collaborative tools permit the members to work independently or collaboratively on a group task. If

the members are working synchronously, the section of code, commands, and/or documentation undergoing modification is visible to everyone.

CSCW technology, depending on the level and nature of the system, support group interactions that occur in four combinations of time and space dimensions: same-time-same-place, same-time-different-place, different-time-same-place, and different-time-different-place (Dennis et al. 1988). Of the four, same-time-same-place has the greatest amount of structure. Same-time-same-place, or synchronous group work, occurs in an electronic meeting room in which members meet to take advantage of the available technology. Different-time-different-place, on the opposite end of the scale, is the most flexible and, consequently, the most difficult to manage. This medium provides the opportunity and the flexibility for SDLC team members to work asynchronously on a joint project from geographically distributed locations or synchronously from their offices at a single site.

CSCW Group Process Support Features

Regardless of the environment, an effective software development environment must provide support for group interaction of all four time and space dimensions. In order to better understand the nature of necessary support features, it is important first to understand the underpinnings of effective software development group processes.

In order for a team of software engineers to function effectively, the following group dimensions must be present: (1) cohesion must be high; (2) participation and leadership must be distributed among the members; (3) clear and accurate communication of ideas and feelings between members must occur; (4) decision-making flexibility must

exist; (5) power and influence should be approximately equal among members and should be determined by expertise not authority; (6) constructive conflicts should be encouraged and handled productively; (7) members should be working towards a common, clearly understood, and agreed upon goal; (8) problem solving ability should be high; (9) the group must be capable of productive work and should be composed of creative, effective, and efficient members; and (10) groupthink, group myopia and other disruptive forces should be low. (Johnson and Johnson 1991; Bennis and Shepard 1956; Dunphy 1974; Mabry and Barnes 1980; Chidambaram, Bostrom and Wynne 1991).

Nunamaker et. al. (1991) refer to factors that strengthen group interaction, and thus the resulting product, as process gains and those that inhibit interactions as process losses. Groups have the potential to function more effectively than individuals for several reasons. (A detailed summary is provided in table 1.) First, groups can possess more information than any single member (Lamm and Trommsdorff 1973; Shaw 1981; Steiner

TABLE 1

REASONS FOR GROUP PROCESS GAINS

Common Process Gains	
More Information	A group as a whole has more information than any one member (Lamm and Trommsdorff 1973; Shaw 1981; Steiner 1972).
Synergy	A member uses information in a way that the original holder did not, because that member has different information or skills (Osborn 1957).
More Objective Evaluation	Groups are better at catching errors than are the individuals who proposed ideas (Hackman and Kaplan 1974; Hill 1982; Shaw 1981).
Stimulation	Working as part of a group may stimulate and encourage individuals to perform better (Lamm and Trommsdorff 1973; Shaw 1981).
Learning	Members may learn from and imitate more skilled members to improve performance (Hill 1982).
Broader Viewpoint	Because members have different views of the problem, they are able to achieve a better solution working together than they are separately (Dewan and Riedl 1993).

Adapted from Nunamaker, et. al., 1991

1972). Second, due to the diversity of knowledge and skills of the team members, groups are more synergistic (Osborn, 1957). Third, a group structure provides superior error-detection capabilities as team members identify flaws in each others' logic (Hackman and Kaplan 1974; Hill 1982; Shaw 1981). Fourth, working in a group may stimulate the thought process as members build on each others ideas (Lamm and Trommsdorff 1973; Shaw 1981; Alavi 1993). Fifth, less experienced members can learn from their more experienced counterparts to improve their performance (Hill 1982; Alavi 1993a). Furthermore, because of their different views of the problem, two or more programmers are likely to arrive at a better solution working together than separately (Dewan and Riedl 1993). A CSCW environment can foster each of these opportunities through communication support, which fosters exposure to the ideas and knowledge of other members.

Disruptive forces in the group process are numerous. (A detailed description of identified process losses may be found in table 2.) Here, too, the CSCW system can play a positive role by mitigating the negative factors that inhibit effective group interaction (Nunamaker et al. 1991). The capability to simultaneously generate ideas has the capability to more evenly distribute contributions among members while reducing domination of the process by a select few.

TABLE 2

CAUSES OF GROUP PROCESS LOSSES

Common Process Losses	
Air Time Fragmentation	Fear of negative evaluation causes members to withhold ideas and comments (Diehl and Stroebe 1987; Jablin and Seibold 1978; Lamm and Trommsdorff 1973).The group must partition available speaking time among members (Diehl and Stroebe 1987; Jablin and Seibold 1978; Lamm and Trommsdorff 1973).
Attenuation Blocking	This (and concentration blocking and attention blocking below) are subelements of "production blocking." Attenuation blocking occurs when members who are prevented from contributing comments as they occur, forget or suppress them later in the meeting, because they seem less original, relevant or important (Diehl and Stroebe 1987; Jablin and Seibold 1978; Lamm and Trommsdorff 1973).
Concentration Blocking	Fewer comments are made because members concentrate on remembering comments (rather than thinking of new ones) until they can contribute them (Diehl and Stroebe 1987; Jablin and Seibold 1978; Lamm and Trommsdorff 1973).
Attention Blocking	New comments are not generated because member must constantly listen to others speak and cannot pause to think (Diehl and Stroebe 1987; Jablin and Seibold 1978; Lamm and Trommsdorff 1973).
Failure to Remember	Members lack focus on communication, missing or forgetting the contributions of others (Diehl and Stroebe 1987; Jablin and Seibold 1978).
Conformance Pressure	Members are reluctant to criticize the comments of others due to politeness or fear of reprisals (Hackman and Kaplan 1974; Shaw 1981).
Evaluation Apprehension	Fear of negative evaluation causes members to withhold ideas and comments (Diehl and Stroebe 1987; Jablin and Seibold 1978; Lamm and Trommsdorff 1973).
Free Riding	Members rely on others to accomplish goals, due to cognitive loafing, the need to compete for air time, or because they perceive their input to be unneeded (Albanese and Van Fleet 1985; Diehl and Stroebe 1987).
Cognitive Inertia	Discussion moves along one train of thought without deviating, because group members refrain from contributing comment that are not directly related to the current discussion (Jablin and Seibold 1978; Lamm and Trommsdorff 1973).
Socializing	Nontask discussion reduces task performance, although some socializing is usually necessary for effective functioning (Shaw 1981).
Domination	Some group member(s) exercise undue influence or monopolize the group's time in an unproductive manner (Jablin and Seibold 1978).
Information Overload	Information is presented faster than it can be processed (Hiltz and Turoff 1985).
Coordination Problems	Difficulty integrating members' contributions because the group does not have an appropriate strategy, which can lead to dysfunctional cycling or incomplete discussions resulting in premature decisions (Hackman and Kaplan 1974; Hirokawa and Pace 1983).
Incomplete Use of Information	Incomplete access to and use of information necessary for successful task completion (Hirokawa and Pace 1983; Mintzberg, Raisinghani and Theoret 1976).
Incomplete Task Analysis	Incomplete analysis and understanding of task resulting in superficial discussions (Hirokawa and Pace 1983).

Adapted from Nunamaker et. al. 1991

Since the 1970s, shared group memory has been recognized as a mechanism that changes group dynamics (Doyle and Straus 1976). Group memory coupled with simultaneous idea support reduces factors which prevent members from contributing ideas as they occur because they (1) must wait to speak, thereby forgetting or discounting their ideas; (2) must concentrate on remembering ideas, while waiting a turn, rather than thinking of new ones; (3) must concentrate on what others are saying rather than thinking of new ideas; and (4) have difficulty remembering what contributions have been made. The team members can, instead, contribute ideas and review all previous comments at any time during the session, thereby significantly reducing the information overload normally experienced.

Because the entire process is recorded, the group and/or designated facilitator(s) can assimilate the thoughts into cohesive chunks for rating and further evaluation. The structure imposed on the process in the reiterative form of brainstorming, idea consolidation, rating, and voting has the potential to improve coordination, use of information, and task analysis.

Anonymity, on the other hand, reduces conformance pressure and evaluation apprehension. Research indicates that members who are not afraid to be identified and, therefore, criticized for their thoughts, are more likely to contribute freely to the process (Nunamaker et al. 1991). In the software engineering environment, anonymity is most likely to be beneficial during the brainstorming process of the planning, analysis, and design stages of the SDLC because successful sharing of rich and numerous high quality ideas affects the resulting product. The benefits are likely to be more pronounced in

teams with major variations in personality dominance and/or perceived member authority. For example, in a group where one or more members are relatively new, the potential exists for development of a pecking order in which long-standing members may intentionally or unintentionally inhibit the contributions of newer members.

Collaborative SDLC Support

The three major advantages of using a collaborative support system in the context of system development include (1) avoidance of direct confrontation of participants, (2) increased creativity in the development process, and (3) increased productivity of project meetings (Chen 1988). In large projects, collaborative support may be the only feasible mechanism available for full participation by project members. Furthermore, the likelihood of information system failure increases with dialogue complexity and poor communication among users (Chen, Nunamaker, and Konsynski 1987).

The SDLC can be divided into five basic and distinct phases: planning, analysis, design, implementation, and maintenance. Planning encompasses determining system and software requirements, generating alternatives, and identifying constraints. Analysis includes evaluating the alternatives, identifying risks, and selecting the most appropriate direction for design. Design consists of creating the detailed framework from which the resulting system will be constructed. Implementation entails coding, testing of all types, and installation.

However, to believe that a system can be developed in a linear form is unrealistic. Software systems are dynamic, evolutionary entities comprised of components that are unlikely always to be at the same stage of development. Rather, each component or

module could be said to have its own life cycle. Furthermore, at any stage of development, the software engineers may recognize the need for redirection in one or more subcomponents of the system. The ability to deal flexibly and efficiently with changes is quite likely to enhance the resulting product.

When the need for change is recognized, modifications should cycle through the same five phases as the system. The engineers should plan, analyze, design, and implement each change as carefully as they developed the initial model to mitigate adverse chain reactions in the rest of the system. Optimally, a collaborative development system should provide the iterative support necessary to the SDLC.

The early SDLC phases of planning, analysis, and design require extensive collaborative communication support to determine the optimum system design and/or best incorporation of a change to the system design. The requirements definition and front-end planning in these stages have become the objects of increased emphasis for three reasons. First, errors in the early stages of system development are more costly. Second, fourth-generation languages and code-generators have made the implementation of systems easier (Chen and Nunamaker 1991). Third, hardware costs have continued to diminish while developer costs have continued to rise. Collaborative support for these processes includes idea generation tools, group memory repositories, and idea consolidation tools (Chen and Nunamaker 1991).

CASE and CSCW have several characteristics in common that provide a starting point for integration: automated support, information repository, use of graphics, and language components (Chen and Nunamaker 1991). CSCW systems provide automated

support for group processes, while CASE tools provide automated support for information systems development processes. CSCW systems maintain group memory of the process, while CASE tools maintain a data dictionary. Most CSCW and CASE tools have the capability for graphical representation of data. CASE tools capture structured information into a data dictionary, while CSCW systems, to date, do not provide an equivalent structure for group memory. However, a CSCW or GDSS tool can be used as a front-end to extract information from users and developers, which can then be used to populate a CASE data dictionary (Chen 1988).

A self-assessment by the software engineering community reveals that CASE tools have the potential to enhance team processes through coordination technology, project-wide consistency checking, and shared design data (Forte and Norman 1991). According to Forte and Norman (1991), CASE vendors must focus on generalized problem-solving skills, software-specific formal and informal methods, requirements elicitation, architectural design principles, team coordination and management, process engineering, and quality management techniques. They recognize that a major dimension of today's software challenge lies in gearing up for large-scale system development by groups comprised of numerous software engineers. Forte and Norman (1991) also state that, in order to significantly improve coordination and reduce overhead costs attributable to interpersonal communication, the software community needs better specification languages, greater understanding of group processes, and advanced groupware. Furthermore, improved coordination will require fast, reliable multimedia communication over heterogeneous networks and broadcast messaging.

Collaborative support can also be beneficial upon reaching the development, implementation, and maintenance stages of the SDLC. Development and maintenance may require an engineer in a traditional setting to download the affected module into his or her individual workspace before performing any necessary modifications. The lack of collaborative support in a traditional environment results in several critical and inherent problems. In a worst-case scenario, nothing prevents two engineers from making conflicting changes in their individual workspace that result in the first set of changes being overwritten by the second. On a less disastrous scale, although still problematic, the system may make use of a merge process that requires human intervention to resolve conflicting changes prior to the merge (Dewan and Riedl 1993). Logistics problems with non-concurrent system support occur as engineers are forced to divide their tasks at version creation time, thereby forcing a schedule of activities that must occur in sequential order; i.e., one engineer's task must be completed before another engineer can proceed (Dewan and Riedl 1993). However, for manageability purposes, these benefits fall outside the scope of this study.

CHAPTER 2

REVIEW OF THE LITERATURE

Although a wealth of literature on GDSS meeting support exists, published studies on electronic collaborative support in a CASE environment are few in number. Additionally, the vast majority of published GDSS and CSCW articles are thought pieces. This section summarizes the results of prior studies on the effects and shortcomings of computer-supported communication on tasks and processes relevant to the proposed research.

Anonymity

Connolly, Jessup, and Valacich (1990) found in a laboratory experiment that groups working anonymously produced the greatest number of high-quality ideas. Perhaps the best expression of the effects of anonymity is contained in the following quote by a Hughes Aircraft manager:

> "I noticed that if someone criticized an idea of mine, I didn't get emotional about it. I guess when you are face-to-face and everyone hears the boss say 'You are wrong' it's a slap to you, not necessarily the idea.... [Here] no one knows whose idea it is, so why be insulted? No one is picking on me. I think I'll just see why they don't agree with me." (Nunamaker et. al. 1991)

However, the benefits of anonymity appear to become mute in better developed teams. Research indicates that groups who have a history of working together can attribute ideas to their contributing member despite the lack of system identification (Alavi 1993a).

The benefits of anonymity may also be negated in same-time-same-place environments. Jarvenpaa, Rao, and Huber (1988) observed that, as discussions held in a synchronous meeting room environment became heated, participants were likely to forget to use the communication media in favor of talking simultaneously, thereby experiencing the same difficulties as those in conventional meetings.

The research, although not conducted in a CASE or even a SDLC environment, suggests that the incorporation of a tool with anonymity options may be beneficial for a team of developers. The potential also exists that the team members may know each other well enough that anonymity may be superfluous, as suggested by Alavi (1993a).

Idea Generation

Other research projects have simply examined the quantity of ideas generated. These studies indicate that electronic support for idea generation is beneficial. In brainstorming tasks, research has found that electronically supported groups generate more ideas than their verbal counterparts, particularly in larger groups (Fellers 1989; Gallupe, Bastianutti, and Cooper 1991; Gallupe et al. 1992; Petrovic and Krickl 1994). In comparisons between electronically supported groups and nominal (non-communicative) groups of more than six members, researchers have found that electronic brainstorming groups, once again, produce more ideas than the control groups (Valacich, Dennis, and Connolly 1994; Dennis and Valacich 1993). Idea generation is an integral part of the early SDLC phases of planning, analysis, and design.

Group Memory

The results of the idea generation process in addition to design and project status information are maintained in group memory. Early research on the effects of group memory in a SDLC environment are quite promising. Group memory has been credited as a key to the phenomenal success of the Digital Equipment Corporation's Alpha AXP project, which coordinated thirty-two teams comprised of more than 2000 individuals geographically located in ten countries and delivered the final product on schedule (Conklin 1992).

A separate empirical study on the effects of an idea consolidation tool produced equally exciting results. Idea consolidation tools provide developers with the capability to assimilate thoughts by manipulating data in group memory. Aiken and Carlisle (1992) performed eight case comparisons between manual and electronic idea consolidation processes. The results of their study show that recall tasks using the idea consolidation tool took an average of 1.12 minutes, with 100% recall and 100% accuracy, in comparison to 42.5 minutes, with 82.6% recall and 73.1% accuracy for the manual process. On average, the time savings using the idea consolidation tool was 97.6%, with a high of 99.2% and a low of 95.9%.

Productivity and Quality

Working under the proper CSCW conditions has proven to be highly effective in shortening the SDLC. According to Zahniser (1993), research indicates that a superior product can be developed in six weeks in a collaborative environment as opposed to six

months. Zahniser credits this occurrence to empowered, cross-functional teams using a CSCW system that supports non-linear iterations of design and development.

Zahniser's (1993) findings are consistent with Pinsonneault and Kraemer's (1989) review and assessment of empirical research on the effects of EMS, which indicates that the utilization of an EMS improves task performance quality while decreasing task performance time. In a more recent study, Petrovic and Krickl's (1994) research results indicate that computer-supported groups generate significantly more "good" contributions than traditionally moderated groups. In the software development arena, research has corroborated significant increases in software design quality resulting from electronic collaborative tools (Ellis, Rein, and Jarvenpaa 1989-90; Olson et al. 1992).

Liou and Chen (1993-94) conducted an experiment to examine the relevance of group support systems (GSS), joint application development (JAD), and CASE in the facilitation of the requirements specification process. An expert system shell was used as a surrogate for a CASE product. Subjects compared electronic brainstorming GSS capabilities to idea organization capabilities. No significant differences in productivity were found between the tools. However, the subjects expressed satisfaction with the GSS tools. Multiple subjects expressed the opinion that the requirements elicitation would have taken at least five times as much effort without the GSS tools.

As suggested by Zahniser (1993), the key to ultimate performance, however, may be to combine CSCW with Total Quality Management (TQM). During a five-year period between 1982 and 1987, using TQM techniques alone, a 1000-person development division of NEC was able to reduce first-year post-shipment software defects from 45 to

0.5 defects per million lines of executable code. Their market share jumped from 20% to 60%. Sales increased by 500% and profits by 400% in the same period (NEC IC Micron 1987).

Effects of Environment and Tool Selection

Research comparing alternative electronic support mechanisms indicates that different tools may be appropriate for different stages of the SDLC (Ellis, Rein, and Jarvenpaa 1989-90). Their results indicated that an electronic blackboard may be more appropriate for early stages, while electronic workstations may be better suited toward later stages of development.

Additional research indicates that group members may prefer to work face-to-face while planning and coordinating their work. Studies show that team members collaborating in a distributed environment experienced a substantially higher level of difficulty in coordinating their work (Smith and Vanecek 1990; Galegher and Kraut 1992).

By observing established groups in an EMS setting, Alavi (1993a) discovered that a substantial amount of verbal and electronic communication existed. Her observations, coupled with user comments, indicated that the electronic communication enhanced rather than replaced verbal communication. She also discovered that the characteristics of the groups affected the EMS process and dynamics. Team members knew each other so well they were able to attribute comments to their counterparts despite the anonymity enforced by the system.

Collaborative CASE

Chen (1991) classified all CASE tools and development methodologies into four primary categories: document recorder, analyzer, intelligent guide, and tutor. Document recorders include HIPO charts, data flow diagrams, and structure charts. Analyzers perform completeness and consistency checking and notify the developer of any missing or inaccurate information. Intelligent guides lead developers through the development process through the use of expertise that has been captured in a knowledge base. Tutors teach the concepts of SDLC methodologies to system developers.

Of all the tools in these classifications, few contain built-in facilities to support group communication. A study of four commercially available PC and Macintosh-based CASE tools found that the only cooperation feature contained by any of the CASE tools was an e-mail capability built into one of the four products (Vessey and Sravanapudi 1995). In contrast to available capabilities, Henderson and Cooprider (1990) discovered, in open-ended interviews with leading CASE designers, that cooperative functionality is deemed quite important. Their research identified nine features that CASE experts believe should be incorporated to support team coordination. Ninety-one percent of those interviewed said that the product should provide the capability to maintain a dialogue with other team members and allow a group to work simultaneously on a single task. Eighty-eight percent said that e-mail capabilities are important. Eighty-five percent indicated that group interaction support, such as brainstorming and concurrent use of the data dictionary and diagraming tools, are significant features. Sixty-two percent perceived the ability to attach electronic notes to objects as desirable, and 53%

recognized the importance of provision for anonymous communication and notification to engineers when a design change affects their work. Fifty percent suggested the capability to build a catalog of macros accessible by multiple team members would be valuable. The results of Henderson and Cooprider's study underscore the necessity of merging the CASE and CSCW environment.

Groupware Failure

As with any technology that is full of promise and embraced as a panacea, groupware is not always successful. A case study done by Grudin (1993) revealed five factors that contribute to the failure of groupware developments. The first of these is termed equity. This concept states that the individuals who benefit the most from groupware are those who have not had to do additional work. The second is social structures. Grudin noted that groupware may lead to activity that threatens or damages existing social structures. The third factor is flexibility. If the groupware tool does not allow for the handling of exceptions that occur within a group environment, the tool may fail. The fourth contributing factor is evaluation issues. Groupware installations are complex at best and as such are frequently difficult to evaluate for successfulness. The final factor Grudin referred to as intuition. This concept states that developments designed to support individual users may be poor designs for supporting group applications.

Team Room

In recognition of the five contributors to groupware failure, Lotus Corporation is developing a Notes application called Team Room. The design of Team Room reflects

four core principles. First, a balance of technical and social analyses of team requirements must be present. Second, the environment must be flexible. Third, the environment must provide a framework that will support the conversion of goals into action. Fourth, information must be readily linkable to the goal it supports as well as to other information (Goodall 1996).

Research conducted by Goodall (1996) on the success of Team Room revealed four key lessons. First, technology is no substitute for the team. Given to a dysfunctional team, Team Room did not have a positive impact on team effectiveness. Rather, it wasted scarce support resources and may have adversely affected team attitudes toward future technological tools. Second, Team Room is valuable only if it is used. Third, using Team Room or Notes without adequate planning is detrimental to the attitudes and patterns of use (Goodall 1996; Orlikowski 1996). Fourth, Team Room is most effective when realistic objectives are set.

Information System Failure and Abandonment

Other factors that have been demonstrated to adversely affect system acceptance include personality and background of the users, the corporate culture and organizational politics and senior management support (Turner 1982; Lin and Hsieh 1990). Lin and Hsieh's findings are consistent with Ewusi-Mensah and Przasnyski's (1991) study on project abandonment. Ewusi-Mensah and Przasnyski discovered that technological inadequacies and behavioral, political, or organizational issues were major contributors to abandonment, with the latter playing the most dominant role. Organizational contributors to system failure are not new. Lucas (1975) reported adverse effects from lack of user

involvement, and Markus (1983) conducted an early study which indicated that user resistance was also a key factor in system failure. However, Janson, Woo, and Smith (1993) discovered that good communication and management support can deal successfully with design uncertainty and user resistance.

In a review and critique of studies, Hirschheim and Newman (1988) categorized studies that indicated that contributing factors to user resistance included conservatism, lack of perceived need, lack of involvement in change, redistribution of resources, lack of management support, poor technical quality, and the personal characteristics of the designer. They further demonstrated that multiple causes could simultaneously be present. In keeping with this finding, a study by Davis et al. (1992) indicates that information system failure is best explored by examining the combination of both the technical system and the sociological environment.

Summary

Groupware exhibits promise through features of anonymity, simultaneous idea generation, and group memory. CSCW tools have been effective in shortening the SDLC. Additional research indicates that CASE developers desire improved communication support possible through the use of a CSCW tool. However, unless the tool is used properly, the technology's capabilities may be insufficient to provide benefit and may even result in impairment of a team's performance. Furthermore, flaws in the system or the organizational culture can contribute to the ultimate failure of the tool.

CHAPTER 3

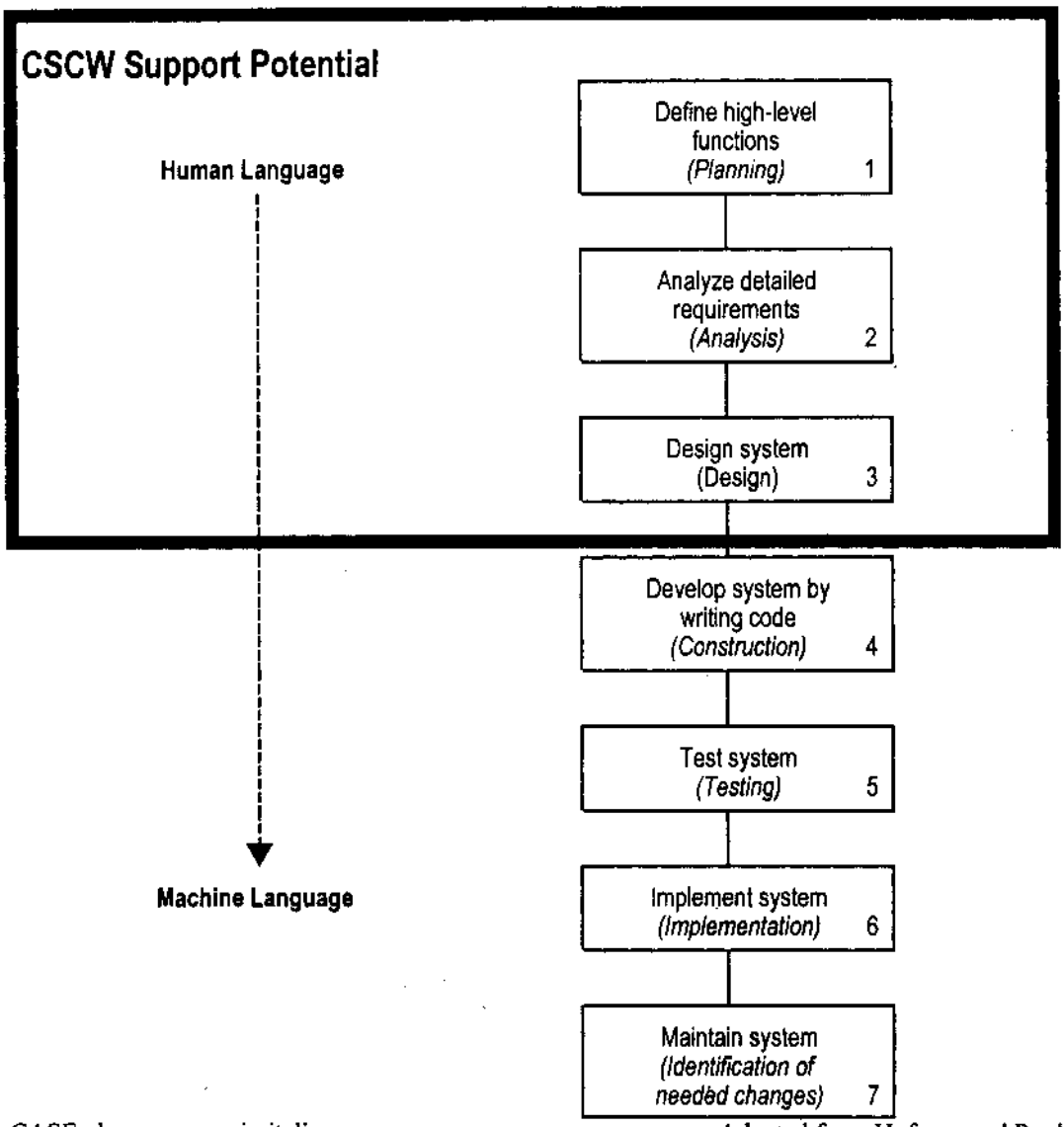
THEORETICAL FRAMEWORK

The premise of this study is that electronic communication support has the potential to affect the CASE environment. In keeping with this concept, three models provide the foundation for the framework in this study. They include a systems development model presented by Hofman and Rockart (1994), a framework for analyzing computer-supported group tasks introduced by Pinsonneault and Kraemer (1989), and a model of variables to study technological support of meetings tendered by Petrovic and Krickl (1994).

Systems Development Model

An adapted version of Hofman and Rockart's (1994) systems development model found in figure 1 depicts the seven major components of the SDLC in conjunction with the primary man/machine language component. The seven SDLC stages presented in non-italicized form are the original descriptions provided by Hofman and Rockart. The italicized term found directly underneath each description has been added to provide terminology consistent with that used by CASE developers. These stages, from earliest to latest in the cycle, are as follows: planning, analysis, design, construction, testing, implementation, and identification of needed change. As the left column indicates, in the earliest stages, the human language or communication between developers is more

prevalent than in later stages when the system is being coded, tested, implemented, and maintained. This is not to say that human communication is excluded in



CASE phases appear in italics

Adapted from Hofman and Rockart 1994

Fig. 1. Systems development model

the latter stages, only that the latter stages undergo a shift in emphasis to machine language.

The primary focus of this research was to determine the relationship between the human language component and the ensuing results. For this reason, although collaborative support may be utilized for such activities as monitoring and code inspection, the scope of this research focused primarily on the planning, analysis, and design phases, as indicated by the dark box superimposed over the systems development model in figure 1.

Computer-supported Group Task Framework

Pinsonneault and Kraemer (1989) presented a computer-supported group task framework (fig. 2), which is one of the most comprehensive published GDSS frameworks available. This framework indicates that the contextual variables of people, situation, group structure, technological support, and task characteristics involved in a project affect the group process which, in turn, affects both task-related and group-related outcomes. The framework further indicates that task-related outcomes affect group attitudes.

The technological support identified in the framework is a GDSS or Group Communication Support System (GCSS). GCSS has been referred to in literature as Computer-Supported Cooperative Work (CSCW) (Dennis et al. 1988), the categorization used in this study. The distinction between the two is that a GDSS is traditionally task oriented, while a GCSS is communication oriented. This differentiation has begun to blur significantly in the last few years. However, for simplification purposes, a GDSS will be considered to possess both task and communication enhancement capabilities.

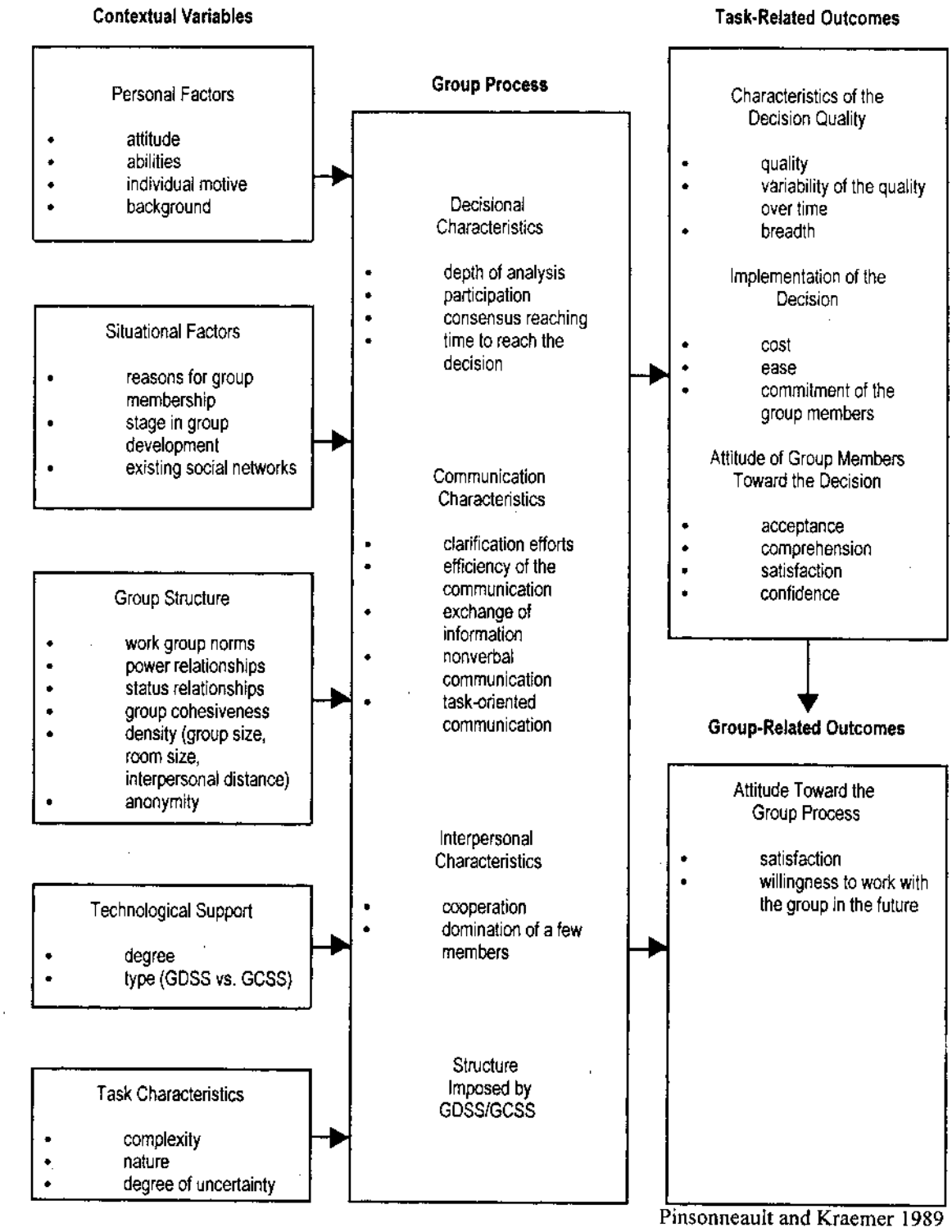


Fig. 2. Framework for analyzing the impacts of GDSS support

A major contribution of this model is the decomposition of group processes into decisional characteristics, communication characteristics, interpersonal characteristics, and structure imposed by the technology. However, an additional group process variable should be added. This variable is EMS utilization. Accessibility to the technology does not necessarily mean that the group will use it or that they will use it properly.

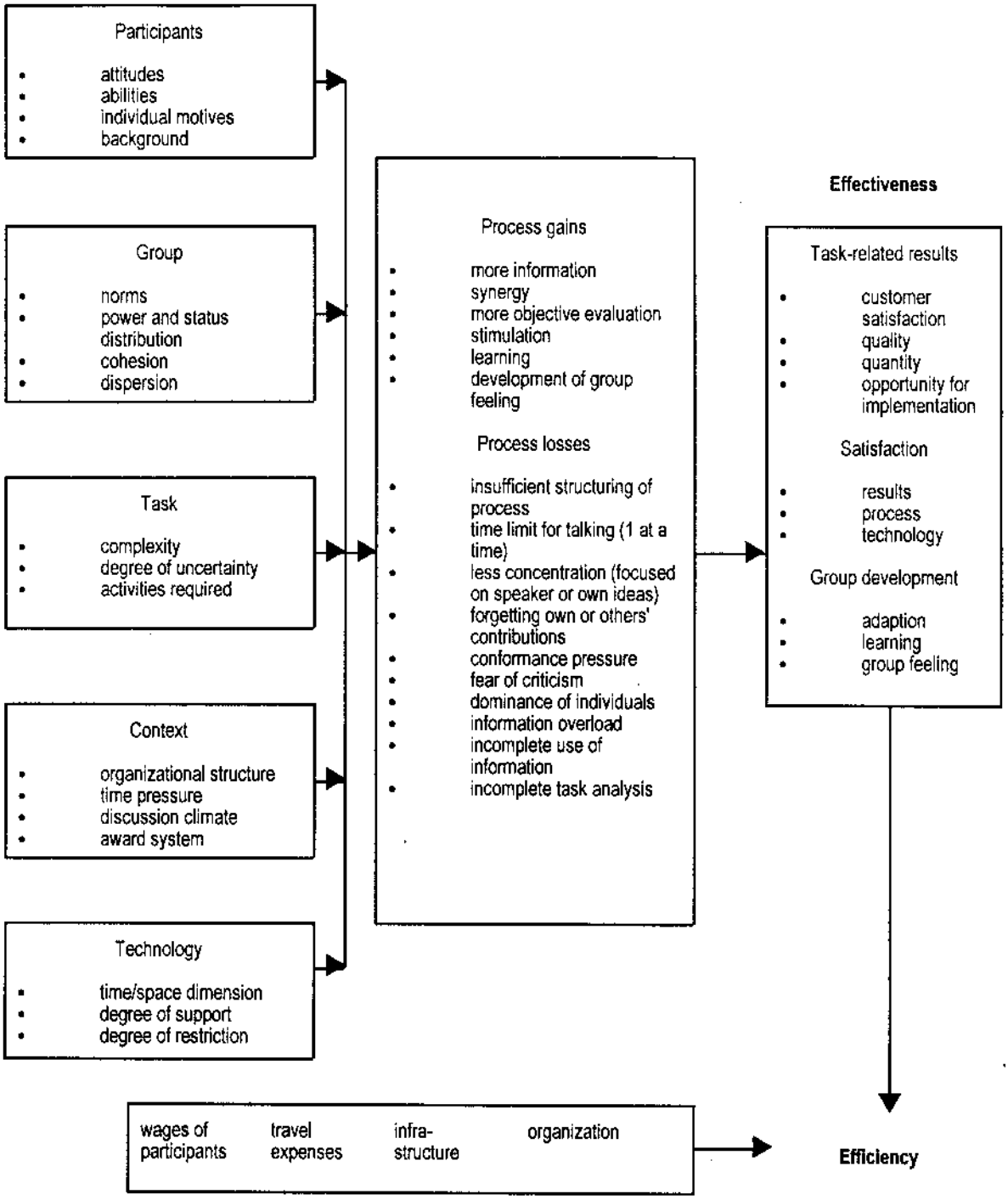
A further contribution of this model is the subdivision of outcomes into task-related and group-related. Task-related outcomes are those that are experienced as a result of the decision-making process, while group-related outcomes are those experienced as a result of the member interaction during the meeting.

In order to make this model more complete, a second category that should be included under group-related outcomes is attitude toward the CSCW tool. While the opinion of the group members regarding the usefulness of the tool may affect their overall satisfaction, they may have a favorable satisfaction rating of the group process and a negative rating of the tool or vice versa.

Another shortcoming of the model is its failure to indicate the importance of the feedback loop. Feedback from the outcomes, both task-related and group-related, is likely to affect future group processes, in addition to the contextual variables of personal factors, situational factors, and group structure.

Technological Meeting Support Framework

Petrovic and Krickl (1994) presented an adapted framework (fig. 3) to study technological support of meetings in terms of efficiency and effectiveness. They replaced



Petrovic and Krickl 1994

Fig. 3. Model of variables to study technological support of meetings

Pinsonneault and Kraemer's (1989) situation factors with context elements of organizational structure, time pressure, discussion climate, and award system. They

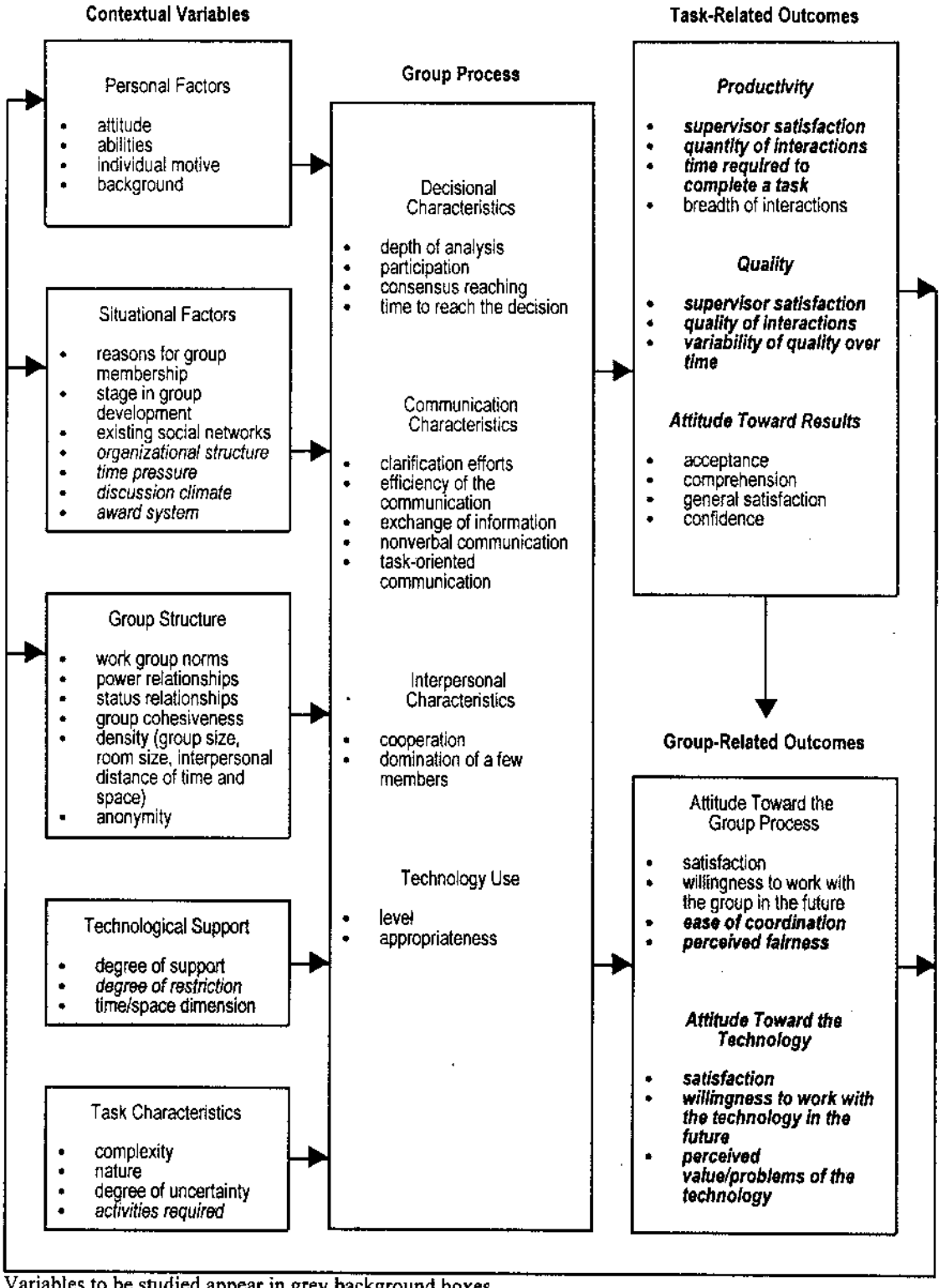
incorporated the process gains and losses of Nunamaker et al. (1991) and devised efficiency measures while eliminating the group process decision, communication, and interpersonal characteristics identified by Pinsonneault and Kraemer. The structure imposed by the GDSS was moved to the technology variable. Petrovic and Krickl further recognized the need for and added a satisfaction variable relating to the technology.

Petrovic and Krickl's (1994) premise is that participants, group, task, context, and technology impact group process gains and losses, which impacts the effectiveness of the group. The group's effectiveness, coupled with wages, travel expenses, infrastructure, and organization, impacts the group's efficiency. This model, like Pinsonneault and Kraemer (1989), fails to incorporate a feedback loop.

Research Framework

The framework in figure 4 is designed to address the limitations outlined above as well as drawing from the best of both models. The model presented in figure 4 is the framework that was used for purposes of this research. The contextual variables in this model are personal factors, situational factors, group structure, technological support, and task characteristics. The contextual variable directly related to this study was technological support, which is highlighted in grey for ease of detection. The structure of this variable was taken from Petrovic and Krickl's (1994) model in figure 3.

The research framework shows the group processes to be affected by task, communication, interpersonal, and technological characteristics. Outcome variables are divided into two classifications: task-related and process-related outcomes. These two



Variables to be studied appear in grey background boxes.
Adapted from Dennis et al. 1988; Pinsonneault and Kraemer 1989; Applegate 1991; Petrovic and Krickl 1994

Fig. 4. Framework for analyzing impacts of GDSS support in a CASE environment

outcome classifications were the focus of this research and are highlighted in grey accordingly. Components shown in bold italics are unique to this framework, while variables in non-bold italics were drawn from Petrovic and Krickl's (1994) model. All other variables were taken from Pinsonneault and Kraemer's (1989) framework.

The task-related outcomes are broken into three major categories: productivity, quality, and attitude toward results. Productivity and quality are defined by this study as the ability to produce a superior product in a shorter period of time. These definitions were adopted in keeping with the demands of downsizing which, as dictated by the current environment, is requiring organizations to produce more, in less time, with fewer participants, without sacrificing quality (Brown 1996).

Previous CSCW and GDSS research has shown that productivity increases through the incorporation of the technological communication support (Zahniser 1993; Pinsonneault and Kraemer 1989). Neither Pinsonneault and Kraemer's 1989 nor Petrovic and Krickl's 1994 frameworks specifically addressed productivity. Petrovic and Krickl incorporate quantity as a task-related result. In brainstorming tasks, studies equate the quantity of ideas generated with productivity (Dennis and Valacich 1993; Petrovic and Krickl 1994). Accordingly, this study considers quantity to be a productivity-related result and includes it in the framework as such. In keeping with Zahniser's (1993) indication that productivity can be measured by the time required to complete a task, this measurement is also included. Unique to this study are supervisor perceptions and breadth of interactions. The rationale behind supervisor perceptions is that supervisors are charged with monitoring team progress. The supervisors can therefore provide an

additional perspective or measurement of the team's productivity. Breadth of interactions has been included to determine the team's focus on the task. This variable is included to capture the different types of communication tasks performed by the team.

Quality outcomes may be evaluated by and are reflected in supervisor satisfaction, quality of communication interactions, and the variability of quality over time. Of these, quality of interactions and supervisor satisfaction are unique to this study.

Attitude outcomes include acceptance and comprehension of, general satisfaction with, and confidence in the results. Each of these measures is drawn from Pinsonneault and Kraemer's (1989) framework.

Group-related outcomes are broken into two categories: attitude toward the group process and attitude toward the technology. New to this framework are the concepts of ease of coordination and perceived fairness within the confines of the group process. The attitude toward the technology category is also unique to the research framework. The first two premises of satisfaction and willingness to work with the technology in the future are drawn from the group process attitudinal concept. Satisfaction and willingness to work with the group do not necessarily translate into satisfaction and willingness to work with the tool or vice versa -- hence, the distinction between group process and technology. A third factor included under attitude toward the technology is perceived value and problems of the technology. Regardless of the group's satisfaction level and desire to continue to work with a given technology, perceived values and problems may still have an effect.

The framework indicates that technological support will ultimately affect the outcomes of the group process which, in turn affects both task- and group-related outcomes. A feedback loop has been added to the framework, which indicates that outcomes of both types will impact personal, situational, and group frames of reference, the influence of which will be recirculated through the process.

In summary, productivity and quality are critical to the ability of an ongoing concern to contend in the highly competitive environment in which all organizations must now operate. The independent observational variables introduced in this study are the degree and nature of CSCW support in a CASE environment. The dependent observational variables are quality, productivity, and satisfaction with results, process, and technology. Specifically, the study focused on productivity, quality, and tool satisfaction after the introduction of CSCW technological support. Variables targeted by this study appear in grey in figure 4.

Research Questions

The primary research questions examined are as follows:

1. Is there a relationship between CSCW tools in a CASE environment and quality, productivity, and team perceptions of task results?
2. How is the technology perceived by participants and supervisors to affect group processes and technological support?
3. Is CSCW used as a communication-extension to CASE a viable and beneficial alternative to traditional modes of operation?

Constructs

The study focuses on three principle constructs: productivity, quality and satisfaction, as illustrated in table 3. Hypotheses associated with productivity are

perceptions of productivity levels by both participants and supervisors, quantity of interactions, time required to arrive at decisions, and the breadth or nature of communication interactions. Quality issues include supervisor and participant perceptions of resulting system quality, quality of interactions as determined by an expert panel, and variability of quality over time. The productivity and quality constructs are associated with research question 1, as is general satisfaction with task results. General satisfaction with attitudes toward the group process and the technology are associated with research question 2. Within the confines of the three primary constructs, research question 3 examines the viability and usefulness of the CSCW tool in a CASE environment.

Through the a priori specification process these constructs were identified as the result of an extensive literature review, and they provided the groundwork for the emerging theory development as recommended by Eisenhardt (1989). These constructs were then explicitly measured in the questionnaires, interviews, and Notes database logs.

Hypotheses

Eisenhardt (1989) prescribes the shaping of hypotheses as a way to fine-tune construct definition, establish validity, and increase measurability. Hence, conveyance of potential outcomes is presented in the form of substantive hypotheses.

TABLE 3

TABLE OF CONSTRUCTS

Construct	Definition	Variables	Associated Hypotheses	
Quality	Degree of excellence of the software product resulting from the team effort.	Supervisor perceptions of quality Participant perceptions of quality Quality of task results Variability of quality over time	H_{11}	The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher quality in resulting software products.
			H_{31}	The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication.
Productivity	Degree of proficiency in creating a software product whether a system, subsystem, or component.	Supervisor perceptions of productivity Participant perceptions of productivity Quantity of interactions Time required for task completion Breadth of interactions	H_{12}	The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher productivity.
			H_{31}	The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication.
Satisfaction	Team perceptions of task results, group process, and technological support for the group development effort.	Reported satisfaction with results Reported satisfaction with group process Reported satisfaction with technology	H_{13}	The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with task results.
			H_{21}	The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the group process.
			H_{22}	The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the technological support.
			H_{31}	The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication.

Three hypotheses emanate from the first research question. The first of these is as follows:

H_{11} The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher quality in resulting software products.

For purposes of this study, quality is defined as the degree of excellence of the resulting software product. Quality is important in a highly competitive global environment. It provides one mechanism for product differentiation. As such, the presence, or lack thereof, ultimately reflects on the company that produced the product. Innovative and competitive organizations seek to produce high-quality products in the most productive and cost-effective manner possible. For this reason, research findings regarding the relationship between incorporation of a CSCW tool and resulting quality provide valuable information.

The second hypothesis, like the first, stems from research question 1 and is as follows:

H_{12} The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher productivity.

Productivity is defined as the proficiency in creating a software product, whether a system, subsystem, or component. In an environment where downsizing is the norm rather than the exception, the ability to enhance productivity has become a necessity. No longer can organizations afford simply to allocate additional resources to projects to ensure their timely completion. Instead, businesses are under increasing competitive

pressure to do more with less. Research findings relating to the relationship between a CSCW tool and productivity are therefore valuable.

These first two hypotheses are geared toward evaluating evidence indicating that group communication support is associated with perceived improvements in resulting software development quality and productivity. The assumption is that Christakis (1987) is accurate when he states that "interdisciplinary teams cannot work productively and efficiently in designing complex systems unless their work is supported and argued by methodologies that have been invented specifically for the task" (53).

The third hypothesis is as follows:

H_{13} The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with task results.

Team satisfaction with task results, as defined for use in this issue, is an overall satisfaction rating closely related to productivity and quality. This issue is deemed important because the development team is the closest to the project and, therefore, is uniquely qualified to determine the value of the tools available and their relationship to the resulting product.

The second research question creates two hypotheses. The first of these is as follows:

H_{21} The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the group process.

Satisfaction with the group process is considered to be important because individuals who are satisfied with the group environment are encouraged to perform better than those who are dissatisfied with the group process (Lamm and Trommsdorff 1973; Shaw 1981).

Better performance, in turn, has the potential to lead to higher quality and/or improved productivity.

The second hypothesis for this research question is as follows:

H_{22} The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the technological support.

Evaluation of the team members' satisfaction with the CSCW tool is important for study in keeping with Christakis's (1987) argument that productive and efficient design of complex systems requires support of tools and methodologies devised specifically for the task. CASE tools are lacking in group communication support. The potential value of this issue rests in the possibility of identifying whether or not a specific CSCW tool introduced into a CASE environment can enhance the toolset provided for the task.

Satisfaction with task results differs from the previous two issues of quality and productivity. Task result satisfaction is affected by perceived quality and productivity and, as such, provides an overall satisfaction rating. The group process satisfaction rating also evaluates the overall satisfaction with the group communication process rather than a specific evaluation of group dynamics.

The third research question is the genesis of one observational issue. This issue is as follows:

H_{31} The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication.

This observational issue is a collective evaluation and is perhaps the most important of the four. The assumption is that, if the benefits of electronic group communication

support do not differ from those of traditional modes of communication -- i.e., meetings, telephone, e-mail, memos, and so on then no benefit to pursuing the incorporation of group communication support into a CASE environment exists. Such a discovery would negate any value of incurring the expense and effort associated with the endeavor to incorporate a CSCW tool into the CASE environment.

CHAPTER 4

METHODOLOGY

This chapter describes the research methodology used to conduct an investigation into the application of Computer-Supported Cooperative Work (CSCW) in a Computer-Assisted Software Engineering (CASE) environment. The research design was a field-based single-site case study. The following sections discuss the setting, subjects, and population; the technological tools studied; and the project (task) description. Instrumentation, data collection techniques, and data analysis methods are also explained.

Research Design

The methodology for this study was a field-based case study design at a single-site using data from multiple sources collected over a ten-month period. Yin (1994) defines a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident"(13). Case research is most beneficial in looking for the details of interaction within the environmental context (Stake 1995). Case research methodology is appropriate when the topic of study needs to be defined broadly, when the study needs to be conducted in context, and when the research needs to rely on multiple rather than singular sources of evidence (Yin 1994).

The justifications for performing qualitative research applicable to this study are as follows: (1) qualitative methods identify and describe complex issues, (2) they identify unanticipated outcomes of an intervention, (3) they help reveal inconsistencies and problems, and (4) they help find "natural" solutions to problems. This research focused on the identification of issues, effects, and potential solutions rather than the statistical significance of specific dependent variables.

The research design of this study adhered to Eisenhardt's (1989) recommended process for building theory from case study research illustrated in table 4. Steps and activities presented in italics indicate the components not addressed by the current study and, as such, are appropriate for future research.

Eisenhardt (1989) identifies two primary strengths applicable to the theory building in this study. First, the emergent theory constructs are likely to be measurable because of the construct measurement that occurred during the theory-building process in the early phases of research design. Second, because the theory-building process is so closely tied to the evidence, a high probability exists that the resulting theory will be consistent with empirical findings.

For purposes of this study, the topic was broadly defined during the theory-building process because of an insufficient foundation from which to identify a narrower research focus. Before research variables can be manipulated, they must first be identified in a real-life setting. Furthermore, in order to determine the effects of CSCW support on CASE development, the CSCW must be placed into a working CASE environment for an extended period of time. Placement of a CSCW tool into an

experimental environment with subjects who have little CASE experience is impractical; the learning curve on the CASE tool and the CSCW tool would confound the results

TABLE 4

PROCESS OF BUILDING THEORY FROM CASE STUDY RESEARCH

Step	Activity	Reason
Getting Started	Definition of research question Possibly a priori constructs Neither theory nor hypotheses	Focuses efforts Provides better grounding of construct measures Retains theoretical flexibility
Selecting Cases	Specified population Theoretical, not random, sampling	Constrains extraneous variation and sharpens external validity Focuses efforts on theoretically useful cases - i.e., those that replicate or extend theory by filling conceptual categories
Crafting Instruments and Protocols	Multiple data collection methods Qualitative and quantitative data combined *Multiple investigators*	Strengthens grounding of theory by triangulation of evidence Synergistic view of evidence *Fosters divergent perspectives and strengthens grounding*
Entering the Field	Overlap data collection and analysis Flexible and opportunistic data collection methods	Speeds analyses and reveals helpful adjustments to data collection Allows investigators to take advantage of emergent themes and unique case features
Analyzing Data	Within-case analysis *Cross-case pattern search using divergent techniques*	Gains familiarity with data and preliminary theory generation *Forces investigators to look beyond initial impressions and see evidence through multiple lenses*
Shaping Hypotheses	Iterative tabulation of evidence for each construct *Replication, not sampling, logic across cases* Search evidence for "why" behind relationships	Sharpens construct definition, validity, and measurability *Confirms, extends, and sharpens theory* Builds internal validity
Enfolding Literature	Comparison with conflicting literature Comparison with similar literature	Builds internal validity, raises theoretical level, and sharpens construct definitions Sharpens generalizability, improves construct definition, and raises theoretical level
Reaching Closure	*Theoretical saturation when possible*	*Ends process when marginal improvement becomes small*

Eisenhardt 1989

thereby severely limiting the richness of the findings. To prevent learning-curve issues, this study was conducted in a corporate environment rather than a laboratory. Due to the qualitative nature of the research, in accordance with Eisenhardt's (1989) and Yin's

(1994) recommendations, the study necessitated collection of data from multiple sources: structured interviews, pre- and post-questionnaires, and electronic database logs. Data were also collected longitudinally to assist in the detection of changes over time.

Project Overview

Due to the case study nature of this research, the proper field setting was critical. To prevent confounding the study results with a learning curve on a CASE tool in addition to a CSCW tool, team selection was limited to large software development firms that would be likely to use a CASE tool on a regular basis. After the choice of firms was made, organization supervisors worked with the researcher in the selection of a team meeting the research criteria. Data were collected from the initial questionnaires regarding participants' experiences from the four months prior to the introduction of the CSCW tool. The project for this time period was a full release of a software system. Data were collected via identical questionnaires after the completion of a four-month study phase. Timing was based on the completion of SDLC milestones rather than on research deadlines. In order to provide a longitudinal data collection process, structured interviews were conducted with participants and expert panel members six months after the second round of questionnaires, with brief follow-up interviews being conducted for clarification purposes.

The following sections discuss specifics regarding the setting, subjects, and population; tool selection; project description; measurements; data collection techniques; data-analysis design; and validity and reliability issues.

Setting

The setting for this study was a large software-development corporation located in the Dallas/Fort Worth Texas metroplex. The research was conducted at a single location within the organization. The organization has a long history as a defense contractor for software as well as hardware projects. As a defense contractor, this enterprise adheres to the Capability Maturity Model as promulgated by the U.S. Department of Defense-funded Software Engineering Institute at Carnegie Melon University. Although the division in which the study took place was not defense related, as a whole the organization adheres to rigorous software process management controls. The participants use Texas Instruments' (TI) CASE tool, Composer, on a regular basis. Geographically, the participants' offices were located in close proximity to each other within the building complex.

Subjects and Population

The population for this study included teams of CASE participants involved in the Systems Development Life Cycle (SDLC) at the participating organization. This population includes software project leaders, developers, engineers, managers, and users. From the software development groups within the organization, a judgmental sample of a single team was selected to participate in the study. The team was selected jointly by the researcher and the organization's information systems managers. The participants were an established team similar in makeup and attitudes to other teams within the organization and were actively engaged in planning, analysis, and design of revisions to a system. The team members were proficient in utilizing a CASE tool for their SDLC tasks.

Due to the necessity for the team to be in the early stages of the SDLC, a theoretical rather than a random-based sampling plan was used. Eisenhardt (1989) states, "While the cases may be chosen randomly, random selection is neither necessary, nor even preferable" (537). Theoretical sampling focuses efforts on cases that extend or replicate theory by providing the mechanism to harvest data on conceptual categories and constructs.

A single team of four was ultimately selected because they had just completed the first revision to the system under development without benefit of any electronic collaborative support outside of traditional e-mail. Data from this experience were available for comparison to data collected from the next revision process, which would occur after the incorporation of the CSCW tool.

The selected team consisted of a software development project leader, two software developers, and one support member. The participants had an average of 10.4 years of experience in systems development, 5 years experience with CASE tools, and 1.5 years with electronic group support tools. All of the participants had been previously exposed to collaborative software (Notes) although proficiencies varied. None of the participants had ever used a CSCW tool in conjunction with a CASE product. The average age of the participants was 40 years. All of the participants held a bachelor's degree and two had accumulated graduate hours although they did not hold a graduate degree at the time of the study.

Tool Selection

The CASE tool used in this study was Composer. Composer is a full life-cycle product that spans and integrates all system development functions for individual applications. Previously known as Information Engineering Facility (IEF), Composer is a commercially available product that, according to Texas Instruments, is used in a significant number of Fortune 2000 organizations. Composer is designed to provide support to complex organizations in the development of custom applications without the uncertainties and risks associated with traditional SDLC techniques.

The CSCW tool selected for this study was Lotus Notes. Notes is a powerful, flexible electronic mail system that incorporates database capabilities for its users. It currently supports scalability for up to 1000 simultaneous users who, with proper security clearance, have access to application development tools that allow for database, screen, and report customization. The Notes Messaging infrastructure supports electronic mail, Internet integration, document libraries, discussion databases, and task management tools.

Other tools considered included two traditional GDSS tools: VisionQuest and Group Systems V. However, early evaluation of team needs determined the necessity for collaborative tracking of communications rather than brainstorming capabilities. This, coupled with the need for the customization features offered by Notes, led to the selection of Notes for the project.

Project Description

The project under development was the Business Operations Support Systems (BOSS) project, which supports the operational businesses of the organization's software

division. BOSS tracks order entry, inventory, order fulfillment, shipments, and customer information for all of the organization's software products. The information that needed to be collaboratively tracked was enhancement requests and software fault issues to be addressed in the current revision. BOSS was developed using Composer, TI's CASE product. Project issues on BOSS Release 2.4.1 prior to the introduction to Notes were tracked using non-collaborative methods. Specifically, prior to Notes, the issues were tracked in each participant's word processor or spreadsheet of choice. Participants needed access to which changes had been made, which were pending, and the priority of each to avoid the duplication of effort and allow for prompt attention to the highest priority issues.

Instrument Development

In order to ensure that the instruments would harvest the desired data, the survey instruments were evaluated by an expert panel within the organization and refined to meet the needs of the participants prior to data collection. Prior to the start of the study, the research design and instruments were approved by an expert panel comprised of professors with research experience in electronic group support and CASE tools. The survey instruments were then evaluated by an expert panel comprised of supervisors from the participating organization. Refinements were made to the instrument in accordance with feedback received from both panels. Additionally, the instruments were adapted from questionnaires that had been used and validated by expert panels for other studies.

The questionnaires were designed to collect biographical data and assess the level of perceived quality, productivity, and general satisfaction with the existing processes,

toolset, and task outcomes prior to the introduction of change into the environment. With the exception of the biographical section, all questions used a seven-point Likert scale with response of a one reflecting extreme dissatisfaction and response of a seven reflecting extreme satisfaction. In order for comparison to be appropriate, all questions were identical between the pre- and post-instruments, with the exception of four questions regarding perceptions of Lotus Notes. The questionnaires were reviewed for face validity by an expert panel prior to administration. Copies of the pre- and post-instruments are in appendix A and appendix B, respectively.

The expert panel was comprised of two systems project leaders, a software process-improvement expert, an infrastructure architect, a senior business analyst, and three academicians with experience in collaborative technologies. With the guidance of the expert panel, a Project Management Methodology Satisfaction section was added to the instrument. Additionally, all questions were phrased in a positive manner so that none required reverse coding. The industry members of the panel contended that switching back and forth between negative and positive wording was confusing. The expert panel believed that reverse coding was unnecessary for two reasons: (1) statistical calculations were impossible due to the small number of participants and (2) the subjects were professionals who were genuinely interested in unbiased results of the research.

Measurements

Eisenhardt (1989) suggests that the use of multiple data collection methods strengthens the grounding of theory through the triangulation of evidence. In keeping with this view, three primary sources of data were used as measures: pre- and post-

questionnaires, structured interviews, and the information contained in the Notes database. Pre- and post-questionnaires were used to evaluate participant satisfaction issues. The Notes database was analyzed to determine the quantity and breadth of interactions. Structured interviews were used as measures of satisfaction and variability of quality over time.

The following discussion presents an overview of the measurements used for each hypothesis, followed by the details on each of the primary measures and their administration. The first two issues were geared toward evaluating evidence indicating group communication support is associated with perceived improvements in resulting software development quality and productivity.

For purposes of this study, quality was defined as the perceived degree of excellence of the resulting software product. The related hypothesis is as follows:

H_{11} The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher quality in resulting software products.

This issue was measured in several ways. First, supervisor and participant interviews revealed perceptions of the quality of the product. Participant responses to questionnaires also provided data on quality perceptions. Finally, an expert panel appraisal provided an evaluation of the quality of the resulting product.

Productivity is defined as the perceived proficiency in creating a software product, whether a system, subsystem, or component. The hypothesis relating to productivity is as follows:

H_{12} The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher productivity.

This issue was measured by evaluating satisfaction with the productivity as elicited from supervisor and participant responses to structured interview questions and from survey responses from the participants. It was further evaluated by studying the quantity of electronic interactions, the breadth of these interactions, and the time required to complete the process.

The last hypothesis from the research question provides a more general satisfaction rating. It is as follows:

H_{13} The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with task results.

Team satisfaction with task results is an overall satisfaction rating based on productivity and quality. Structured interviews and questionnaires given to participants provided the measurement for this issue.

The first of two hypotheses emanating from the second research question is as follows:

H_{21} The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the group process.

The measurements used for this issue resulted from the structured interviews and questionnaires administered to the research participants.

The second hypothesis related to this research question is as follows:

H_{22} The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the technological support.

Analysis of the structured interviews and questionnaires administered to the participants provided measures of tool satisfaction.

The final hypothesis is a collective evaluation and is perhaps the most important of the four:

H_{3I} The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication.

Questionnaire data, structured interview comments, and expert panel judgments provided the measures for this issue.

Data Collection Techniques

A key strength of case study research is the ability to collect data from multiple sources (Yin 1994). Analysis has revealed that case studies using multiple sources of evidence are higher in quality than case studies that rely on a single source of data (Yin, Bateman, and Moore 1983). The reliance on multiple data collection methods is common in theory-building research (Eisenhardt 1989). In keeping with these findings, the present study collected evidence from questionnaires, the Notes database, and structured interviews.

Pre- and Post-Questionnaires

The first technique used to collect data regarding the incorporation of a distributed CSCW tool -- Lotus Notes -- into the team's live work environment was the utilization of pre- and post-questionnaires. Data were collected from pre- and post-implementation questionnaires administered before and after incorporation of Lotus Notes into the environment.

Notes Database

In addition to the data collected from the questionnaires, data were also collected from the BOSS Notes database, a sample of which is included in appendix C. This database was used to count the number of interactions by team members in addition to evaluating the breadth and quality of interactions. The database was studied to determine whether or not usage patterns of Notes changed over time. In order to ensure that any changes in usage patterns were the result of familiarity with the tool and not the task, the issues contained in the database were compared to determine that the task demands were equivalent during the life of the project.

Structured Interviews

Structured interviews with the design participants were conducted at the end of the study to debrief the participants and to obtain feedback on the effects of the integration of the CSCW tool into the CASE environment. The participants were interviewed on perceived improvements and/or problems related to the introduction of the technology. The list of questions answered by each participant is located in appendix D. Suggestions were solicited from the participants regarding which features of the collaborative communication support were beneficial and which were not.

Additionally, the industry expert panel members participated in structured interviews as well. The list of questions answered by expert panel members is located in appendix E. Expert panel members were interviewed to obtain additional data regarding quality, productivity, and changes in the group process.

Effectiveness and Viability Measures

The effectiveness and viability of the incorporation of Notes into the Composer environment were established by several methods. First, evaluation of quality and productivity were performed by the expert panel established for the questionnaire review. Second, ratings were obtained from team members and supervisors. Third, the database was studied for communication and usage patterns. Fourth, opinions derived from the self-report measures were compiled, categorized, and analyzed.

Data Analysis

According to Yin (1994), analysis of case study evidence is one of the most difficult and least developed aspects of the case study process. Due to the small sample size, statistical analysis of the data was not feasible. However, five methods for data analysis were performed as discussed by Yin (1988).

1. The data were organized for presentation in keeping with Miles and Huberman (1994). Responses were placed in a matrix of categories for analysis.
2. A case description was prepared.
3. Pattern matching using nonequivalent dependent variables was performed.
4. Content analysis was conducted.
5. A chain of evidence was formulated.

This combination of divergent techniques was selected because multiple forms of data analysis in a case setting are espoused as valuable in that they provide the mechanism to examine data from multiple perspectives (Eisenhardt 1989).

The initial method of analysis involved organizing the data into matrices for presentation. These matrixes were then studied for patterns. Table 5 shows the measures used to assist in the analysis of the structured interviews and the electronic logs. The data from the structured interviews were transcribed to clarify and confirm the tabulation of the questionnaire responses.

TABLE 5

CONSTRUCTS AND MEASURES

Construct	Variable	Measures
Quality	Supervisor perceptions of quality	Post-implementation structured interviews with expert panel
	Participant perceptions of quality	Post-implementation structured interviews and pre- and post-questionnaires
	Quality of task results	Post-implementation structured interviews with expert panel and participants
	Variability of quality over time	Post-implementation structured interviews with expert panel and participants
Productivity	Supervisor perceptions of productivity	Post-implementation structured interviews with expert panel
	Participant perceptions of productivity	Post-implementation structured interviews and pre-post-questionnaires
	Quantity of interactions	Post-implementation electronic logs
	Time required for task completion	Post-implementation electronic logs and post-implementation structured interviews with expert panel and participants
	Breadth of interactions	Post-implementation electronic logs
Satisfaction	Reported satisfaction with results	Post-implementation structured interviews and pre- and post-questionnaires with expert panel and participants
	Reported satisfaction with group process	Post-implementation structured interviews and pre- and post-questionnaires with expert panel and participants
	Reported satisfaction with technology	Post-implementation structured interviews and pre- and post-questionnaires with expert panel and participants

Table 6 is a sample of the matrices used to analyze the questionnaire data. Responses from the pre- and post-implementation instruments were compared to reveal

trends. A detailed description of the data analysis process is found in chapter 5 of this document.

TABLE 6

MATRIX OF COMMUNICATION PROCESS RESULTS

Topic / Question	Satisfaction Score		Satisfaction %		% Change
	Before	After	Before	After	
How satisfied are you with the communication process you use?					
How satisfied are you with the effect the communication process has on your productivity?					
How satisfied are you with the effect the communication process has on the quality of the resulting system?					
How satisfied are you with your mastery of the communication process?					
Cumulative					

Tables 7, 8 and 9 were utilized in the initial analysis of the Notes database which tracked all BOSS project issues and communications. Detailed discussions of data analysis using these tables is included in chapter 5 of this document.

TABLE 7

QUANTITY OF INTERACTIONS

Communication Support Type	# of System Issues Tracked	# of Low Priority Issues	# of Normal Priority Issues	# of High Priority Issues
Non-collaborative				
Notes				

TABLE 8

DEPTH OF INTERACTIONS

Type of Communication Support	Average # of Descriptive Lines			
	Overall	Low Priority Issues	Normal Priority Issues	High Priority Issues
Non-collaborative				
Notes				
% Increase				

TABLE 9

BREADTH OF INTERACTIONS

Type of Communication Support	# of Issues Tracked				
	Design Issue	Maintenance Issue	Enhancement Request	Software Fault	Other
Non-collaborative					
Notes					

The second data analysis method used was a case description (Yin 1994). This technique involved creating a summary of the information obtained during the study. The case description served as a foundation for chapter 5. Appendix F contains an outline of the case description.

The third method utilized a pattern matching technique suggested by Yin (1994). For this technique, theory is used to predict certain outcomes. The theory is supported if the predicted outcomes occur and the alternative outcomes do not. Group Decision Support Systems (GDSS) literature was used to predict the anticipated results. If the incorporation of Notes into a CASE environment resulted in an outcome similar to that of previous collaborative research in the software engineering environment, then the data would suggest that Notes was of positive benefit to the environment.

For the fourth technique, content analysis was employed. Content analysis is considered to be a powerful tool for analyzing qualitative data (Yin 1994). This process consists of reviewing and sorting text-based data into categories based on key words and phrases. The transcriptions of the structured interviews were analyzed based on positive and negative comments about productivity, quality, and satisfaction with the technology and the process.

Finally, a chain-of-evidence procedure was used to connect the research questions with the data, the analysis, and the research protocols. Suggested by Yin (1994), the chain-of-evidence procedure lists the steps in the researcher's reasoning process. This process thus facilitated the process of drawing conclusions and answering the research questions.

QSR NUD.IST, a content-analysis tool available from Sage Publications, was used to assist in the analysis of participant and expert panel interview transcripts. NUD.IST stands for Non-numerical Unstructured Data Indexing Searching and Theorizing. It is a computerized tool designed to assist users in the analysis of qualitative data. NUD.IST was used to create a document database that stored the transcriptions of all interviews. The tool was further used to manage, explore, and search the interview text. NUD.IST supported the exploration and linkage of ideas and theories about the data in addition to fostering theory testing. Selection of NUD.IST was made based on reports of an independent evaluation of NUD.IST performed by Fielding and Lee (1991) who state that NUD.IST tackles the content analysis model directly. NUD.IST supports movement between data, the subsequent thought and indexing process in an easy and

quick manner. Overall, NUD.IST facilitates movement of data between categories without imposing clerical costs.

NUD.IST is comprised of two major components. The first is a document system that provides the capability to hold text from interviews, databases, and other sources of text-based data. The text maintained by NUD.IST in this study was the resulting dialog of the structured interviews. The second component is an index system that allows the user to create and manipulate concepts and emerging ideas. This index system improves the researcher's evaluation process by providing hierarchical links and graphical display features that facilitate the data analysis process (Richards and Richards 1991; Richards and Richards 1994). A more detailed description of NUD.IST's capabilities may be found in appendix G.

Validity and Reliability

In order for research findings to be meaningful, the constructs and measures must be valid and reliable. Four major types of validity exist: statistical conclusion, construct, internal, and external (Cook and Campbell 1979.) Due to the small sample size and case study nature of this research, statistical conclusion validity is not applicable. Therefore, three principle types of validity are considered in this study: construct, internal, and external.

Construct Validity

Construct validity exists when the correct operational measures for the concepts that are being studied have been established (Yin 1994). Yin suggests three techniques for establishing construct validity. The first is to rely on multiple sources of data. The

second is to establish a chain of evidence for the study. The last is to have key research site personnel review the case study draft.

The multiple sources of data collected included pre- and post-implementation questionnaires, structured interviews with participants and expert panel members, and the Notes database maintained for the system under development. Details of each of these data collection methods are discussed in chapter 5 of this study.

A chain of evidence was utilized to allow tracing of the reasoning from the research questions to the study's conclusions (Yin 1989). This technique, when used in combination with a review by key personnel, permits the reader of the research to analyze the adequacy of the conclusions. This research established the chain of reasoning by presenting the steps performed in the reasoning process and relating how they supported the conclusion.

The key personnel who reviewed the report included two systems project leaders, a software process improvement expert, an infrastructure architect, and a senior business analyst.

Internal Validity

Internal validity is present when causal relationships between dependent and independent variables can be identified (Yin 1994). Yin suggests achieving internal validity by focusing on nonequivalent dependent variables, explanation building, and time-series analysis.

The use of the nonequivalent dependent variables method addresses causal relationships by using theory to predict outcomes. The usage of this method within the confines of this study is discussed in chapter 5.

Explanation building involves analysis of causal relationships by identifying the steps in a chain of cause and effects. Explanation building was established by preparing a chain of evidence for each question, which is presented later in this chapter.

Longitudinal analysis requires the collection of data at multiple points over a time and space continuum. To address the possibility of changes over time, data were collected regarding the subjects' perceptions prior to the installation of Notes via pre-implementation questionnaires. Data were collected via post-implementation questionnaires after the subjects had accumulated four months of experience with Notes in the Composer environment. The BOSS database was examined for changes in usage over a six-month period. Structured interviews were conducted ten months after the Notes installation. Results from the structured interviews were compared to those of the questionnaires to determine whether satisfaction levels had changed over time.

External Validity

External validity is present when the research findings are generalizable. According to Yin (1994), external validity in a case study requires the replication of the findings at other sites and other times to ensure that the results apply in more than just a single site at a single point in time. This research was designed to be a single-site case study performed during a single time interval. Although not directly generalizable, the findings still have meaning in organizations possessing similar organizational

characteristics, processes, and team composition. As such, the findings have relevance to large organizations using CASE tools to support large and complex system development processes. Further research is encouraged, and chapter 6 contains suggestions designed to guide future research in order to assist with the replication process.

Reliability

Reliability is present when the same results are obtained at another place and time when the process is repeated. As suggested by Yin (1994), a case study protocol and a case study database were used. The case study protocol identifies the procedure followed by the researcher so that another researcher could follow the same steps. To assist future duplication studies, the case study protocol is provided in appendix H. A case study database affords future researchers the opportunity to compare their results with those of previous research. Because limited research has been conducted in the combination of CSCW and CASE environments, the ability to establish reliability within the confines of the current research was restricted.

Summary

The methodology used by this research was a field-based case study at a single site using data from multiple sources with data collected over a ten-month period. Data were collected from structured interviews, pre- and post-questionnaires, and electronic database logs. The study focuses on three principal constructs: productivity, quality, and satisfaction. Conveyance of potential outcomes took the form of substantive hypotheses. Methods for analyzing the data included organizing the data for presentation, developing

a case description, pattern matching, and maintaining a chain of evidence. Each question was analyzed using a different chain of evidence.

CHAPTER 5

DATA COLLECTION AND ANALYSIS

This chapter presents and analyzes the data collected during the research study. Data are presented from pre- and post-implementation questionnaires, the BOSS Notes database, and structured interviews with participants and the expert panel industry members.

Data about the four-month process of tracking BOSS revision 2.4.1 issues without electronic collaborative support were collected retrospectively during the structured interviews. The pre-test instruments also reflected the participants' satisfaction with this experience. At the completion of BOSS 2.4.1, Notes was introduced to the BOSS team, and all project issues for BOSS 2.4.2 were tracked in the collaborative workspace provided by Notes. Issues that had been previously tracked in a manual mode were entered into the Notes database created for BOSS. This version of BOSS, 2.4.2 was completed four months later. Further enhancements were still being made to revision 2.4.2+ when the post-study questionnaires were administered. To determine if history and experience caused changes in participant opinions during the months after completion of version 2.4.2, the structured interviews were conducted six months after the post-implementation questionnaires were administered.

Implementation of Data Collection and Analysis

The following sections discuss the specific ways these techniques were developed and employed in the chain of evidence for each of the three research questions. Previous research indicated that the incorporation of collaborative support tools, in this instance, Lotus Notes, had improved SDLC quality and productivity performance. Using these findings as a basis, a pre-existing team, with no electronic collaborative support other than e-mail, was selected for participation in the study. At the time of selection, the team had completed release 2.4.1 of the BOSS system and were about to begin release 2.4.2.

Data were analyzed both quantitatively and qualitatively. Pre- and post-questionnaires and the Notes database provided the quantitative analysis data. The quantitative data were beneficial for revealing relationships that were not readily apparent to the researcher. Quantitative data analysis was followed by qualitative data collection in the form of structured interviews. As suggested by Eisenhardt (1989), the qualitative data were useful for understanding the "why" of the relationships revealed in the quantitative analysis. The following chains of evidence were developed to evaluate the research findings.

Chain of Evidence for Question 1

Research question 1 was Is there a relationship between CSCW tools in a CASE environment and quality, productivity, and team perceptions of task results? To demonstrate this relationship, the following steps were performed:

1. Data were collected via questionnaires regarding the team's perceptions regarding productivity, quality, and satisfaction prior to the implementation of Notes. Responses were collected to identical questions administered after the completion of release 2.4.2. The comparison of the two data sets made it possible to establish whether a relationship existed.
2. Comparison of results from the pre- and post-study questionnaires led to the development and conduct of structured interviews with participants to further clarify the findings on productivity, quality, and satisfaction.
3. To further investigate productivity, the compilations of issues from each BOSS release were counted, time dated, and evaluated for detail.
4. The expert panel was interviewed to provide additional measures of quality.
5. Analysis of the data collected in each of the first four steps in this chain of evidence indicated how the participants and expert panel perceived Notes to affect the issues of productivity, quality, and satisfaction.

These steps established whether a relationship existed between the incorporation of Notes and productivity, quality, and satisfaction. The probability existed that these three issues would experience different levels of change. However, lack of improvement in one would not diminish the value of the findings but rather would result in a foundation for future research.

Chain of Evidence for Question 2

Research question 2 was How is the technology perceived by participants and supervisors to affect group processes and technological support? To demonstrate how the

collaborative communication support technology was perceived to affect group processes and task performance, the chain of evidence was organized around the following steps:

1. Data were collected via questionnaires regarding the team's perceptions of group processes and electronic support technology prior to the implementation of Notes. The results were compared to responses collected from identical questions administered after the completion of the project, BOSS release 2.4.2. This comparison made it possible to establish whether Notes was perceived to affect group process and task performance.
2. The comparison of results from the pre- and post-study questionnaires led to the development and conduction of structured interviews with participants to further clarify how Notes was perceived to affect the group process and task performance.
3. The expert panel was interviewed to provide additional insight into the group process and task performance.
4. The results of the interviews were subjected to content analysis using NUD.IST.

These steps established whether a relationship existed between the incorporation of Notes and the group process and task performance. As with the issues of productivity, quality, and satisfaction, the possibility existed that these two issues might experience a different level of change.

Chain of Evidence for Question 3

Research question 3 was Is CSCW used as a communication-extension to CASE a viable and beneficial alternative to traditional modes of operation? To determine whether

or not collaborative communication support technology was a viable and beneficial alternative to traditional modes of operation, the following steps were performed:

1. Questionnaire data collected on methods of communication prior to Notes established the traditional modes. This step was necessary for evaluation of the traditional environment.
2. To establish participant's opinions of Notes, open-ended questions designed to collect participant's views were included on the post-implementation questionnaire. This step was performed to provide the mechanism for designing structured interview questions regarding the alternative mode of communication provided by Notes.
3. Structured interviews with participants and the expert panel provided the richest data for this question. The results from these interviews, when compared to those of the previous step, provided a barometer for the attitudes and awareness of the participants.
4. Structured interview data were analyzed for content using NUD.IST.

Successful implementation of each of these steps established the value of incurring the expense and effort associated with the implementation of Notes into an organizational and CASE-supported SDLC environment.

Questionnaire Data

Two questionnaires were administered. The first instrument collected participants' perceptions after the completion of the 2.4.1 release of BOSS project prior to the incorporation of Notes. The pre-implementation questionnaire is found in

appendix A. The second instrument collected participants' perceptions after the four-month completion of BOSS release 2.4.2 using Notes as a communication tool. This questionnaire is found in appendix B.

Both instruments used a seven-point Likert scale and were identical, with the exception of four questions that were added to the post-instrument to collect perceptions on Notes. Participants were to assign a value of one to a question if they were extremely dissatisfied with the subject about which the question was written, a value of seven if they were extremely satisfied, and a value of four if they were neutral on the subject. The individual responses assigned by the participants were summed by question. Each question fell into a category of perceptions regarding productivity, quality, or satisfaction. The responses were analyzed individually and collectively within these three categories. The question totals, designated in the tables found later in this chapter as Satisfaction Score, were recorded, transformed into percentages, and evaluated. Data were collected about communication process and technology, system development technology and methodology, project management methodology, CASE technology benefits, group process, task results, and communication support technology.

For analysis, the questions were arranged by the three major categories of quality, productivity, and satisfaction. The data were further evaluated in the order and categories in which they were found on the questionnaires themselves. The Satisfaction Score was derived by adding up the ratings given to each question on both the pre- and post-test instruments. The following formulas were used.

Satisfaction Score Before = $\sum$ (# of Pre-Test Points Awarded By Each Participant)

Satisfaction Score After = $\sum$ (# of Post-Test Points Awarded By Each Participant)

To calculate percentages, the highest possible score obtainable by any single question was calculated and termed Maximum Possible Score. The satisfaction percentages were derived by dividing the Satisfaction Score by the Maximum Possible Score. The formula for the Maximum Possible Score was calculated by multiplying the number of Likert-scale points by the number of participants. The formulas used for the Maximum Possible Score and the Satisfaction Percentages are as follows:

Maximum Possible Score = # of Likert Scale Points * # of Participants

Satisfaction % Before = Satisfaction Score Before / Maximum Possible Score

Satisfaction % After = Satisfaction Score After / Maximum Possible Score

After the satisfaction percentages were calculated, the change in satisfaction was calculated by subtracting the satisfaction percentages prior to the incorporation of Notes from the satisfaction percentages after the incorporation of Notes. The formula used is shown below.

% Change = Satisfaction % After - Satisfaction % Before

To evaluate the collective satisfaction within a given category, cumulative subtotals were calculated for each of the columns by summing all values in the respective column within the topic section. Changes in satisfaction by individual questions were evaluated in addition to a review of the collective subtotals. The calculations and

evaluations for each section and category of questions were performed in a consistent manner.

Questions were evaluated independently and collectively for satisfaction levels. As previously stated, the seven-point Likert scale provided the mechanism for the users to score a particular question from one to three if they were dissatisfied, four if they were neutral, and five to seven if they were satisfied. If all participants scored a question with a four, the satisfaction percentage would be 50%, indicating that they were neither dissatisfied nor satisfied. Therefore, a score of less than 50% would indicate that they were dissatisfied and, likewise, a score of more than 50% would indicate that they were satisfied. The responses were evaluated to see if the inclusion of Notes into the environment resulted in movement from dissatisfaction to satisfaction in particular venues.

Due to the team size of four, reliability testing for internal consistency, unidimensionality, and convergent validity was not possible. Such testing is important when items on a scale are summed to derive a cumulative score, as was done in this study (Crano and Brewer 1973). However, this study was designed to make an initial foray into the research arena in the area of collaborative support for CASE developers. While recognizing the weakness of being unable to determine a Cronbach's (1951) alpha, the data analysis was performed with the understanding that further research is necessary to establish reliability.

The following sections present tables that were used in the data analysis process. To assist the reader in relating questions in each table to the instrument from which they came, a code appears in front of each question in the table. The letters are an

abbreviation for the section title in the instrument, while the number references the question within the section. For example, CP1 references Communication Process question 1. The complete legend of abbreviations is as follows:

CP = Communication Process
CT = Communication Technology
SDT = System Development Technology
SDM = Systems Development Methodology
PMM = Project Management Methodology
TB = Technology Benefit
ATP = Attitude Towards Process
ATR = Attitude Towards Results
ATT = Attitude Towards Technology

Quality

Table 10 contains the data from the responses to all questions relating to team perceptions of quality. Questions about each individual quality issue were taken from each of the instruments. These questions were then placed collectively into the table to evaluate the Cumulative Quality Ratings as well as the individual ratings. The formulas used for the Cumulative Quality Ratings are as follows:

Cumulative Maximum Possible Score = $\sum$Maximum Possible Score

Cumulative Quality Rating Before = $\sum$Satisfaction Score Before

Cumulative Quality Rating After = $\sum$Satisfaction Score After

Cumulative Quality Rating % Before = $\sum$Satisfaction % Before

Cumulative Quality Rating % After = $\sum$Satisfaction % After

Cumulative Quality Rating Change = Cumulative Quality Rating % After - Cumulative Quality Rating % Before

TABLE 10

MATRIX OF QUALITY RESULTS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
CP3	How satisfied are you with the effect the communication process has on the quality of the resulting system?	15	18	53.57%	64.29%	+10.71%
CT7	How satisfied are you with the effect the electronic communication tools have on the quality of the resulting system?	17	18	60.71%	64.29%	+3.57%
SDT4	How satisfied are you with the effect the software development tools have on the quality of the resulting system?	18	17	64.29%	60.71%	-3.57%
SDM8	How satisfied are you with the effect the software development methodology has on the quality of the resulting system?	11	15	39.29%	53.57%	+14.29%
PMM3	How satisfied are you with the effect the project management methodology has on the quality of the resulting system?	13	15	46.43%	53.57%	+7.14%
TB1	CASE benefit: higher quality system	18	21	64.29%	75.00%	+10.71%
ATR19	I am confident that the results are good.	13	19	46.43%	67.86%	+21.43%
ATR22	The work we've produced so far is of high quality.	13	16	46.43%	57.14%	+10.71%
Cumulative		118	139	52.68%	62.05%	+9.38%

Productivity

As with the quality table, questions about each individual productivity issue were taken from each of the instruments. These questions were then placed collectively into table 11 to evaluate the Cumulative Productivity Ratings as well as the individual ratings. The formulas used for the Cumulative Productivity Ratings are as follows:

Cumulative Maximum Possible Score = ∑Maximum Possible Score

Cumulative Productivity Rating Before = ∑Satisfaction Score Before

Cumulative Productivity Rating After = ∑Satisfaction Score After

Cumulative Productivity Rating % Before = ∑Satisfaction % Before

Cumulative Productivity Rating % After = ∑Satisfaction % After

Cumulative Productivity Rating Change = Cumulative Productivity Rating % After - Cumulative Productivity Rating % Before

TABLE 11

MATRIX OF PRODUCTIVITY RESULTS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
CP2	How satisfied are you with the effect the communication process has on your productivity?	13	17	46.43%	60.71%	+14.29%
CT6	How satisfied are you with the effect the electronic communication tools have on your productivity?	16	20	57.14%	71.43%	+14.29%
SDT3	How satisfied are you with the effect the software development tools have on your productivity?	17	17	60.71%	60.71%	0.00%
SDM7	How satisfied are you with the effect the software development methodology has on your productivity?	14	18	50.00%	64.29%	+14.29%
PMM2	How satisfied are you with the effect the project management methodology has on your productivity?	13	16	46.43%	57.14%	+10.71%
CASE benefits:						
TB2	more reusable code	17	18	60.71%	64.29%	+3.57%
TB7	lower development costs	15	18	53.57%	64.29%	+10.71%
TB8	faster development	18	18	64.29%	64.29%	0.00%
TB9	easier modification of preliminary designs	17	17	60.71%	60.71%	0.00%
TB10	easier to make transition from logical to physical system	17	18	60.71%	64.29%	+3.57%
TB14	easier prototyping	16	20	57.14%	71.43%	+14.29%
TB15	easier sharing of work with others	18	20	64.29%	71.43%	+7.14%
AT[4	The abilities of other participants are well utilized.	14	16	50.00%	57.14%	+7.14%
ATP3	Our cooperation is efficient.	14	17	50.00%	60.71%	+10.71%
ATP6	I am satisfied with the progress we are making in completing our tasks.	11	17	39.29%	60.71%	+21.43%
ATP7	We have no difficulty coordinating our work.	12	16	42.86%	57.14%	+14.29%
Cumulative		242	283	54.02%	63.17%	+9.15%

Satisfaction

Tables 12 to 22 contain participant responses on communication process, communication technology, system development technology, system development methodology, project management methodology, CASE technology benefits, group process, task results, and communication technology assessment. Consistent with the style of the previous tables, the formulas used for the Cumulative Satisfaction Ratings are as follows:

Cumulative Maximum Possible Score = ∑Maximum Possible Score

Cumulative Satisfaction Rating Before = ∑Satisfaction Score Before

Cumulative Satisfaction Rating After = ∑Satisfaction Score After

Cumulative Satisfaction Rating % Before = ∑Satisfaction % Before

Cumulative Satisfaction Rating % After = ∑Satisfaction % After

Cumulative Satisfaction Rating Change = Cumulative Satisfaction Rating % After - Cumulative Satisfaction Rating % Before

The first factor for evaluation was satisfaction with the communication process. No changes in the communication process other than the incorporation of Notes occurred between the before and after responses. Results of this evaluation are contained in table 12.

TABLE 12

MATRIX OF COMMUNICATION PROCESS RESULTS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
CP1	How satisfied are you with the communication process you use?	12	19	42.86%	67.86%	+25.00%
CP2	How satisfied are you with the effect the communication process has on your productivity?	13	17	46.43%	60.71%	+14.29%
CP3	How satisfied are you with the effect the communication process has on the quality of the resulting system?	15	18	53.57%	64.29%	+10.71%
CP4	How satisfied are you with your mastery of the communication process?	17	20	60.71%	71.43%	+10.71%
Cumulative		57	74	50.89%	66.07%	+15.18%

Similar in nature to that for the communication process, table 13 was created to evaluate change in satisfaction levels with the available communication tools. As discussed in previous chapters, Notes was incorporated into the team's communication

TABLE 13

MATRIX OF COMMUNICATION TECHNOLOGY RESULTS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
CT5	How satisfied are you with the electronic communication tools you use?	16	19	57.14%	67.86%	+10.71%
CT6	How satisfied are you with the effect the electronic communication tools have on your productivity?	16	20	57.14%	71.43%	+14.29%
CT7	How satisfied are you with the effect the electronic communication tools have on the quality of the resulting system?	17	18	60.71%	64.29%	+3.57%
CT8	How satisfied are you with your mastery of the electronic communication tools?	19	20	67.86%	71.43%	+3.57%
Cumulative		68	77	60.71%	68.75%	+8.04%

technology toolkit. The analysis from table 13 was designed to evaluate the communication technology. Previous communication technology included word processors and e-mail.

Table 14 contains the data regarding the changes in satisfaction with the system development technology used by the team. No change in the system development tools was made during the study.

TABLE 14

MATRIX OF SYSTEM DEVELOPMENT TECHNOLOGY RESULTS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
SDT1	How satisfied are you with the software development operating environment you use?	17	17	60.71%	60.71%	0.00%
SDT2	How satisfied are you with the current software development tools you use?	16	15	57.14%	53.57%	-3.57%
SDT3	How satisfied are you with the effect the software development tools have on your productivity?	17	17	60.71%	60.71%	0.00%
SDT4	How satisfied are you with the effect the software development tools have on the quality of the resulting system?	18	17	64.29%	60.71%	-3.57%
SDT5	How satisfied are you with your mastery of the software development tools?	19	19	67.86%	67.86%	0.00%
Cumulative		87	85	62.14%	60.71%	-1.43%

As with the system development technology, the system development methodology did not change between the pre- and post-questionnaires. These responses, located in table 15, were analyzed to determine if any relationship could be detected between Notes and the team's perceptions of the system development methodology being utilized.

TABLE 15

MATRIX OF SYSTEM DEVELOPMENT METHODOLOGY RESULTS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
SDM6	How satisfied are you with the software development methodology you use?	12	15	42.86%	53.57%	+10.71%
SDM7	How satisfied are you with the effect the software development methodology has on your productivity?	14	18	50.00%	64.29%	+14.29%
SDM8	How satisfied are you with the effect the software development methodology has on the quality of the resulting system?	11	15	39.29%	53.57%	+14.29%
SDM9	How satisfied are you with your mastery of the software development methodology?	15	18	53.57%	64.29%	+10.71%
Cumulative		52	66	46.43%	58.93%	+12.50%

Table 16 contains the results of changes in project management perceptions after the incorporation of the CSCW tool. Expert panel members indicated that project management data was valuable, and the questions found in table 16 were added as a result of the expert panel's evaluation of the instruments.

TABLE 16

MATRIX OF PROJECT MANAGEMENT METHODOLOGY RESULTS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
PMM1	How satisfied are you with the project management methodology you use?	13	16	46.43%	57.14%	+10.71%
PMM2	How satisfied are you with the effect the software development methodology has on your productivity?	13	16	46.43%	57.14%	+10.71%
PMM3	How satisfied are you with the effect the software development methodology has on the quality of the resulting system?	13	15	46.43%	53.57%	+7.14%
PMM4	How satisfied are you with your mastery of the software development methodology?	15	17	53.57%	60.71%	+7.14%
Cumulative		54	64	48.21%	57.14%	+8.93%

CASE technology is designed to provide benefits. Research by Yellen (1992) identified 15 potential benefits of using CASE products. Participants rated the degree to which each of the 15 benefits had been realized in their shop since the introduction of the CASE technology. The Technology Benefit Assessment questionnaire was adapted from Yellen's (1992) instrument. Like the other instruments, these data were collected prior to and after the incorporation of Notes. The results of this data collection process are contained in table 17.

TABLE 17

MATRIX OF CASE TECHNOLOGY BENEFIT RESULTS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
TB1	higher quality system	18	21	64.29%	75.00%	+10.71%
TB2	more reusable code	17	18	60.71%	64.29%	+3.57%
TB3	easier documentation	16	19	57.14%	67.86%	+10.71%
TB4	more user input	15	20	53.57%	71.43%	+17.86%
TB5	better user input	15	21	53.57%	75.00%	+21.43%
TB6	better project control	18	21	64.29%	75.00%	+10.71%
TB7	lower development costs	15	18	53.57%	64.29%	+10.71%
TB8	faster development	18	18	64.29%	64.29%	0.00%
TB9	easier modification of preliminary designs	17	17	60.71%	60.71%	0.00%
TB10	easier to make transition from logical to physical system	17	18	60.71%	64.29%	+3.57%
TB11	increased formalization of process due to discipline required when using tool	18	20	64.29%	71.43%	+7.14%
TB12	better standardization of resulting system	18	22	64.29%	78.57%	+14.29%
TB13	better integration of system components	19	20	67.86%	71.43%	+3.57%
TB14	easier prototyping	16	20	57.14%	71.43%	+14.29%
TB15	easier sharing of work with others	18	20	64.29%	71.43%	+7.14%
Cumulative		255	293	60.71%	69.76%	+9.05%

Table 18 contains data regarding the group communication process. The participants were asked to rate their attitudes to each statement with respect only to their work in software planning, analysis, and design activities.

TABLE 18

MATRIX OF ATTITUDES TOWARDS THE GROUP PROCESS

Topic / Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
ATP1	I enjoy the team communication process.	15	16	53.57%	57.14%	+3.57%
ATP2	I can present all my ideas.	19	18	67.86%	64.29%	-3.57%
ATP3	Our cooperation is fair.	18	17	64.29%	60.71%	-3.57%
ATP4	The abilities of other participants are well utilized.	14	16	50.00%	57.14%	7.14%
ATP5	Our cooperation is efficient.	14	17	50.00%	60.71%	+10.71%
ATP6	I am satisfied with the progress we are making in completing our tasks.	11	17	39.29%	60.71%	+21.43%
ATP7	We have no difficulty coordinating our work.	12	16	42.86%	57.14%	+14.29%
ATP8	I am satisfied with the procedures that our team uses to communicate.	15	15	53.57%	53.57%	0.00%
ATP9	We are all contributing fairly to this project.	15	16	53.57%	57.14%	+3.57%
ATP10	Other members of our project team have worked very hard on this project.	18	19	64.29%	67.86%	+3.57%
ATP11	I am doing more than my share of the work for our team.	16	17	57.14%	60.71%	+3.57%
ATP12	The other members of the group seem to respect my contributions.	17	17	60.71%	60.71%	0.00%
ATP13	I have enjoyed working with members of my project team.	18	18	64.29%	64.29%	0.00%
ATP14	I feel that I am a part of this project team.	17	16	60.71%	57.14%	-3.57%
ATP15	I have learned a lot from the other members of this group.	17	19	60.71%	67.86%	+7.14%
ATP16	I'd like to work with this group again.	15	16	53.57%	57.14%	+3.57%
Cumulative		251	270	56.03%	60.27%	+4.24%

Table 19 was used to capture the team's attitudes toward the task results. Specifically, participants were rating the resulting BOSS revision that had just been completed. This applies to both the pre- and post-instruments since both were capturing data about a BOSS revision that had just been completed. The "before" column represents opinions regarding BOSS 2.4.1, whereas the "after" column represents opinions regarding BOSS 2.4.2.

Table 19

Matrix of Attitudes Towards the Task Results

Topic/Question n = 4		Satisfaction Score		Satisfaction %		% Change
		Before	After	Before	After	
ATR17	I feel personally responsible for the results.	17	19	60.71%	67.86%	+7.14%
ATR18	I am satisfied with the results.	14	18	50.00%	64.29%	+14.29%
ATR19	I am confident that the results are good.	13	19	46.43%	67.86%	+21.43%
ATR20	The results correspond largely to my own contributions.	14	18	50.00%	64.29%	+14.29%
ATR21	I endorse the results.	15	17	53.57%	60.71%	+7.14%
ATR22	The work we've produced so far is of high quality.	13	16	46.43%	57.14%	+10.71%
Cumulative		86	107	51.19%	63.69%	+12.50%

The data in table 20 differ from the data found in the previous ten tables in that they do not report "before" data. Because Notes was not in place to be evaluated prior to the study, no data were collected prior to the intervention. The columns presented represent data that was evaluated for team satisfaction regarding the incorporation of Notes into the environment.

TABLE 20

MATRIX OF TECHNOLOGY ASSESSMENT

Topic/Question n = 4		Satisfaction Score	Satisfaction %
ATT23	I want to continue to use Lotus Notes.	23	+82.14%
ATT24	Computer support helped us find and structure ideas.	18	+64.29%
ATT25	Computer supported teamwork is better suited to this task than traditional methods.	18	+64.29%
ATT26	Computer support helped us reach our goal.	18	+64.29%
Cumulative		77	+68.75%

After the data were placed in matrixes corresponding to the layout of the data collection instruments, the results were analyzed for major changes in patterns. The first of the patterns identified were items which had received average scores of less than 50% prior to the incorporation of Notes, indicating dissatisfaction by the participants. In each case the satisfaction rating improved after the incorporation of Notes. No questionnaire items earned a rating of less than 50% after the incorporation of Notes although three earned relatively neutral ratings. Table 21 contains the items for which participants reported prior dissatisfaction. The items come from different sections of the instrument. Thus, no cumulative values were calculated due to the lack of comparability between questions.

TABLE 21

MATRIX OF ATTITUDINAL SHIFTS PAST MIDPOINT

Topic/Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
CP1	How satisfied are you with the communication process you use?	12	19	42.86%	67.86%	+25.00%
CP2	How satisfied are you with the effect the communication process has on your productivity?	13	17	46.43%	60.71%	+14.29%
SDM6	How satisfied are you with the software development methodology you use?	12	15	42.86%	53.57%	+10.71%
SDM7	How satisfied are you with the effect the software development methodology has on your productivity?	13	16	46.43%	57.14%	+10.71%
SDM8	How satisfied are you with the effect the software development methodology has on the quality of the resulting system?	11	15	39.29%	53.57%	+14.29%
PMM1	How satisfied are you with the project management methodology you use?	13	16	46.43%	57.14%	+10.71%
ATP4	The abilities of other participants are well utilized.	14	16	50.00%	57.14%	+7.14%
ATP5	Our cooperation is efficient.	14	17	50.00%	60.71%	+10.71%
ATP6	I am satisfied with the progress we are making in completing our tasks.	11	17	39.29%	60.71%	+21.43%
ATP7	We have no difficulty coordinating our work.	12	16	42.86%	57.14%	+14.29%
ATR18	I am satisfied with the results.	14	18	50.00%	64.29%	+14.29%
ATR19	I am confident that the results are good.	13	19	46.43%	67.86%	+21.43%
ATR20	The results correspond largely to my own contributions.	14	18	50.00%	64.29%	+14.29%
ATR22	The work we've produced so far is of high quality.	13	16	46.43%	57.14%	+10.71%

Table 22 contains the survey items for which satisfaction levels changed by more than 15%. This table was incorporated to assist in the identification of opinions with the

greatest shift during the four-month trial period. The items came from multiple instruments and unlike the previous tables, cumulative totals are inappropriate.

TABLE 22

MATRIX OF GREATEST SHIFTS IN SATISFACTION RATINGS

Topic/Question		Satisfaction Score		Satisfaction %		% Change
n = 4		Before	After	Before	After	
CP1	How satisfied are you with the communication process you use?	12	19	42.86%	67.86%	+25.00%
ATR19	I am confident that the results are good.	13	19	46.43%	67.86%	+21.43%
ATP6	I am satisfied with the progress we are making in completing our tasks.	11	17	39.29%	60.71%	+21.43%
TB5	better user input	15	21	53.57%	75.00%	+21.43%
TB4	more user input	15	20	53.57%	71.43%	+17.86%

Notes Database

The BOSS database issues were divided into two categories during the research process. All issues with a log date and a final revision date prior to the completion date for revision 2.4.1 were identified as using a non-collaborative communication support type, while all other issues were identified as supported by Notes. Issues that were originally logged manually, but had been reactivated due to the need for revision after the installation of Notes, were included in the Notes support category. The total number of issues tracked for each category were counted and placed in the respective cells shown in table 23. Each of these two major categories was then subdivided into three subsets based on priority. Each issue was designated as having a low, normal (medium), or high priority. Each of these was counted and placed in the respective cells.

Table 23 contains the comparison data for BOSS revision 2.4.1, which had no collaborative support and revision 2.4.2, which used Notes for communication support. This table indicates the total number of issues tracked as well as the number of each of

TABLE 23

MATRIX OF ISSUES

Type of Communication Support	# of System Issues Tracked	# of Low Priority Issues	# of Normal Priority Issues	# of High Priority issues
Non-collaborative	66	12	29	15
Notes	64	4	43	17

the three priority classifications assigned by the organization. These data were collected to establish comparability between the two revisions. The depth of the interactions was defined by the amount of detail communicated per issue. After the issues were separated by category, the number of descriptive lines per issue were counted, summed, and averaged. The descriptive line averages for low, normal, and high priority issues were then placed into table 24. The overall average reflects the average number of descriptive lines per issue for non-collaborative support and Notes support.

TABLE 24

MATRIX OF DESCRIPTIVE LINES

Type of Communication Support	Average # of Descriptive Lines			
	Overall	Low Priority Issues	Normal Priority Issues	High Priority Issues
Non-collaborative	3.48	3.75	3.25	3.43
Notes	5.70	5.5	4.47	7.13
% Increase	63.95%	46.67%	37.54%	107.87%

Lack of adequate communication between users, developers, and managers has been cited as a primary factor in the failure of information system projects (Chen, Nunamaker, and Konsynski 1987). Lines of descriptive text were counted per issue as a measure of communication. The lines of text in the non-collaborative section were entered into the Notes database after the fact. The data entered were not modified in any way.

The following is a listing of the abbreviations and formulas used for each of the first two rows of cells in table 24:

NCO = Non-collaborative Overall

NO = Notes Overall

NCLP = Non-collaborative Low Priority Issues

NLP = Notes Low Priority Issues

NCNP = Non-collaborative Normal Priority Issues

NNP = Notes Normal Priority Issues

NCHP = Non-collaborative High Priority Issues

NHP = Notes High Priority Issues

DL = # of Descriptive Lines per issue within the given category

I = # of Issues within the given category

$NCO = \sum DL / I$

$NO = \sum DL / I$

$NCLP = \sum DL / I$

$NLP = \sum DL / I$

$NCNP = \sum DL / I$

$NNP = \sum DL / I$

$NCHP = \sum DL / I$

$NHP = \sum DL / I$

The last row of table 24 shows the percentage increase in the number of descriptive lines found on issues tracked using Notes. The purpose of this information was to determine whether or not more in-depth information was available to the software developers after the incorporation of Notes. These values were calculated using the following formula:

% Increase = (Notes Avg # of Lines / Non-collaborative Avg # of Lines) - 1

The breadth of the interactions, analyzed through the use of table 25, was determined by separating the issues by topic, i.e. the reason for the communication. Four major categories were identified: design issues, maintenance issues, enhancement

TABLE 25

MATRIX OF INTERACTION BREADTH

Type of Communication Support	# of Issues Tracked				
	Design Issue	Maintenance Issue	Enhancement Request	Software Fault	Other
Non-collaborative	3	5	22	36	0
Notes	1	4	25	30	4

requests, and software faults or "bugs". A fifth category was added to count issues that did not fall cleanly into one of the other categories. Issues in the "other" category were evaluated to identify alternative uses of the Notes database. As with table 23, the issues were categorized and counted. No other calculations were performed.

Structured Interviews

Data analysis of structured interviews was conducted using QSR NUD.IST. NUD.IST allows for the creation of an index database, which permits analysis of a

TABLE 26

QSR NODES

Level 1	Level 2	Level 3		Level 4	
Research Question #1	Quality	Positive	3	detail node unnecessary	
		Minor	0		
		No Effect	5		
	Productivity	Positive	5		
		Minor	0		
		No Effect	2		
	Satisfaction	Positive	3		
		Minor	1		
		No Effect	0		
		Negative	6		
Research Question #2	Process	Improvement	4		
		No Improvement	3		
	Performance	Improvement	1		
		No Improvement	1		
	Communication	Improvement	9		
		No Improvement	1		
		Decrease	1		
	Enhancement	Responsiveness	3		
		Design	6		
		Collaborative Tools		Yes	1
				No	5
		Co-existence		Yes	3
				No	4

TABLE 26 - CONTINUED

QSR NODES

Level 1	Level 2	Level 3	Level 4
Research Question #3	Phone	Reduced 2	detail node unnecessary
		No Effect 7	
	Teleconferencing	Reduced 2	
		No Effect 7	
	Voice Mail	Reduced 1	
		No Effect 8	
	Memos	Reduced 2	
		No Effect 7	
		Viable Alternative	Yes 1
			No 0
	Documentation	Reduced 4	detail node unnecessary
		No Effect 5	
		Increased 0	
		Viable Alternative	Yes 1
			No 0
	E-mail	Reduced 2	detail node unnecessary
		No Effect 7	
		Viable Alternative	Yes 0
			No 1
	Meetings	Reduced 1	detail node unnecessary
		No Effect 8	
	Hall Talk	Reduced 2	
		No Effect 8	
	Better Systems	Yes 1	
		No 3	
	Continue to Use	Yes 5	
		No 1	
		Indifferent 1	

research project through the definition and interrelation of concepts relevant to the data. The data, in this case the transcription of the interview, are maintained in a document which can be indexed via nodes. Table 26 provides a representation of the nodes used for analysis of the structured interview data for this study. End nodes hold categorizations of data, whereas upper level nodes identify the hierarchical branching taken in the analysis process. The numbers in parentheses by each description correspond to the nodes in the NUD.IST database. Corresponding nodes can be seen on the sample output from the NUD.IST analysis included in appendix I. The number to the far right of each description is the number of comments made within that category. Comments generated in response to a question were categorized under multiple nodes if applicable to those nodes. The number of comments per construct varies due to the format of the interviews. For example, productivity questions generated comments applicable to group process, quality questions generated comments applicable to productivity, and so on.

At the inception of the data analysis phase, initial nodes were created from the observational issues found in chapter 4. As the interview transcriptions were being processed, the need for further nodes arose. NUD.IST provides the capability to quickly and easily address this need. The hierarchical nature of NUD.IST allows data to be recorded at the lowest level of detail while still maintaining the ability to see the relationship to the original research question.

Summary

Three forms of data were analyzed in this chapter. To establish equivalence of the scope and nature of the two revisions, electronic database data from the non-collaborative

2.4.1 BOSS release were compared to the Notes-supported 2.4.2 BOSS release. Questionnaire data collected at the completion of release 2.4.2 was analyzed quantitatively and showed positive results. Structured-interview data were analyzed using QSR NUD.IST, a commercially available electronic content analysis tool.

CHAPTER 6

FINDINGS, IMPLICATIONS, AND FOCUS OF FUTURE RESEARCH

This chapter draws conclusions based on the analysis of the data in chapter 5. The conclusions address the three research questions regarding the relationship between CSCW and software engineering in a CASE environment:

1. Is there a relationship between CSCW tools in a CASE environment and quality, productivity, and team perceptions of task results?

2. How is the technology perceived by participants and supervisors to affect group processes and technological support?

3. Is CSCW used as a communication extension to CASE a viable and beneficial alternative to traditional modes of operation?

This chapter presents the conclusions drawn by the researcher regarding each of the three research questions, the chain of evidence supporting the conclusions, additional findings that resulted from the research, the limitations and key assumptions of the research, and recommended future research.

Review of Methodology

This research study used a case study methodology, with the three research questions listed in the previous section providing the direction for the study. The research questions were broken into substantive hypotheses that were developed using nonequivalent dependent variables suggested by Yin (1994) and consistent with Eisenhardt's (1989) theory-building process. This technique involves using theory to

predict outcomes. If the theory predicts the outcomes, then causal inferences can be made. In this study, theory based on GDSS literature was used to predict the kinds of results that would be obtained.

In order to determine that the correct causal inferences were drawn concerning the use of theory, a chain of evidence was established for each research question. The chain of evidence contains the steps in the reasoning process that led to the conclusions reached by the researcher. This chapter presents these chains of evidence.

Overview of Findings

Table 27 presents an overview of the findings of this research. To provide consistency with the table representations of the three constructs evaluated by this study, the hypotheses are presented as they relate to the constructs rather than the research questions. The following sections provide an expanded discussion of the findings for each hypothesis.

TABLE 27

SUMMARY OF FINDINGS

Construct	Associated Hypotheses		Findings
Quality	H_{11}	The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher quality in resulting software products.	Perceived improvements in resulting system quality were not seen. However, perceived improvements in quality in terms of process improvement and customer service were found.
	H_{31}	The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication.	Benefits were seen to differ from traditional modes. Data was readily available and current which translated into perceived improvements in process and customer service quality. Previous modes had required team members to identify and catch up with the team member with the necessary information.
Productivity	H_{12}	The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher productivity.	Participants reported mixed opinions as to whether or not the tool improved productivity as the second revision took the same amount of time to complete as the first. However, they did report improvements in task performance and efficiency. This apparent discrepancy appears to be explained by political and training issues.
	H_{31}	The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication.	The productivity benefits of the tool differed from traditional modes. Immediate and accurate access to the data improved access time and thus task efficiency.
Satisfaction	H_{13}	The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with task results.	CSCW incorporation was associated with higher confidence levels in project task results and increased satisfaction with communication tasks.
	H_{21}	The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the group process.	A marginal improvement in group process was seen but may be associated with team development rather than CSCW support. Outside of improvement in the communication process, no support was found for this hypothesis.
	H_{22}	The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the technological support.	Early findings revealed higher levels of team satisfaction with collaborative technological support. However, within six months of this reported findings the collaborative support had been replaced with a non-collaborative tool. The apparent cause was political and training issues.
	H_{31}	The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication.	The benefits differ. Results indicate that CSCW is a viable supplement to, rather than a viable replacement for, traditional modes of communication.

Findings for Research Question 1

Research question 1 was Does a relationship between CSCW tools in a CASE environment and quality, productivity, and team perceptions exist? This research question was broken down into three hypotheses. Chapter 5 contains a list of the steps in a chain of evidence to support an answer to research question 1. These steps were followed for each of the three hypotheses.

Hypothesis $_{11}$

The first hypothesis for this question was as follows: The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher quality in resulting software products.

Researcher's Conclusions

The incorporation of Notes was associated with perceptions of higher quality in terms of process improvement and customer service rather than the resulting software release, as predicted. Quality benefits of the tool were seen in the immediate and accurate accessibility of the data.

The findings are consistent with Aiken and Carlisle's (1992) study, which demonstrated that group memory improves recall and accuracy. The group memory component in this study was provided by the Notes database. The improvement in recall and accuracy is fundamental to the improvements seen in customer support quality, task process quality, group process quality, communication process quality, and confidence in the quality. However, the findings differ from prior studies that found an increase in

system design quality as a result of electronic collaborative support (Ellis, Rein, and Jarvenpaa 1989-90: Olson et al. 1992).

Chain of Evidence Supporting the Conclusion

The following discussion presents a summary of evidence collected at each of the applicable steps.

1. As predicted by GDSS and CSCW theory, group memory assists with quality improvement.

Questionnaire ratings indicate that overall quality ratings improved by 9%. The greatest improvement -- 21% -- was in confidence in the quality of the results.

2. Structured interview questions were designed to probe for additional data that would facilitate the understanding of the findings from the questionnaire.

The results of these structured interviews indicate that because of the electronic data repository or group memory, participants were able to locate the information they needed to assure them that the system release was good. This finding, however, does not correlate strongly to an improvement in actual system quality. The structured interviews revealed the participants' definition of quality to include customer support quality, process quality, and confidence in the quality rather than the degree of excellence in the resulting software product. Customer support quality was improved because participants could tell customers, in an expedient manner, what issues had been changed in addition to the status of any changes waiting to be worked. The process quality improved because the participants had one location to go to for the necessary information. Confidence in

quality occurred as a result of knowing which issues had been worked and which still needed attention.

Data analysis of the structured interview transcriptions revealed that the improvement in quality was not seen in the finished release of the BOSS product. As previously stated, the increase in quality was seen, rather, as an improvement in the availability of the data, the process, and customer support.

The following comments from the structured interviews illustrate this point.

> "For those that did use it [Notes], it did improve the quality of the system. There was an immediate availability [of the data]."

> "Quality in my mind -- helping us to communicate with our customers when they ask us questions. You could say, yes, this is the status of that issue; these are the issues you need to test. Just the quality of the process, I guess, is what it improved, but of the final product maybe not as much because -- even using Word by the end, we got it all figured out. It was just a lot harder to figure out. So I think it improved the quality of the process more than it improved the quality of the product. But it helped in the communication with the customers, which I think is part of the whole package. I mean the quality of your release is your ability to communicate with your customers, and their frustration level is part of what they picture as quality. If you can't even tell them what they need to test, they get really frustrated."

> "The change in the quality would be a change in the process, and I think the change in the process is probably a bigger percentage than the improvement to the final product because, in the old way of doing it, there was just more confusion. In the end we got it all figured out but it was just after a lot more cycles than it was doing it the new way. I think the changes in process do filter through to the final product, but the focus of this improvement is the process."

These findings reveal that quality is a multi-dimensional variable that should be broken into sub-variables. Quality variables revealed by this study are customer support

quality, task process quality, group process quality, communication process quality, confidence in the quality, and availability of the data.

3. The expert panel was interviewed to provide additional views and measures of quality.

Interviews with the expert panel confirmed that the value of the tool established by the participants was indeed accurate. The panel, in agreement with the team, contended that the team produced as high a quality product without benefit of Notes. However, they confirmed an improvement in the process and in customer service. The following two comments are representative opinions.

> "I didn't see a quality shift one way or the other."
>
> "But as far as just getting the issues into a common issue management system as opposed to the three or four files they were in, there was an improvement in that too, and everyone could go in and edit it at multiple time. Multiple people at the same time so that in itself was an improvement. "

Hypothesis $_{12}$

The second hypothesis for this question was as follows: The incorporation of a CSCW tool into a CASE environment will be associated with perceptions of higher productivity.

Researcher's Conclusions

The incorporation of Notes was associated with improvements in task performance and efficiency, but participants reported mixed opinions as to whether the tool affected overall productivity as predicted. This apparent discrepancy appears to have occurred due to political and training issues. The CSCW-supported revision took the

same number of months to complete as the previous non-collaborative revision. However, possible confounding factors were uncovered during the structured interviews, which revealed a lack of understanding of the tool due to insufficient training and resistance issues. Team dissention over whether or not to use the tool, coupled with learning curve issues, resulted in delays that caused a loss of productivity in the early stages of revision 2.4.2.

The productivity findings are consistent with Pinsonneault and Kraemer's (1989) review and assessment of empirical research on the effects of EMS, which indicate electronic support task performance time. Had a decrease in task performance time not been present, the early loss of productivity, due to training and behavioral issues, would have prevented the 2.4.2 from being completed in a time frame equivalent with 2.4.1.

Chain of Evidence Supporting the Conclusion

The following discussion presents a summary of evidence collected at each of the applicable steps.

1. As predicted by GDSS and CSCW theory, the technology has the capability to improve system development productivity.

Questionnaire ratings indicate that overall productivity satisfaction ratings improved by 9%. The largest improvement -- 21% -- was in the team's satisfaction with their progress in completing the task.

2. Structured interview questions were designed to probe for additional data that would facilitate the understanding of the findings from the questionnaire.

The results of these structured interviews indicate that the electronic data repository allowed participants to locate the information they needed in a timely manner, making them much more efficient. The participants saw this as a task improvement more than a productivity improvement. They reported mixed opinions as to whether or not Notes improved the overall productivity for the project.

> "I don't believe so [improved productivity], because I don't think there was enough usage. There were some people that were resistant to using that particular mode of communication, so there was more of a mind set that, no, it was not going to do its job -- no, I don't want to use it because. That was the kind of stuff we were fighting. Those that did use it did see that there was a benefit to it, but they could not understand the power of the tool. I believe that will change over time. . . . Lotus Notes, specifically, is a very powerful, flexible tool. The flexibility is the thing that sets it apart because, if you don't understand what you can do with it, you lose the power."

> "It helped us be able to keep track of what had already been fixed and what needed to be fixed. So in my mind, yes, we were a lot more efficient. We weren't reworking and answering the same question. So I think, yes, it made us more productive. We were getting by on Word; it was just a lot more confusing as to what had already been worked, what issues were in this release, what's the status of it. It helped us track the status more efficiently."

> "That's a tough one. Yeah, it probably improved the productivity, but a lot of the increase in productivity came from experience within the system. You have to remember that a lot of people were doing the system at the time, so you anticipate things not going smoothly the first time; so I don't how much of that was attributed to Notes. It was definitely more organized and was more of a cookbook recipe, but that was about it."

3. To further investigate productivity, the issues from each BOSS release were counted, time dated, and evaluated for detail.

Analysis of the Notes database revealed that the number of issues tracked in non-collaborative development of BOSS 2.4.1 was 66. The number of issues tracked using

Notes for BOSS 2.4.2 was 64, making comparison of the two viable. Each release took approximately four months. This finding confirms the team's view that overall productivity was not affected.

4. The expert panel was interviewed to provide additional views and measures of productivity.

Interviews with the expert panel confirmed that the perceptions regarding the effects of Notes established by the participants were accurate. The panel, in agreement with the team, contended that Notes made the team more efficient and provided task improvement, but they were unclear regarding overall productivity.

> "I don't know that there was a significant productivity improvement. There were some task improvements. You didn't have to go to three file and try to find issues, and you didn't have to resolve duplication when something was in multiple files. So for that particular task, there was productivity improvement. As far as using Notes for the overall project and it helping, I didn't see a lot of that."

> "There probably was. I know that after going to Notes, they seemed to be more organized and were able to find things quicker. If a question came up about an issue, they were able to find the answer quicker."

Productivity and group process responses also revealed initial team dissention about using Notes.

> "I don't think there was enough usage. There were some people that were resistant to using that particular mode of communication, so there was more of a mind set that, no, it was not going to do its job. No, I don't want to use it because -- that was the kind of stuff we were fighting."

> "When something comes in new, you always have some resistance. I was one of them. But after a while, after I used it, I realized this is the only tool that can really help us because we don't have another choice. So after I used it, I liked it. It's better than nothing."

Hypothesis $_{13}$

The third hypothesis for this question was as follows: The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with task results.

Researcher's Conclusions

The hypothesis predicted higher levels of satisfaction with project task results. Findings indicated that the incorporation of Notes was associated with higher levels of team satisfaction with communication task results and higher confidence levels in project task results. Participants reported no change in satisfaction with project task results.

Chain of Evidence Supporting the Conclusion

The following discussion presents a summary of evidence collected at each of the applicable steps.

1. As predicted by GDSS and CSCW theory, satisfaction with the technology and task results is positive even in the absence of productivity differences.

Questionnaire ratings indicated that overall satisfaction ratings improved by 9%. The largest improvement of 25% occurred in the team's satisfaction with the communication process used. A rating increase of 21% was assigned to better user input. Additionally, confidence in the quality of task results increased by 21%.

2. Structured interview questions were designed to probe for additional data that would facilitate the understanding of the findings from the questionnaire.

In the structured interviews, participants expressed positive benefits regarding a central database repository, accessible by all, for issue information. User input was improved because information could be keyed into the database at the time the user called and was not lost in a single member's word processor or on a slip of paper. Participants also had the capability to provide better user support because they could share the status and changes affecting the user. A common thread throughout the responses was the improvement in organization.

> "It just helped us be organized more. It helped someone who was not familiar with all the individual issues to go in and get a status of it. This team member knew about this issue and that team member knew about that issue, but it helped someone get an overall picture by going to one place, but the team pretty much functioned the same way. It would help someone who was not familiar with every individual issue come and get a status on it and to look at the big picture. Like from a project management standpoint, it would help your project manager go and see where you were instead of having to go to this person to find out the details of this issue and this person to find the details of that issue; they could just go get the big picture in one place."

> "It helped improve the process that we were working through. It helped us track the status of all these issues of each release. Because I mean there have been releases before we even started using Word, where we couldn't tell the customers all the enhancements that had been implemented. They didn't know what to test. Using IEF you just said we'll just regen the whole model and everything that has been changed will be in there, but you couldn't tell your customers specifically what was going to change before we started using Word. It got a little bit better with Word, and then it got a little bit better with Notes."

> "Lotus Notes strictly is a documentation tool. It tells us what problem has occurred, what problem we have fixed. That's it. It doesn't really help us to do our job . . . . It doesn't really help us to fix the code. We still have to go ahead and look into the code and fix it then come back and do the recording stuff. It helped our productivity in the documentation side, but other than that -- no way."

> "When we had Notes, we had all the problems within one program right there. It was like a title that said these are all the bugs in this particular program. So when we actually went and fixed that program, we actually fixed all the bugs, whereas I think in the previous release, it was different people getting into the same program and you tend to step on each other and that can cause a lot of problems. In Notes you have one person working in one program."

3. To further investigate reasons for task result satisfaction, the lines of descriptive text for issues from each BOSS release were counted and evaluated for detail.

Analysis of the Notes database revealed an overall 64% increase in the amount of information available for all issues after the incorporation of Notes. High priority issues benefited from an 108% increase in information available to the participants. However, participants did not seem to be aware that, in addition to the benefits of a central repository, they had immediate access to a twice as much data.

4. The expert panel was interviewed to provide additional views and measures of satisfaction with task results.

Interviews with the expert panel confirmed the value of Notes in respect to user support and communication task results. In agreement with participants, expert panel members stated that the most positive benefits were realized through the improvement in the communication process facilitated by a central location for the data, although team evolution may have played a role.

> "Each project that we did, we started working together a little bit better. So the collaboration on getting information into Notes, converting into Notes was a positive experience. But in general I could not attribute it to just using Notes; it was more the evolution of the team."

> "I think it did improve some, especially in the areas of communication and documenting those areas of communication because now they had one

> common repository for gathering all that information. A lot of the times that we communicate we are here physically close. We communicate well, but everybody's using something different. It may be as different as electronic and paper and fax and everything else, and it's not collected so there is no one place to go look for everything. Everything got communicated, but when you need to back and find it later a lot of time it doesn't happen. So I think from that respect it benefited from Notes."

Findings for Research Question 2

Research question 2 was How is the technology perceived to affect group processes and task performance? This research question was broken down into two hypotheses. Chapter 5 listed the steps in a chain of evidence to support an answer to research question 2. These steps were followed for both hypotheses.

Hypothesis $_{21}$

The first hypothesis for this question was as follows: The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the group process. GDSS research suggests that established groups view electronic communication as an enhancement to the group process. This hypothesis was designed to confirm or refute previous findings.

Researcher's Conclusions

The findings did not support the premise that the incorporation of a CSCW tool into a CASE environment would be associated with higher levels of team satisfaction in the group process. Although satisfaction increased a marginal 4%, this increase, as indicated by several respondents, may be associated with team development rather than the tool. In contrast, the findings supported higher levels of satisfaction with the group communication process.

Chain of Evidence Supporting the Conclusion

The following discussion presents a summary of evidence collected at each of the applicable steps.

1. Data were collected via questionnaires regarding the team's perceptions of group processes prior to the implementation of Notes. The results were compared to responses collected from identical questions administered after the completion of the project, BOSS release 2.4.2. This comparison made it possible to establish whether Notes was perceived to affect group process and task performance.

Questionnaires indicated that a minimal overall improvement of 4% was seen after the second BOSS release. Only two items revealed a significant increase in satisfaction: Satisfaction with the progress in task completion improved by 21%. Satisfaction with task coordination improved by 14%.

Communication processes within the group were the focus of the greatest increase in satisfaction, with an overall elevation of 15%. Satisfaction with the communication process increased by 25%, whereas satisfaction with the effect of the communication process on productivity increased by 14%.

2. The comparison of results from the pre- and post-study questionnaires led to the development and conduction of structured interviews with participants to further clarify how Notes was perceived to affect the group process and task performance.

When asked about the effects on the group communication process, the common thread among responses was that the database repository made the group more organized

and that data were easier to find. The following is a representative sample of the comments obtained.

> "I feel like it improved it because there were some issues that were just in someone's head or on paper but not recorded, and once they implemented Notes and instituted it, made to follow it and use it, they had better visibility of all the issues."

Structured interview questions regarding the group process revealed a group suffering from disorganization and resistance. The group was initially split, with one faction wanting to use Notes, the other seeing no reason to change. One member said that Notes had improved group communication and thus the group process because, while the group was arguing, they were at least communicating.

> "I think it improved it because one half was saying 'there it is go look at it', and they were at least talking to one another even if it was arguing. It's sad to, say but that is what I see."

> "If only one person is doing it and the rest are not, it is not going to work -- even worse than before. Some people record and some are not. It causes even more conflicts because when you have nothing to report you know nothing. Once you are recording you will see the problem. It was not a function of the utility itself. It is how our group used it."

> "It definitely improved our communication by getting us to talk to each other. Prior to that everyone would stay in their own cube and go about their own business."

Questions regarding whether or not Notes had improved the process generated further negative comments about the team.

> "It will improve it depending on the team. If you have a disorganized team like we did, then yeah, Notes is definitely going to improve it. But if you have an organized team that uses Microsoft Project or someone who is very structured needing it, then I don't think it makes any difference."

> "Those that wanted to use it seemed to benefit, and they would have seen and produced a lot of the benefit from it. Those that didn't want to use it would find reasons why it wasn't going to work. I wouldn't want to say they sabotaged it, but there was an awful lot of foot dragging to become accustomed and learn it."
>
> "I think that I saw some of the motivation to make it work, and I saw that they started to scratch some of the productivity, but I couldn't speak they had a lot of it. Because I still think it was affected by some of the people that said 'no, we ain't going to use it.' But then again I think the small groups are going to use it and are going to benefit, and those that don't want it are going to find ways of not accepting it and let it die."

3. The expert panel was interviewed to provide additional insight into the group process and task performance.

The expert panel was also aware of the battle over the mandated shift to Notes. One member's view was that, once the team realized that they were about to miss deadlines over the disagreement, they united, albeit grudgingly, to make Notes work.

> "In my opinion they stirred up the pot and they wanted to see where the dust was going to settle. And they figured they better do something because they were getting nowhere fast by arguing among themselves. So I did see that there was a benefit to that. They rallied around a focus point. They are finally going to agree to just get on with it. That's kind of what I see. External forces had been changed. I think that they didn't have the focus anymore on resistance. I think the focus was on 'Oh God, we won one battle; now we better get to work.' I think that they said, 'we don't want to use, we don't want to use, we do want to use, we do want to use.' I think that they battled that for so long that, finally, a lot of the other external forces finally took effect. 'Let's take this tool and get in place with it and either prove that it works or prove that it doesn't.' "

4. The results of the interviews were subjected to content analysis using NUD.IST.

The results of the content analysis indicated a split in views as to whether or not Notes had improved the group process. Four comments indicated improvement, while three indicated no improvement. However, content analysis confirmed the separation of

the communication process from the group process. Nine comments regarding improvement in the communication process surfaced, with one referencing no improvement, and one contending a deterioration.

Hypothesis $_{22}$

The second hypothesis for this question was as follows: The incorporation of a CSCW tool into a CASE environment will be associated with higher levels of team satisfaction with the technological support. GDSS research suggests that participants were more satisfied with collaborative tools, than non-collaborative tools even in the absence of gains in productivity. This hypothesis was designed to confirm or refute these findings.

Researcher's Conclusions

Early findings from questionnaires supported this premise in terms of communication and CASE technology. Structured interviews revealed that, although participants had expressed satisfaction with Notes six months earlier, Notes was no longer being used by the team.

Chain of Evidence Supporting the Conclusion

The following discussion presents a summary of evidence collected at each of the applicable steps.

1. Data were collected via questionnaires regarding the team's perceptions of electronic support technology prior to the implementation of Notes. The results were compared to responses collected from identical questions administered after the completion of the project, BOSS release 2.4.2.

Questionnaires allowed for analysis of participant satisfaction changes for communication technology, system development technology, and CASE technology. It further allowed for analysis of two closely related topics: system development methodology and project management methodology.

Although communication process satisfaction had increased by 15%, communication technology satisfaction increased by only 8%, indicating a discrepancy between the process supported by the tool and the tool itself. System development methodology satisfaction increased by 12.5%, while team members reported an increase of 9% in project management methodology satisfaction. However, the BOSS project manager reported a 28% increase in satisfaction with the project management methodology.

System development technology had a minor decrease in satisfaction (1%), while CASE technology benefited from a 9% increase in satisfaction. The four CASE technology benefits most fully realized were more user input (17%), better user input (21%), better standardization of resulting system (14%), and easier prototyping (14%).

Questions specifically referencing Notes indicated that participants had a 68% satisfaction rating with the communication technology. Participants reported an 82% desire to continue to work with Notes.

2. The comparison of results from the pre- and post-study questionnaires led to the development and conduction of structured interviews with participants to further clarify how Notes was perceived to affect the group process and task performance.

Structured interview questions regarding the technology revealed frustration with the lack of training, which led to insufficient understanding of Note's capabilities. Several participants believed limitations in the application to be flaws in Notes instead of design flaws in the application. Another complaint was the lack of adequate response time. The issue-tracking application was cumbersome and slow.

Structured interviews revealed complaints about data fields needed but not included in the Notes database. Lack of training and understanding of the tool's capabilities led team members to believe that this was a limitation in Note's capabilities.

Complaints that Notes did not have an intuitive graphical user interface (GUI) were also verbalized. One respondent anticipates that products which allowed users to interface with Notes via a standard Web browser will significantly improve ease of access. He advocates allowing the user to choose between a Web interface and the traditional access interface.

Response time in the database application being used by the team was cumbersome and slow. A speed issue encountered in the early stages of utilization was a database design flaw that caused the system to rewrite a record after every field change. After correction of this problem, response time improved significantly but was still unwieldy enough to be reflected in dissatisfied comments by the team.

3. The expert panel was interviewed to provide additional insight into the group process and task performance.

Expert panel interviews revealed yet another problem that arose from lack of realistic expectations. Expert panel members had heard that "one could do anything" with Notes and were disappointed with its performance.

Another expert panel member who, at the time of the interviews, had left the BOSS project and was working in a different area of the organization with a Notes database that provided full SDLC support stated that the technological support was greatly improved. The product unfortunately did not possess any better response time.

The structured interviews also revealed that participants and expert panel members alike did not feel it was necessary to incorporate collaborative capabilities into Composer. In fact, the general consensus was that any attempt to incorporate such tools would cause massive problems within the CASE tool. One respondent stated that the linking between the two technologies should occur at the library level.

4. The results of the interviews were subjected to content analysis using NUD.IST.

Content analysis revealed that 50% of the respondents believed the coexistence between Notes and Composer was smooth, whereas the other 50% believed that because the two were separate tools, there was no coexistence between them. One respondent contended that Notes and Composer should link at the library level, and one stated that a desirable enhancement would be the ability to share reports between the two although they were not optimistic about ever having this capability.

Findings for Research Question 3

Research question 3 was Is CSCW used as a front-end to CASE a viable and beneficial alternative to traditional modes of operation?

Hypotheses $_{31}$

The single hypothesis for this question was as follows: The benefits of CSCW incorporation into a CASE environment will differ from traditional modes of communication. GDSS literature suggests that different tools are better suited for different tasks. This hypothesis was designed to confirm or refute previous findings.

Researcher's Conclusions

The findings indicate that CSCW is a viable supplement to traditional modes of operation rather than a viable alternative. This finding is consistent with Alavi's (1993a) study, which found that electronic communication enhance rather than replace verbal communication.

Chain of Evidence Supporting the Conclusion

The following discussion presents a summary of evidence collected at each of the following steps.

1. Questionnaire data collected on methods of communication prior to Notes established the traditional modes. This step was necessary for evaluation of the traditional environment.

From the data collected, it was ascertained that the following list represents all forms of communication prior to the incorporation of Notes: personal phone conversations, teleconferencing, voice mail, memos, documentation, e-mail, meetings, and informal discussions referred to as "hall talk" by participants.

2. To establish participant's opinions of Notes, open-ended questions designed to collect participant's views were included on the post-implementation

questionnaire. This step was performed to provide the mechanism for designing structured interview questions regarding alternative mode of communication provided by Notes.

The open-ended responses identified no forms of communication that had been omitted from the list.

3. Structured interviews with participants and the expert panel provided the richest data for this question. The results from these interviews, when compared to those of the previous step, provided a barometer for the attitudes and awareness of the participants.

All respondents agreed that Notes was a viable supplement to the traditional forms of communication. None of the participants regarded Notes as a replacement for any of the traditional communication modes. Responses varied by participant, indicating that each individual may have a differing level of dependence on Notes.

> "Personal phone conversations it reduced because they could go out and look at the status on Notes instead of having to call someone. It was used in conjunction with teleconferencing -- we would use that as a tool during the teleconference, so it probably didn't reduce the number that we held. It just helped facilitate that process. It probably reduced phone conversations by 10-20%, and the probably voice mail would be the same because usually when you try to call someone they aren't there and you wind up having to go back and forth. Memos -- there is probably the same number we don't really write memos -- we use the internal message system, which is like e-mail, so there probably wasn't a whole lot of memos to start with. Documentation -- there is probably the same amount of documentation. It is just stored in Notes, and it is all in one place because the documentation was probably there -- somebody had it stored on their PC. You just couldn't get to it. So it didn't reduce the amount of documentation; it just helped the accessibility of it. E-mails were probably the same because they were still sending e-mails. We were tracking them and attaching them to Notes. It didn't change the number of

> meetings. Informal discussions we refer to as "hall talk", and that is probably the same as phone conversations because you are either going to talk to someone in person or call them up because the kind of stuff we would be asking each other was informal type. If you wanted to find out the status of something you would find them and ask. We wouldn't hold a meeting to do that."
>
> "No, it hadn't replaced any of it. Has it simplified it or reduced it? Yes. A lot of e-mail. I think it should have, but I don't know if it actually had any effect on meetings and teleconferencing. But once again, the mindset and the attitude of some of the folks was 'Hell no. It isn't going to change anything. We're still going to have to make our trips.' They still have a guy that runs back and forth across the pond. I think he is on boondoggle. It is truly pathetic that happens."

4. Structured interview data were analyzed for content using NUD.IST.

Two respondents stated that Notes had reduced their phone, teleconferencing, and voice mail usage by 10-25%. Two participants also stated that the number of memos had been reduced. The general consensus was that the quantity of documentation had not changed; rather, the form was different. The number of e-mail messages had not been reduced. However, e-mails, which previously had documents attached, were simply referencing issues in the Notes database, thus reducing the physical size of the e-mail.

The number of meetings had not changed. However, one respondent stated that it would have been valuable to have access to the Notes database during the meetings. Two respondents contended that hall talk had been reduced, while others contended that it was a lot easier to pass someone in the hall and ask a question than check the database.

Of the respondents, one did not want to use Notes in the future, one was indifferent, and the others stated that Notes was still the best tool available for the task.

Additional Findings

Despite the positive responses given at the completion of the four-month trial period with Notes and a 82% response rating that team members wanted to continue to use Notes, six months later, a decision was made within the organization to discontinue the use of Notes in favor of a different tool, Expert Advisor (EA). EA is not a collaborative tool, thus placing team members, once again, in a position in which they must contact a single individual to find out the status of system issues.

> "We are not using Lotus Notes anymore. Right now we are relying on EA, which uses one person to input into EA. . . . Like with Bill [name has been changed], he is the one to input into EA. If he couldn't solve the problem, he pushed it to become a discretionary item, which means the second line of production support which we can work on later when we have time. When we push it to discretionary then we use Lotus Notes. So in my mind it is the same old stuff. Why put it in two different places? I still enter into Lotus Notes because I believe that is still the only thing that fully serves what we need. It's not perfect, but it's ok."

Despite very positive initial findings at the end of a four-month period of using Notes, the tool appears to have been ultimately rejected for several reasons: First, a lack of training and understanding of the tool caused the team to believe that Notes database design flaws were the fault of the tool, when in reality they were a limitation of the Notes database design and coding created by one of the team members. This lack of training resulted in a failure to understand Note's capabilities:

> "It doesn't have a field or a place to record what we changed because one transaction can have several blocks external, internal, action block. So when you just say this transaction has problem, you don't know where it actually changed. Do you see what I'm saying? So it doesn't have the ability to record what really has been changed as far as the location in the code."

The lack of training also led to frustration on the part of the team members. The following comment also illustrates the lack of user involvement during the early phases. The adverse effects thus are consistent with previous research (Lucas 1975; Hirschheim and Newman 1988).

> "I think there was a level of frustration because I'm not sure they did all the training they needed to do on how to use Notes, and it may be to the point where they say 'Here's Notes. Install it on your machine. Go use it.' . . . Notes is not intuitive. Unlike a web browser, it is not intuitive on how you use it. And once you get much beyond the surface of Notes, especially if you want to originate content, it can be very confusing. So I think they probably didn't do as good a job on training. And I think that is across the board. I think we always make the mistake on training. In general, training always gets the short shrift on things. It is always the last thing to be considered. It is sometimes the most important thing to be successful. Otherwise, you put the technology out there and people don't know how to use it. So I think in this case they probably underestimated what they could have done with training."

A second reason for the failure appears to be user interface and response issues. This is compatible with Hirschheim and Newman's (1988) categorization of factors contributing to user resistance.

> "Companies build self-serve automation with Notes, but the ones that I have seen are very crude, and it is multiple databases for a single self-serve automation and I would prefer to see it as one integrated GUI front end, not having to understand Notes for the tools you develop."

> "It [Notes] seems to be very cumbersome in responsiveness. It could be the way the database is designed, but it seems to take forever for it to respond. I live in a fast society and I work really fast and I type really fast and I want Lotus Notes to work really fast and it doesn't work as fast as I do."

Yet another problem surfaced in the lack of realistic expectations of Notes capabilities:

> "I would think there would be some limitations, although I hear through the grapevine that you can do anything with it [Notes]."

Using Notes also required extra time on the part of the team members who were required to document issues using Notes. This finding replicates Grudin's (1993) finding that the individuals who benefit the most from groupware are not those who have to use it.

> "[Notes is] time consuming to actually document everything and actually use it."

> "Well, it's just the typical, 'It takes more time to input' as you go. You have to input the status, but it is kind of a necessity. You have to invest that time so you can track it better when you go back and try to reference it. Also, it was a new tool, so everybody was trying to learn how to use it. It was a new application, but it's going to be that way any time you try and start using something new. There are people who didn't know how to use Word when we started using Word. Pretty sad, huh?"

The increase in the number of descriptive lines regarding each issue indicates that more information was available to the team. The cost associated with this increase in information was in time. Each team member incurred overhead costs in maintaining sufficient detail to communicate the nature and status of each issue.

The tool also forced communication and social interaction on the team members. Potentially, this may have been viewed as a loss of autonomy and privacy. The nature and structure of the database provided a mechanism for each team member to view the status of issues being worked by their counterparts. Grudin (1993) noted in his research that groupware may lead to activities that threaten or damage the existing social structures, which in turn contributes to the ultimate failure of the tool.

Additionally, the team was dysfunctional and, as confirmed by research, technology is no substitute for the team (Goodall 1996). The group was split as to whether to use Notes or not. When asked if the team worked together better, worse, or the same after they started using Notes, one participant replied,

> "That's a hard question. Those that wanted to use seemed to benefit, and they would have seen and produced a lot of the benefit from it. Those that didn't want to use it would find reasons why it wasn't going to work. I wouldn't want to say they sabotaged it, but there was an awful lot of foot dragging to become accustomed and learn it."

One of the expert panel members also stated,

> "To me, strong interpersonal communication and physical, verbal communication is imperative for a team to work well and if we are not doing that then we have other problems. No tool can help you combat that problem. "

Furthermore, a change in managers cost Notes its champion. The new manager did not fully understand the power of the tool, and the response to the disagreements within the team was to replace the Notes with a different tool. Additionally, the project manager, who was a major supporter of Notes, took a leave of absence thereby further weakening support for the tool. Observation by the researcher raised the possibility that the team member responsible for programming the tool may have lost interest in Notes once the task was no longer challenging.

Notes was also being used in a globally distributed environment. Although this study focused on the communication process among team members at a single site, the Notes database was being replicated for use by a European counterpart. The replication

process was cumbersome, at best, due to telecommunication delay factors and the size of the database.

Lastly, Notes' full range of capabilities was not fully utilized. The database design created for the project did not provide full life cycle support. However, research has shown that even full life cycle support tools fail in the hands of dysfunctional teams (Goodall 1996). Additionally, Notes was not used for communication support. The team continued to use their own e-mail system.

> "I think Notes would make a bigger difference if you use Notes as a communication tool -- you know, like your e-mail. I've been to other accounts where that was their e-mail, which is great if you are off site or remote like we are, but we never used it in that capacity. We used our own internal mail."

As a whole these factors lend additional support for the findings of Davis, et al. (1992) that information system abandonment should be evaluated by examining the combination of both technical and sociological difficulties.

Implications of the Findings

This study explored the possibility for the formation of a synergistic union between CSCW and CASE tools. Modern organizations use cross-functional teams of developers to develop large and complex software systems. CASE tools, while designed to assist in the development process, have relatively little collaborative support built in. The complexity of the dialogue and poor communication between users, developers, and managers are major factors in information system failure (Chen, Nunamaker, and Konsynski 1987). CSCW tools are designed to enhance communication by providing process and task support. This study revealed positive improvements in areas of quality,

productivity, and satisfaction. However, despite the positive findings, the tool was ultimately rejected.

After the incorporation of the CSCW tool, Notes, positive improvements were seen in customer support and process improvement but not in the quality of the resulting product. Perhaps most important was the improvement in customer support. Any team member could log customer requests and answer customer questions rather than deferring to a single member of the team, who might be unavailable. In today's complex and competitive environment, customer service and satisfaction are key elements in maintaining or improving an organization's competitive position.

The developers were able to quickly identify the status of a particular issue via the Notes database. This provided a benefit to the organization in terms of valuable resource savings and improved customer support. Data were readily available and current in contrast to the previous mode of having to identify the team member with the necessary information, followed by attempts to catch up with the individual either in person or by telephone. Prior to the incorporation of Notes, team members ran the risk of working the same issue without knowledge of the duplication of effort. The quality of the documentation improved, which, in turn, also improved the communication process and efficiency.

Through the improvements in communication support, the tool provided increased task performance. Increased task performance relates to resource savings in time, people, and money, which, in turn, is important to an organization's competitive position. However, although the study revealed that the two BOSS revisions were virtually

identical in scope and nature, each took approximately four months to complete. Findings suggest several reasons for similar completion periods despite the process and efficiency improvements. First, the learning curve cost the team time in the earlier stages of the second revision. Inadequate training compounded this problem. Second, the Notes database had to be designed, programmed, and tested. Third, resistance to the new tool and dissention in the team resulted in lost time due to arguments and foot-dragging. Contributing factors to user resistance may have been the lack of up-front user buy-in compounded by a lack of unified management support for the tool.

The CSCW incorporation resulted in higher confidence levels with the project task results. This finding appears to be related to the availability of the data that assured the members that the necessary work had been performed. Additionally, the team reported increased satisfaction with the communication tasks. If, indeed, poor communication contributes to system failures, then communication task improvements are important.

The CSCW tool did not appear to have a major effect on the group process other than getting the team members to communicate, albeit through discussion regarding individual opinions concerning tool utilization. A marginal improvement in the group process was seen, but this may have been associated with team development rather than the CSCW support.

After four months of CSCW usage, team members reported strong positive opinions regarding satisfaction with the technological support and an even stronger desire to continue using the tool. Yet, as previously mentioned, within six months the tool was

no longer being used. Implementation of a new tool such as Notes is an expensive and time-consuming investment. Knowledge of factors that cause a CSCW tool to fail is important to an organization that wishes to avoid the expense and effort associated with CSCW incorporation. Contributing factors included insufficient training, unrealistic expectations, additional work load on team members, team dysfunction, loss of tool champion, design issues, replication issues in a globally distributed environment, and capability underutilization. Adequate training of management as well as team members would potentially mitigate several of these factors. Newer releases and faster equipment may, in the near future, address the replication problems. The organization may also wish to consider incorporating group skills training and user buy-in before dictating the use of a new tool.

Finally, the research found that CSCW support supplements traditional modes of communication but does not replace them. The support reduced the amount of telephone tag and catch-up playing engaged in by the team members but did not replace personal conversations, either formal or informal. Organizations should keep in mind that a CSCW tool would be an addition to their toolset. Cost justifications and precautions should be taken accordingly. While this research focused on the incorporation of CSCW and CASE, many of the lessons learned are applicable to the introduction of new technologies in general.

Limitations and Key Assumptions

The inherent limitations due to the nature of the case study approach used in this study are numerous (Cook and Campbell 1979; Buckley, Buckley and Chiang 1976; and

Campbell and Stanley 1963). Many of these limitations were identified prior to data collection, and all precautions that were identified and feasible were taken.

First, the study was primarily limited to the present. Although retrospective questioning was performed, the effects of history and time may have affected the subjects' opinions or memory of events. Because time effects were a concern, multiple data collection points were used to mitigate any serious effects in perceptions due to historical events.

Secondly, a lack of control due to the field setting was present. This limitation, in a case study setting, however, is more of a strength than a weakness. A broader range of findings is possible in a case setting than in a tightly controlled, closely defined experimental study.

A further limitation attributable to the nature of the field setting was the size of the study group. However, the availability for a comparison data prior to the intervention was believed to outweigh this limitation.

Next, measures were primarily self-reported and may have suffered from the problems inherent with this type of data collection. This limitation, like the lack of control in the field, was viewed instead as a strength. By collecting opinions of IS professionals in industry, the research was able to target the perceptions of the technology's greatest strengths and weaknesses in addition to the technological support needs of the participants.

Without experimental control, exact determination of cause and effect was impossible. Nonetheless, the chain of evidence did provide the opportunity to build

toward causal inferences. Additionally, the nature of the field setting, coupled with the design of the study, precluded study of additional teams because of availability and time constraints. Thus, generalizability is limited. Future case studies should be added to the results of this research to address this limitation, as suggested by Eisenhardt (1989).

Although every precaution was taken, researcher bias and observational deficiencies may have weakened the value of the findings. This limitation was addressed by evaluations of the findings by the expert panel. Furthermore, boundaries were difficult to draw around the research problem. However, discovery of future research directions and variables would have been curtailed in a more highly defined study.

Because of the lack of research in the realm of CSCW / CASE integration, flaws may have been present in the data collection tools. Multiple data collection techniques were used to mitigate this limitation, as suggested by Eisenhardt (1989).

Lastly, the CSCW tool (Notes) selected for the study may itself have been a threat. Notes is not intuitive to use, and this, coupled with the lack of training and the natural resistance to a new product, may have biased the outcome. Additionally, the Notes database design was flawed, and although this was not the fault of the tool itself, the design problems resulted in dissatisfaction by participants. Furthermore, the lack of a GUI interface and response time issues may have adversely affected participants' opinions.

The key assumption was that the benefits of field research studying established teams that actively used a CASE tool would offset the negatives of the research design. The participants were an established team of professionals who were considered unlikely

to succumb to a Hawthorne effect. A corporate decision had been made to incorporate Notes into the environment, and the participants, the expert panel, and the organization were extremely interested in unbiased results from the research. The participants knew that Notes was to be installed whether or not the research took place. The expert panel thought that the participants were more interested in whether Notes would improve their work environment and work flow than they were with the presence of the researcher.

A further key assumption was that, although no comparable control group was available, before and after data were available on comparable SDLC tasks. The ability to collect data on an identical process within the same system prior to the incorporation of Notes provided the opportunity to compare the findings to a control set of data.

Focus of Future Research

Due to the foundational nature of this study, operalization was limited to a single site. However, future research should extend the findings by investigating additional cases to strengthen and further clarify the findings. Building theories from case study research is an iterative process (Eisenhardt 1989). This study focused on a limited number of perspectives and, although beneficial, the value of the findings would be significantly strengthened by determining whether differing group characteristics, organizational settings, and technological environments produce similar results.

This study confirmed Grudin's (1993) findings that those who benefit the most from groupware are those who have not had to do extra work and that if the groupware tool is not flexible enough to deal with the exceptions that occur within a group environment, the tool may fail. The findings further support Goodall's (1996) findings

that (1) technology is no substitute for an efficient and effective team, (2) a CSCW tool is valuable only if it is used, and (3) inadequate planning is detrimental to the attitudes and patterns of use. Additional research should be directed at determining the effects of user buy-in, training, more flexible designs, full SDLC support, and characteristics needed by the tool. Having the researcher act as a facilitator in future research would potentially mitigate the training and design problems encountered by the current research, thus providing improved controls for the implementation process.

Future research should also focus on the effects of group dynamics and political environments on CSCW adoption and success. Within this context, research on autonomy and privacy issues should be included. Longitudinal data collection is desirable, as shown by the results of this study. Had the data collection occurred over only a four-month period, the findings and conclusions of this study would have been completely different. Research should also investigate response time effects in addition to contrasting different interface designs such as GUI and Web browsers with Notes' current interface. There should also be evaluations of the relationship between combinations of different CASE and CSCW tools.

Further clarification of variables is also needed. This study revealed that quality may encompass customer support, communication process, task results, and confidence levels. Productivity, in a similar manner, was seen to differ from task performance and efficiency. Research designed to focus on these individual components and perhaps identify further subcomponents is potentially a fruitful avenue of study.

Summary

This research investigated the application of a CSCW tool, Lotus Notes, to software engineering in a CASE environment. The participants were an established team of software engineers with extensive experience with Composer, the CASE tool supporting the system development. After an initial four-month revision of a software system developed with no collaborative communication support, Notes was installed and used during a second four-month revision of the same system. Data collected at the completion of the second revision revealed positive changes in satisfaction levels, and yet, six months later, the CSCW support was abandoned.

The setting for this study was a large software development corporation located in the Dallas/Fort Worth Texas metroplex. The participants use Texas Instruments' (TI) CASE tool, Composer, on a regular basis. The participants were an established team of professionals using Composer to develop a project referred to as BOSS (Business Operations Support Systems) project, which supports the operational businesses of the organization's software division. BOSS tracks order entry, inventory, order fulfillment, shipments, and customer information for all of the organization's software products. At the completion of one iteration of BOSS development, Notes was installed to support the group communication requirements of the team. Data were collected via pre- and post-implementation questionnaires, the Notes database maintained on BOSS, and structured interviews. Data were analyzed using a matrix system proposed by Miles and Huberman (1994), preparation of a case description, pattern matching, content analysis, and a chain

of evidence as proposed by Yin (1994) and Eisenhardt (1989). Validity and reliability issues were addressed in addition to a discussion of limitations and key assumptions.

The study focused on three primary constructs: quality, productivity, and satisfaction. Quality improvements were seen in customer support, communication process, and documentation but not in resulting system quality. Productivity improvements were realized in task performance and efficiency. However, productive time was lost due to inadequate training and learning curve issues, tool setup, dissention among team members, and resistance to change. Participants expressed greater confidence in the quality of task results and higher levels of satisfaction with the communication process. The CSCW tool supplemented rather than replaced traditional modes of communication.

At the completion of the collaboratively support revision of the project, the team expressed strong positive opinions about the collaborative tool. Nevertheless, within six months, tool utilization had been discontinued. Contributing factors included insufficient training, unrealistic expectations, additional work load on team members, team dysfunction, loss of tool champion, replication issues in a globally distributed environment, and capability underutilization.

APPENDIX A

PRE-IMPLEMENTATION INSTRUMENTS

BIOGRAPHICAL INFORMATION

1. Which of the following best describes your job function? (Check one)
   [ ]Software development project leader [ ]Analyst
   [ ]Software developer [ ]Systems maintenance
   [ ]MIS or data processing manager [ ]Support
   [ ]User of IS developed applications

2. What percentage of your working hours are consumed with the following processes (including supervisory and educational involvement)?
   _____% planning _____% development
   _____% analysis _____% maintenance
   _____% design _____% usage of completed application
   _____% overhead

3. How much **total** experience do you have in systems development?
   _____ years _____ months

4. How much **total** experience, **if any**, do you have in using CASE technology on system development projects?
   _____ years _____ months

5. How much **total** experience, **if any**, do you have in using electronic Group Decision Support System (GDSS) or collaborative tools? i.e. VisionQuest, LOTUS Notes, etc.
   _____ years _____ months

6. If you reported experience in question 5, which product(s) have you used?
   _____
   _____

7. What major projects (more than 6 staff months) have you participated in during the last year?
   _____
   _____

8. What academic level have you achieved? (check one)
   [ ] some college
   [ ] bachelor's degree
   [ ] some graduate hours
   [ ] masters degree
   [ ] additional graduate hours

9. What is your age group?
   [ ] under 25 [ ] 46 - 50
   [ ] 25 - 30 [ ] 51 - 55
   [ ] 31 - 35 [ ] 56 - 60
   [ ] 36 - 40 [ ] 61 - 65
   [ ] 41 - 45 [ ] over 60

pre

Adapted from Yellen, 1992 and Troboy, 1994

COMMUNICATION NEEDS ASSESSMENT

1. What percentage of your working hours do you spend communicating with fellow team members about information necessary for collaborative (group) decisions during the following processes?

_____% planning
_____% analysis
_____% design
_____% development
If other specify: _____

_____% maintenance
_____% usage of completed application
_____% other
_____
_____
_____

2. What percentage of your project team communications take place in each of the following media?

_____% personal phone conversations
_____% teleconferencing
_____% voice mail
_____% memos
_____% documentation
_____% email
_____% face-to-face meetings **w/o** electronic support
_____% face-to-face meetings **with** electronic support
_____% face-to-face informal discussions
_____% documentation
_____% other
If other specify: _____
_____

In the first column list all electronic communication support tools you use in the course of system planning, analysis, and design. In the second column indicate the average number of times you use each tool per week.

Tool	***Frequency***

pre

COMMUNICATION PROCESS/TECHNOLOGY SATISFACTION

This section refers to the electronic tools and communication methods (process) for information sharing and decision making utilized by your software development team. Examples of electronic tools include E-mail, Lotus Notes, electronic meeting room environments, etc. Please rate your satisfaction level only with respect to your work in developing software systems.

1	2	3	4	5	6	7
Extremely Dissatisfied	*Dissatisfied*	*Slightly Dissatisfied*	*Neutral*	*Slightly Satisfied*	*Satisfied*	*Extremely Satisfied*

	Process	Extremely Dissatisfied			Neutral			Extremely Satisfied
1.	How satisfied are you with the communication process you use?	1	2	3	4	5	6	7
2.	How satisfied are you with the effect the communication process has on your productivity?	1	2	3	4	5	6	7
3.	How satisfied are you with the effect the communication process has on the quality of the resulting system?	1	2	3	4	5	6	7
4.	How satisfied are you with your mastery of the communication process?	1	2	3	4	5	6	7
	Technology							
5.	How satisfied are you with the electronic communication tools you use?	1	2	3	4	5	6	7
6.	How satisfied are you with the effect the electronic communication tools have on your productivity?	1	2	3	4	5	6	7
7.	How satisfied are you with the effect the electronic communication tools have on the quality of the resulting system?	1	2	3	4	5	6	7
8.	How satisfied are you with your mastery of the electronic communication tools?	1	2	3	4	5	6	7

pre

Adapted from Troboy, 1994

SYSTEMS DEVELOPMENT TECHNOLOGY SATISFACTION

This section refers to tools, environment and methodology. Examples of software development tools include compilers, editors, debuggers, MicroFocus, INCASE, and Composer. Examples of operating environments include CMS, ISPF, Unix, OS/2, Windows, CICS, and TSO. Please rate your satisfaction level only with respect to your work in software planning, analysis, and design activities.

1	2	3	4	5	6	7
Extremely Dissatisfied	*Dissatisfied*	*Slightly Dissatisfied*	*Neutral*	*Slightly Satisfied*	*Satisfied*	*Extremely Satisfied*

	Technology	Extremely Dissatisfied			Neutral			Extremely Satisfied
1.	How satisfied are you with the software development operating environment you use?	1	2	3	4	5	6	7
2.	How satisfied are you with the current software development tools you use?	1	2	3	4	5	6	7
3.	How satisfied are you with the effect the software development tools have on your productivity?	1	2	3	4	5	6	7
4.	How satisfied are you with the effect the software development tools have on the quality of the resulting system?	1	2	3	4	5	6	7
5.	How satisfied are you with your mastery of the software development tools?	1	2	3	4	5	6	7
	Methodology							
6.	How satisfied are you with the software development methodology you use?	1	2	3	4	5	6	7
7.	How satisfied are you with the effect the software development methodology has on your productivity?	1	2	3	4	5	6	7
8.	How satisfied are you with the effect the software development methodology has on the quality of the resulting system?	1	2	3	4	5	6	7
9.	How satisfied are you with your mastery of the software development methodology?	1	2	3	4	5	6	7

pre

Adapted from Troboy, 1994

PROJECT MANAGEMENT METHODOLOGY SATISFACTION

Are you directly involved in project management activities? (circle one) yes no

This section refers to project management methodology. Please rate your satisfaction level only with respect to your work in or how you have been affected by project management activities.

1 *Extremely Dissatisfied* 2 *Dissatisfied* 3 *Slightly Dissatisfied* 4 *Neutral* 5 *Slightly Satisfied* 6 *Satisfied* 7 *Extremely Satisfied*

Methodology	Extremely Dissatisfied			Neutral			Extremely Satisfied
1. How satisfied are you with the project management methodology used?	1	2	3	4	5	6	7
2. How satisfied are you with the effect the project management methodology has on your productivity?	1	2	3	4	5	6	7
3. How satisfied are you with the effect the project management methodology has on the quality of the resulting system?	1	2	3	4	5	6	7
4. How satisfied are you with your mastery of the project management methodology?	1	2	3	4	5	6	7

pre

TECHNOLOGY BENEFIT ASSESSMENT

CASE is designed to provide benefits. Please indicate the degree with which each specific benefit listed below has been realized in your shop since the introduction of CASE technology. *Indicate by circling the appropriate number from 1 to 7 next to the benefit.*

Benefit	***benefit not realized***						***benefit greatly realized***
higher quality system	1	2	3	4	5	6	7
more reusable code	1	2	3	4	5	6	7
easier documentation	1	2	3	4	5	6	7
more user input	1	2	3	4	5	6	7
better user input	1	2	3	4	5	6	7
better project control	1	2	3	4	5	6	7
lower development costs	1	2	3	4	5	6	7
faster development	1	2	3	4	5	6	7
easier modification of preliminary designs	1	2	3	4	5	6	7
easier to make transition from logical to physical system	1	2	3	4	5	6	7
increased formalization of process due to discipline required when using tool	1	2	3	4	5	6	7
better standardization of resulting system	1	2	3	4	5	6	7
better integration of system components	1	2	3	4	5	6	7
easier prototyping	1	2	3	4	5	6	7
easier sharing of work with others	1	2	3	4	5	6	7

Describe the benefits of CASE you would most like to see expanded upon.

pre

Adapted from Yellen, 1992

ATTITUDE ASSESSMENT

The following section contains statements regarding your project team's group communication process, the results of the group's efforts, and the technological support for the group communication. Please rate your attitudes to each statement only with respect to your work in software planning, analysis and design activities.

1	2	3	4	5	6	7
Totally Disagree	*Disagree*	*Slightly Disagree*	*Neutral*	*Slightly Agree*	*Agree*	*Totally Agree*

	Totally Disagree			Neutral			Totally Agree
Attitude towards process							
1. I enjoy the team communication process.	1	2	3	4	5	6	7
2. I can present all my ideas.	1	2	3	4	5	6	7
3. Our cooperation is fair.	1	2	3	4	5	6	7
4. The abilities of other participants are well utilized.	1	2	3	4	5	6	7
5. Our cooperation is efficient.	1	2	3	4	5	6	7
6. I am satisfied with the progress we are making in completing our tasks.	1	2	3	4	5	6	7
7. We have no difficulty coordinating our work.	1	2	3	4	5	6	7
8. I am satisfied with the procedures that our team uses to communicate.	1	2	3	4	5	6	7
9. We are all contributing fairly to this project.	1	2	3	4	5	6	7
10. Other members of our project team have worked very hard on this project.	1	2	3	4	5	6	7
11. I am doing more than my share of the work for our team.	1	2	3	4	5	6	7
12. The other members of the group seem to respect my contributions.	1	2	3	4	5	6	7
13. I have enjoyed working with members of my project team.	1	2	3	4	5	6	7
14. I feel that I am a part of this project team.	1	2	3	4	5	6	7
15. I have learned a lot from the other members of this group.	1	2	3	4	5	6	7
16. I'd like to work with this group again.	1	2	3	4	5	6	7
Attitude towards results							
17. I feel personally responsible for the results.	1	2	3	4	5	6	7
18. I am satisfied with the results.	1	2	3	4	5	6	7
19. I am confident that the results are good.	1	2	3	4	5	6	7
20. The results correspond largely to my own contributions.	1	2	3	4	5	6	7
21. I endorse the results.	1	2	3	4	5	6	7
22. The work we've produced so far is of high quality.	1	2	3	4	5	6	7

pre

Adapted from Petrovic & Krickl, 1994; Galegher & Kraut, 1994

APPENDIX B

POST-IMPLEMENTATION INSTRUMENTS

COMMUNICATION PROCESS/TECHNOLOGY SATISFACTION

This section refers to the electronic tools and communication methods (process) for information sharing and decision making utilized by your software development team. Examples of electronic tools include e-mail, Lotus Notes, electronic meeting room environments, etc. Please rate your satisfaction level only with respect to your work in developing software systems.

1 *Extremely Dissatisfied* 2 *Dissatisfied* 3 *Slightly Dissatisfied* 4 *Neutral* 5 *Slightly Satisfied* 6 *Satisfied* 7 *Extremely Satisfied*

	Extremely Dissatisfied			Neutral			Extremely Satisfied
Process							
1. How satisfied are you with the communication process you use?	1	2	3	4	5	6	7
2. How satisfied are you with the effect the communication process has on your productivity?	1	2	3	4	5	6	7
3. How satisfied are you with the effect the communication process have on the quality of the resulting system?	1	2	3	4	5	6	7
4. How satisfied are you with your mastery of the communication process?	1	2	3	4	5	6	7
Technology							
5. How satisfied are you with the electronic communication tools you use?	1	2	3	4	5	6	7
6. How satisfied are you with the effect the electronic communication tools have on your productivity?	1	2	3	4	5	6	7
7. How satisfied are you with the effect the electronic communication tools have on the quality of the resulting system?	1	2	3	4	5	6	7
8. How satisfied are you with your mastery of the electronic communication tools?	1	2	3	4	5	6	7

post

Adapted from Troboy, 1994

SYSTEMS DEVELOPMENT TECHNOLOGY SATISFACTION

This section refers to tools, environment and methodology. Examples of software development tools include compilers, editors, debuggers, MicroFocus, INCASE, and Composer. Examples of operating environments include CMS, ISPF, Unix, OS/2, Windows, CICS, and TSO. Please rate your satisfaction level only with respect to your work in software planning, analysis, and design activities.

1 *Extremely Dissatisfied* 2 *Dissatisfied* 3 *Slightly Dissatisfied* 4 *Neutral* 5 *Slightly Satisfied* 6 *Satisfied* 7 *Extremely Satisfied*

	Extremely Dissatisfied			Neutral			Extremely Satisfied
Technology							
1. How satisfied are you with the software development operating environment you use?	1	2	3	4	5	6	7
2. How satisfied are you with the current software development tools you use?	1	2	3	4	5	6	7
3. How satisfied are you with the effect the software development tools have on your productivity?	1	2	3	4	5	6	7
4. How satisfied are you with the effect the software development tools have on the quality of the resulting system?	1	2	3	4	5	6	7
5. How satisfied are you with your mastery of the software development tools?	1	2	3	4	5	6	7
Methodology							
6. How satisfied are you with the software development methodology you use?	1	2	3	4	5	6	7
7. How satisfied are you with the effect the software development methodology has on your productivity?	1	2	3	4	5	6	7
8. How satisfied are you with the effect the software development methodology has on the quality of the resulting system?	1	2	3	4	5	6	7
9. How satisfied are you with your mastery of the software development methodology?	1	2	3	4	5	6	7

post

Adapted from Troboy, 1994

PROJECT MANAGEMENT METHODOLOGY SATISFACTION

Are you directly involved in project management activities? (circle one) yes no

This section refers to project management methodology. Please rate your satisfaction level only with respect to your work in or how you have been affected by project management activities.

1 *Extremely Dissatisfied* 2 *Dissatisfied* 3 *Slightly Dissatisfied* 4 *Neutral* 5 *Slightly Satisfied* 6 *Satisfied* 7 *Extremely Satisfied*

Methodology	Extremely Dissatisfied			Neutral			Extremely Satisfied
1. How satisfied are you with the project management methodology used?	1	2	3	4	5	6	7
2. How satisfied are you with the effect the project management methodology has on your productivity?	1	2	3	4	5	6	7
3. How satisfied are you with the effect the project management methodology has on the quality of the resulting system?	1	2	3	4	5	6	7
4. How satisfied are you with your mastery of the project management methodology?	1	2	3	4	5	6	7

post

TECHNOLOGY BENEFIT ASSESSMENT

CASE is designed to provide benefits. Please indicate the degree with which each specific benefit listed below has been realized in your shop since the introduction of CASE technology. *Indicate by circling the appropriate number from 1 to 7 next to the benefit.*

Benefit	***benefit not realized***			***benefit partially realized***			***benefit greatly realized***
higher quality system	1	2	3	4	5	6	7
more reusable code	1	2	3	4	5	6	7
easier documentation	1	2	3	4	5	6	7
more user input	1	2	3	4	5	6	7
better user input	1	2	3	4	5	6	7
better project control	1	2	3	4	5	6	7
lower development costs	1	2	3	4	5	6	7
faster development	1	2	3	4	5	6	7
easier modification of preliminary designs	1	2	3	4	5	6	7
easier to make transition from logical to physical system	1	2	3	4	5	6	7
increased formalization of process due to discipline required when using tool	1	2	3	4	5	6	7
better standardization of resulting system	1	2	3	4	5	6	7
better integration of system components	1	2	3	4	5	6	7
easier prototyping	1	2	3	4	5	6	7
easier sharing of work with others	1	2	3	4	5	6	7

Describe the benefits of CASE you would most like to see expanded upon.

post

Adapted from Yellen, 1992

ATTITUDE ASSESSMENT

The following section contains statements regarding the group communication process, the results of the group's efforts, and the technological support for the group communication. Please rate your attitudes to each statement only with respect to your work in software planning, analysis and design activities.

1	2	3	4	5	6	7
Totally Disagree	*Disagree*	*Slightly Disagree*	*Neutral*	*Slightly Agree*	*Agree*	*Totally Agree*

		Totally Disagree			Neutral			Totally Agree
Attitude towards process								
1.	I enjoy the team communication process.	1	2	3	4	5	6	7
2.	I can present all my ideas.	1	2	3	4	5	6	7
3.	Our cooperation is fair.	1	2	3	4	5	6	7
4.	The abilities of other participants are well utilized.	1	2	3	4	5	6	7
5.	Our cooperation is efficient.	1	2	3	4	5	6	7
6.	I am satisfied with the progress we are making in completing our tasks.	1	2	3	4	5	6	7
7.	We have no difficulty coordinating our work.	1	2	3	4	5	6	7
8.	I am dissatisfied with the procedures that our team uses to communicate.	1	2	3	4	5	6	7
9.	We are all contributing fairly to this project.	1	2	3	4	5	6	7
10.	Other members of our project team have worked very hard on this project.	1	2	3	4	5	6	7
11.	I am doing more than my share of the work for our team.	1	2	3	4	5	6	7
12.	The other members of the group seem to respect my contributions.	1	2	3	4	5	6	7
13.	I have enjoyed working with members of my project team.	1	2	3	4	5	6	7
14.	I feel that I am a part of this project team.	1	2	3	4	5	6	7
15.	I have learned a lot from the other members of this group.	1	2	3	4	5	6	7
16.	I'd like to work with this group again.	1	2	3	4	5	6	7
Attitude towards results								
17.	I feel personally responsible for the results.	1	2	3	4	5	6	7
18.	I am satisfied with the results.	1	2	3	4	5	6	7
19.	I am confident that the results are good.	1	2	3	4	5	6	7
20.	The results correspond largely to my own contributions.	1	2	3	4	5	6	7
21.	I endorse the results.	1	2	3	4	5	6	7
22.	The work we've produced so far is of high quality.	1	2	3	4	5	6	7
Attitudes towards technology								
23.	I want to continue to use Lotus Notes.	1	2	3	4	5	6	7
24.	Computer support helped us find and structure ideas.	1	2	3	4	5	6	7
25.	Computer supported teamwork is better suited to this task than traditional methods.	1	2	3	4	5	6	7
26.	Computer support helped us reach our goal.	1	2	3	4	5	6	7

post

Adapted from Petrovic & Krickl, 1994; Galegher & Kraut, 1994

PROCESS SUGGESTIONS / OPEN COMMENTS

Describe any suggested improvements you would like to see made in the process that resulted from incorporating Lotus Notes into the Composer environment.

post

APPENDIX C

SAMPLE LOTUS NOTES DATABASE FOR BOSS PROJECT

Issue Entry

User ID: Teimo Tokoro **Issue Number:**811/1 **Date Logged:**10/23/95 02:46 PM

Project: BOSS North America **Release No.:** 2.4.1
Region:

Task(s): BOSS432 **Type of Problem:**
(Keywords)

Short Description: When you try and sign an Order, makes you perform a find first

Full Description:
When you try and sign an Order, makes you perform a find first

Priority: high **Priority Ranking:**

Attached Files (If Applicable):

(To attach a file select 'File - Attach' from the menu bar.)

Resolution:
This is a user education issue. If the last database action was successful then you are allowed to continue without refreshing the screen. If the las DB action Failed then you must refresh (e.g validation failed then you must refresh the screen to make sure that what you are signing is actually what will be held on the database.

Comments:

Status: Closed
Completed Date: 10/31/95 07:56 AM

Last Edited By Teimo Tokoro

Issue Entry

User ID: Kerrin Evans **Issue Number:**1392/4 **Date Logged:**04/11/96 01:41 PM

Project: BOSS
Region: Europe; Middle East; Africa
Release No.: 2.4.2+

Task(s): BOSS994
(Keywords)
Type of Problem: Operating Environment Problem

Short Description: FTP instability

Full Description:
FTP download of MB report inconsistently works. Primarily a problem in EU since NA still using BDT.

Priority: High **Priority Ranking:** 1

Attached Files (If Applicable):

STATUS.904

-MSG M#= 364055 FR=DEMM TO=RMC SENT=04/03/96 11:35 AM
R#=086 ST=C DIV=0006 CC=00028 BY=DEMM AT=04/03/96 10:26 AM

To: DOUG BIENIEK DBIE ROGER CORNISH RMC

Copy: NETWK PROBLEM MGT *NPMS PAUL BREAUX EPB

From: DAN MCGEE DEMM

Subj: FTP Problems to Europe...Status (complete msg...sorry)

Background:
In late March we began hearing of problems sending data to/from Europe via FTP. Initially the reports came from Freising and our investigation started there. At this time we know that all of Europe is having difficulties with FTP. We have at times been able to duplicate the

problem has eluded us.

In reviewing network utilization stats provided by Pat M. we've come to the
conclusion that the problem is probably related to the high utilizaiton between BE-DA (presently a 512Kb ckt). Because the routers are configured to favor interactive traffic (telnet etc.) the possibility exists that FTP
(considered a background activity) could be held in a queue for an excessive
amount of time or even dropped.

To address these issues / concerns the following has been planned for execution over the next few days:

To test the theory we will configure an access list to allow ftp to/fm the NT server in FR in a priviledged fashion. I.E. all traffic to/fm this server will be allowed the same priority as interactive traffic.

In addition, plans are underway to bring up a second connection btwn BE-DA.
Will Thomas and his team are making plans to have this in place (tested and
ready to use) by friday evening. The new aggregate b/w to Europe will be at least 768Kb and possibly as high as 1024Kb.

Paul Breaux and his team are working router config issues. In addition to activating a second router connection to idam09 they will implement "ip header compression" to help squeeze a little more out of the available
bandwidth.

On another note....the question has been raised regarding IP Mobility and its role in the problem. There does appear to be a direct correlation between utilization (DA-BE) and the implementation of IP mobility. Presently the popular theory is that since the 128.247.0.0 network is now stable, interactive connections are being made and are staying

Additional status will be forth coming as we formulate specific plans.

Regards, Dan McGee
(To attach a file select 'File - Attach' from the menu bar.)

Resolution:

Comments:
Teimo working with FTP support, work around - EU CS requesting reports to BDT node and forwarding to OpCo manually.

Status: In Progress
Completed Date:

Last Edited By Kerrin Evans

Release	Issue #	Transaction	Status	Description
2.4.1				
	852	BOSS432	Closed	Op Co's sometimes are unable to attach an agreement t
	339	BOSS403	Closed	Should only list all the outstanding orders
	451	BOSS308	Closed	Unable to add Cost and/or Discount Types to an agreem
	564	BOSS994,PROC5	Closed	Contact department information was printed on every he
	802	BOSS308	Closed	Is is possible to unprotect the end dates for cost/discoun
	803	BOSS994	Closed	Ensure that the date invoiced attribute on install item is
	809	BOSS952	Closed	Garbage - Remaining pieces to be fixed in 2.4.1.
	810	BOSS516	Pending	On Xfer Config should default to current Customer and
	811	BOSS432	Closed	When you try and sign an Order, makes you perform a fi
	812	BOSS431	Closed	Year End in OPF out of synch with Year End in BOSS
	814	BOSS405	Closed	Need ability to view closed purchase orders
	815	BOSS504	Closed	Need to be able to cancel or close purchase orders
	828	BOSS433	Closed	When an order is in BOSS stock check gives weird mes
	832	BOSS461	Closed	Request the insertion of an extra field for product enviro
	833	BOSS525	Closed	The literal for config type 'O' should say "Ordered", not "
	835	BOSS520	Closed	Negative stock is not being highlighte d
	839	BOSS432	Closed	AER, 851442 brought back a contact automatically but o
	841	BOSS752	Closed	F3 Dosn't work
	845	BOSS449	Closed	Contact Usage flag not being set correctly. (eg: set to B
	847	BOSS433	Closed	If Validate items with no price fields(upper)..fields are no
	848	BOSS529	Not Fixed	If perform Find on a CS contact and change to MB then
	851	BOSS911	Closed	Order Value in US$ is not correct. Should pick up conve
	866	BOSS449	Closed	Need to add a search from field.
	935	BOSS530	Closed	Write (in OPF) new mass transfer configs transaction to
	1040	BOSS431	Closed	F12 and then F6 to items abends
	1117	BOSS441	Closed	Cannot change site of unused contact
	1130	BOSS432	Closed	AER, 851442 brought back a contact automatically but o
	1144	BOSS523	Closed	Appear to have hard coded annual cycle start/end dates
	1188	BOSS752	Closed	Does not submit if you specify all datails down to contac
	1199	BOSS432	Closed	For Op.Co. users msg id being updated
	1206	BOSS752	Closed	F3 Dosn't work
	1233	BOSS523	Closed	Remove BI from screen if not working
	1236	BOSS437	Closed	F11 from list screen , the record that was previously vie
	1245	BOSS432	Closed	On Add of an Order - sometimes doesn't recognise the

Release	Issue #	Transaction	Status	Description
	1256	BOSS432,BOSS4	Closed	Updating status in 432 does not propagate this to the as
	1259	BOSS432	Closed	Op Co's sometimes are unable to attach an agreement t
	1285	BOSS520	Closed	Negative stock is not being highlighted
	1286	BOSS432	Closed	Disallow update of Customer once an order has been au
	1290	BOSS752	Closed	Change batch job names for JD and Test
	1294	BOSS433	Closed	In word BOSS in BOSS order the O is a 0
	1294	BOSS452	Closed	When adding a new Customer, if the effective currency
	1248	BOSS434	Pending	When an MSG is sent Can this be indicated automaticall
	1249	BOSS431	Pending	When printing an order via this transaction an extra pag
	1250	BOSS921	Pending	If a product has a install date in the future then the 921 s
	1296	BOSS921	Pending	Want to add the CUL flag to the 921 report
	6	BOSS431	Pending	When going to order from list and return list has no data
	1317	BOSS445	Closed	REPATRIATION DISCOUNT VALUES NOT CALCULAT
	8	BOSS445	Pending	Value revert back to before changes or double their valu
	9	BOSS305	Pending	Information not appearing on screen
	1311	BOSS517	Closed	A change has been made to add a case statement to loo
	1312	BOSS517	Pending	The add_installed_item cab of the 517 transaction need
	10	BOSS433	Pending	If an order has maintenance overides, the item pages is
	11	BOSS444	Pending	concesion not found message
	12	BOSS508	Pending	Is it possible to display the Maintenance Due flag for eac
	13	BOSS525	Pending	SCROLL KEYS REQUIRED LIKE ON 508
	1314	BOSS452	Closed	Expanded the Central Office length from 7 positions to 8
	1316	BOSS994	Closed	Quarterly billing calculating one day.
	14	BOSS202	Pending	unable to add customer to a structure
	1251	BOSS504	In Progress	Transaction times out with u240 on add
	15	BOSS452	Pending	Unable to update country, as in some cases been incorr
	1224	BOSS900	Pending	DB Last Status = DU on cab_decode_report_parameters
	18	BOSS525	Pending	Is it possible to have scoll keys installed on this transact
	19	BOSS508	Pending	Is it possible to display the maintenance due flag for eac
	17	BOSS444	Pending	retieval sequance numbers are causing concession not f
	1226	BOSS407	Pending	Add Environment To Invoice
	1225	GENERAL	Pending	Description of System Shortcomings as perceived by
	1229	BOSS915	Pending	prices and dates on this report are incorrect
	1227	BOSS445	Pending	Sometimes values reverse to original or get doubled
	1228	BOSS906	Pending	Add Environment to trial/real add reports

Release	Issue #	Transaction	Status	Description
2.4.2				
	474	BOSS525	Closed	Don' t allow cancel date to be set on a base if the add-o
	509	BOSS517	Closed	When using the ' include' action to add an upgrade on 5
	522	BOSS515,BOSS5	Closed	These screens should perform a look-aside to determine
	523	BOSS517	Closed	This screen should perform a look-aside to determine if
	836	BOSS517,BOSS5	Closed	Update should perform a check to ensure only valid Ver/
	1331	BOSS517	Closed	Add logic to ensure that two bases cannot be added to a
	1332	BOSS517	Closed	Populate initial ship date
	1337	BOSS517	Closed	Add logic for internal orders (018's) for NA users to set p
	1338	BOSS517	Closed	Modified the "Backout" logic for upgrade/swap items that
	1340	BOSS517	Pending	Set maintenance_chargeable flag to product_type attrac
	1354	BOSS530	Closed	Cosmetic changes to the 530 screen.
	1359	BOSS135,BOSS5	In Progress	BOSS changes to address C3 issues.
	1365	CD Dispatcher	Awaiting signoff	Detail Amendments screen only allows 3 comment lines
	1366	CD Dispatcher	Closed	If you key in an II Quantity greater than the outstanding
	1364	CD Dispatcher	Closed	When you open CD Dispatcher it flicks back to Program
	1396	ACCESS OPF_R	In Progress	Some items the dollar value on the MB report are 1000
	1400	OPF Reports	Pending	Errors in calculating IC maintenace % rate via OPF repo
	2	BOSS994	Pending	Invalid ship date
	1402	BOSS994	Closed	Printed incorrect ship date
	1403	BOSS752	Pending	Take out the misleading prompt "Copy to Datawarehous
	1408	BOSS753	Pending	Without entering TI_OFFICE , the 921 will process the

Release	Issue #	Transaction	Status	Description
2.4.2+				
	504	BOSS508	In Progress	Shipped Date on an upgraded item shows the upgrade' s
	1343	Price List	In Progress	Processing of Price List business rules
	1371	BOSS468	In Progress	Screen on Maint Chargeable flag and Cancelled Date
	1372	BOSS468	In Progress	Erase any selections if Find is requested
	1378	BOSS501	In Progress	Ship Qty cannot be greater than Outstanding Qty
	1379	BOSS468	In Progress	Change F4 to another function key
	1380	BOSS468	In Progress	Rename F10 function key
	1381	BOSS994	In Progress	Performance tuning on Maintenance Billing job
	1388	CD Dispatcher	Pending	Post 2.4.2 enhancements to CD Dispatcher
	1391	BOSS752	Closed	904 requests (IC MB) not being deleted
	1392	BOSS994	In Progress	FTP instability
	1393	BOSS994	Pending	International Characters not being downloaded by FTP
	1394	Exporting	Pending	David Barry's export compliance enhancement request
	1395	BOSS	In Progress	3rd Party Distribution Support for Alternate Channels &
	1399	BOSS994	In Progress	European Infrastructure Problems
	1401	Multiple	Pending	YEAR 2000
	1404	BOSS994	Pending	Activate Flat Fee and SPMO logic for NA users
	1410	BOSS434	Pending	Unable to use MSG function for North America.

APPENDIX D

STRUCTURED INTERVIEW QUESTIONS ADDRESSED TO PARTICIPANTS

Participant Interviews

1. Is there a relationship between CSCW tools in a CASE environment and quality, productivity, and team perceptions?
    1. Did Notes improve the team's productivity? How? If not, why?
    2. Did Notes improve the quality of the BOSS system? How? If not, why?
    3. Did Notes help you do a better job? In what way? What were the disadvantages of using Notes?
    4. What did you like the most about using Notes on the BOSS project?
    5. What did you like the least about using Notes on the BOSS project?

2. How is the technology perceived to affect group processes and task performance?
    1. As a team, did the group work together better, worse, or the same after you started using Notes? Why?
    2. Did the 2.4.2 revision of BOSS take more or less time to develop than 2.4.1? Was this because of Notes or team familiarity with 2.4.1?
    3. Did you have more or less errors in BOSS using Notes than you would have without Notes? Why?
    4. Did you have more or less understanding of the BOSS project parameters before or after Notes? Why?
    5. In general, how did Notes affect your group's communication?

3. What improvements or enhancements need to be made in the technological support?
    1. What improvements or enhancements need to be made to Notes to make it a better tool in the SDLC process?
    2. Should Composer have collaborative tools built in or is using Notes in the environment sufficient?
    3. Do Composer and Notes co-exist smoothly together or do improvements need to be made? If so, what improvements?

4. Is CSCW used as a front-end to CASE a viable and beneficial alternative to traditional modes of operation?
    1. Did Notes replace any of the forms of communication on the list I have provided for you? Did you use any of the forms of communication less frequently after the implementation of Notes? If so, which ones? By how much?
    2. Did Notes improve the SDLC effort? If so, how? Do you believe Notes will it result in "better" systems (on-time, less cost, fewer errors, improved user acceptance)?
    3. Do you want to continue to use Notes in the SDLC effort? If so why? If not, why not?

Forms of Communication

personal phone conversations
teleconferencing
voice mail
memos
documentation
e-mail
meetings
informal discussions “hall talk”

APPENDIX E

STRUCTURED INTERVIEW QUESTIONS ADDRESSED TO INDUSTRY EXPERT PANEL MEMBERS

Expert Panel Interviews

1. Is there a relationship between CSCW tools in a CASE environment and quality, productivity, and team perceptions?
    1. Was there any change in the quality of the systems produced by the BOSS development team after the implementation of Notes? What kind of a change? What do you attribute it to?
    2. Was there any change in the productivity level of the BOSS development team after the implementation of Notes? What kind of a change? What do you attribute it to?
    3. Was there any change in the attitudes (satisfaction level) of the BOSS development team after the implementation of Notes? What kind of a change? What do you attribute it to?

2. How is the technology perceived to affect group processes and task performance?
    1. As a team, did the BOSS development team appear to work together better, worse, or the same after they started using Notes? If there was a change, what do you believe caused the change?
    2. In general, how do you perceive that Notes affected the group's communication?

3. What improvements or enhancements need to be made in the technological support?
    1. What improvements or enhancements need to be made to Notes to make it a better tool in the SDLC process?
    2. Should Composer have collaborative tools built in or is using Notes in the environment sufficient?
    3. Do Composer and Notes co-exist smoothly together or do improvements need to be made? If so, what improvements?

4. Is CSCW used as a front-end to CASE a viable and beneficial alternative to traditional modes of operation?
    1. Do you believe that Notes replaced any of the forms of communication on the list I have provided for you? If so, which ones?
    2. To date, has using Notes it resulted in "better" systems (on-time, less cost, fewer errors, improved user acceptance)?
    3. Do you want to see continued use of Notes in the SDLC effort? If so why? If not, why not?

Forms of Communication

personal phone conversations
teleconferencing
voice mail
memos
documentation
e-mail
meetings
informal discussions "hall talk"

APPENDIX F

CASE DESCRIPTION OUTLINE

CASE DESCRIPTION OUTLINE

I. Question 1- Is there a relationship between CSCW tools in a CASE environment and quality, productivity, and team perceptions of task results, group process, and technological support?

A. Administer questionnaires
   1. Quality
      a. Resulting software product
      b. Communication
      c. Customer support
   2. Productivity
      a. Project completion time
      b. Task performance
      c. Efficiency
   3. Satisfaction shift

B. Analyze Notes database data
   1. Count number of issues
   2. Count number of descriptive lines per issue
   3. Categorize by priority
      a. High
      b. Medium
      c. Low
   4. categorize by issue type
      a. Design issue
      b. Maintenance issue
      c. Enhancement request
      d. Software Fault
      e. Other

C. Conduct interviews
   1. Participants
      a. Quality
         (1) Resulting software product
         (2) Communication
         (3) Customer support
      b. Productivity
         (1) Project completion time
         (2) Task performance
         (3) Efficiency
      c. Satisfaction shift

2. Expert panel
   a. Quality
      (1) Resulting software product
      (2) Communication
      (3) Customer support
   b. Productivity
      (1) Project completion time
      (2) Task performance
      (3) Efficiency
   c. Satisfaction with task results

II. Question 2 - How is the technology perceived by participants and supervisors to affect group processes and task performance?

A. Administer questionnaires
   1. Satisfaction
      a. Group process
      b. Technological support

B. Conduct interviews
   1. Participants
      a. Group process
      b. Technological support
   2. Expert panel
      a. Group process
      b. Technological support

III. Question 3 - Is CSCW used as a front-end to CASE a viable and beneficial alternative to traditional modes of operation?

A. Establish traditional modes of communication with questionnaire

B. Collect participants views of Notes via open-ended questions on instrument

C. Conduct interviews
   1. Participants
      a. Reduction or replacement
         (1) personal phone conversations
         (2) teleconferencing
         (3) voice mail
         (4) memos
         (5) documentation

(6) e-mail
(7) meetings
(8) informal discussion

b. Better systems
(1) on-time
(2) less cost
(3) fewer errors
(4) improved user acceptance

c. Desire for continued use of Notes

2. Expert panel

a. Reduction or replacement
(1) personal phone conversations
(2) teleconferencing
(3) voice mail
(4) memos
(5) documentation
(6) e-mail
(7) meetings
(8) informal discussion

b. Better systems
(1) on-time
(2) less cost
(3) fewer errors
(4) improved user acceptance

c. Desire for continued use of Notes

APPENDIX G

QSR NUD.IST

The following is a brief selection from the mini-manual provided with NUD.IST 3.0.4. Purchasing information has been included.

Introduction to NUD.IST

NUD.IST stands for Non-numerical Unstructured Data Indexing Searching and Theorizing. It is a computer package designed to aid users in handling non-numerical and unstructured data in qualitative analysis. NUD.IST does this by supporting processes of indexing, searching and theorizing.

NUD.IST helps users to:
- manage, explore and search the text of documents;
- manage and explore ideas about the data;
- link ideas and construct theories about the data;
- test theories about the data, and
- generate reports including statistical summaries.

NUD.IST handles data such as:
- text, for example, reports or minutes, transcripts of unstructured conversational interviews, evidence transcripts, historical or literary documents, personnel records, field notes by an anthropologist, newspaper clippings and abstracts, and
- non-textual records, for example, musical scores, photographs, tape recordings, films, maps and plans.

The Document System

NUD.IST creates a DOCUMENT DATABASE for each project which stores all data records. Text of online data is stored in the NUD.IST database but only a reference to offline data is held in the database. You can use the document database to:
- store and retrieve documents whether or not they are typed onto a computer;
- store and show when needed, information about the document and its context;
- handle online documents from any word processor;
- edit their text after they are in the system, and investigate them as required;
- list documents with options of information about them and index references of them;
- write and edit memos recording changing ideas about documents;
- search for actual words or strings of characters in the text of the documents, and automatically index the result, and
- create a report on any part of a document which can be edited, saved or printed without affecting the document in NUD.IST.

What Is a Document?

In NUD.IST, a document is any source of data. An ONLINE document is a file of plain ASCII text, no formatting required, which can be "introduced" into the database of a NUD.IST project. OFFLINE documents are anything else, e.g books.

A document contains

- a HEADER: brief text that you write to describe the document;
- the BODY which is divided into TEXT-UNITS. For on-line files, the body is the text of the file, and each text-unit is the text between successive carriage returns. For offline files, the body is what you like, but you need to mark it into a series of text-units. Text-units get CODED or INDEXED (see below).
- The body of an on-line file can be divided into SECTIONS by having text-units beginning with asterisks (*) - these text-units are then the SECTION SUB-HEADERS. Sections are useful for dividing a document according to speaker, or question/topic, etc.
- a MEMO, which is an attached text document, in which you can write or edit comments at any time.

The Index System

NUD.IST creates an INDEX DATABASE for each project which allows users to define and interrelate concepts and categories relevant to the data, and to index the data using those categories. New theories can be constructed and tested by exploring their links with data. NUD.IST helps create such categories for thinking about the data, and manage those categories in an index system which provides facilities to:

- create and manage an unlimited number of index categories;
- organize a flexible index system in which those categories and subcategories can be stored at the NODES of hierarchical tree structures;
- INDEX (or CODE) segments of text at nodes by any of several very quick and efficient methods;
- store and edit definitions for these nodes;
- record emerging theoretical understanding and explanations in a node MEMO;
- list nodes with definitions and information about index references at them;
- flexibly reorganize the index system, alter index references, shift, copy and cut index nodes;
- report all the references to passages of text at a node, from all or selected documents for interpretation and analysis;
- search the index system for combinations of index references expressing answers to simple or complex questions;
- store the results of text or index system searches as new categories for further exploration of the data;
- express and test theories or hypotheses, and
- create a report on any node or the text indexed at it, which can be edited, saved or printed without affecting the node in NUD.IST.

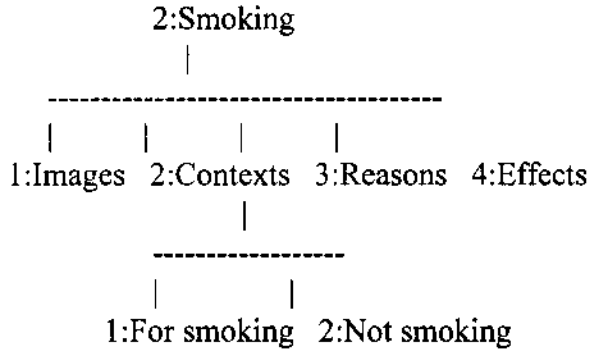
What Is an Index Category?

An INDEX CATEGORY or NODE is a place for holding information about the project. An index category can be anything: a place to hold coding (references to the text) for ideas, themes etc seen in the documents, a place to hold an idea or concept of yours together with notes on it, a way of holding facts about people or things the project is about, temporary storage for results you have obtained using NUD.IST, etc.

An indexing category has:

- A TITLE, such as "Dislike"
- A NODE NUMBER, such as 6.
- A DEFINITION, brief text you write to describe the category.
- CODING OR INDEXING, references to text units of documents. E.g. the node "Dislike" might contain index references to all text where dislike of something is expressed.

An index category can have any number of index categories attached below it as "children", to represent cases, examples, values, parts, aspects, etc of their parent category. In this way categories form TREES, e.g. in the "Nosmoke" sample project database, the category "2:Smoking" (we are showing the number and title here) has four children: "1:Images", "2:Contexts", "3:Reasons", and "4:Effects". "3:Reasons" has under it "1:For smoking" and "2:Not smoking". So the tree looks like this:



Reading down to a node from the top gives a useful and clarifying HIERARCHICAL TITLE for the node, e.g. /Smoking/Reasons/For smoking. Similarly the numbers can be collected on the way down to give the NODE ADDRESS, e.g. for the same node it is (2 3 1). The numbers are written with spaces between so nobody will think this is node 231.

Design of NUD.IST

NUD.IST is designed to do much more than just cataloguing and finding documents and parts of documents, though it does this very well. It is also designed to assist in shaping understanding of the data, helping researchers to form and test theories.

NUD.IST is designed to embody that emerging understanding in the computer environment. It does this by the processes of 'system closure'. Results are fed back into

the system rather than taking them out of the system. The user has control in re-organizing and re-shaping all aspects of the system.

References

Fielding, R. & Lee, R. (eds.) (1991). Using Computers in Qualitative Analysis, Sage Publications, Berkeley.

Miles, Matthew B. & Huberman, A. Michael (1994). Qualitative Data Analysis: An Expanded Sourcebook, Sage Publications, Berkeley.

Richards, T. & L. (1991). 'The NUD.IST Qualitative Data Analysis System', Qualitative Sociology, v.14.

Richards, Tom & Lyn Richards. "Using computers in qualitative analysis". In Denzin, N. & Lincoln, Y. (eds), Handbook of Qualitative Research, Berkeley, Sage, 1994, pp. 445-462.

Purchasing Information

NUD.IST is available for purchase from Sage Publications. The authors of the software may be reached at e-mail: nudist@latcs1.lat.oz.au.

APPENDIX H

CASE STUDY PROTOCOL

CASE STUDY PROTOCOL

Research Question 1:

Is there a relationship between CSCW tools in a CASE environment and quality, productivity, and team perceptions of task results, group process, and technological support?

Research Protocol:

1. Collect data via questionnaires regarding the team's perceptions regarding productivity, quality, and satisfaction before and after completion of CSCW supported revision

2. Use results from the pre- and post-study questionnaires to develop structured interview questions for participants and expert panel.

3. Count number of database issues from each BOSS release. Record as collaborative and non-collaborative. Use results to determine equality of collaborative and non-collaborative revisions.

4. Categorize and count database issues by priority. Record as collaborative and non-collaborative. Use results to determine equality of collaborative and non-collaborative revisions.

5. Categorize and count database issues by type. Record as collaborative and non-collaborative. Use results to determine equality of collaborative and non-collaborative revisions.

6. Count number of descriptive lines per issue, sum, and average by collaborative and non-collaborative. Compare for information quantity.

7. Conduct structured interviews with industry expert panel and participants.

8. Analyze content of interviews using QSR NUD.IST. Search for patterns within quality, productivity, and satisfaction.

Research Question 2:

How is the technology perceived by participants and supervisors to affect group processes and task performance?

Research Protocol:

1. Collect data via questionnaires regarding the team's perceptions of group processes and electronic support technology before and after completion of CSCW supported revision.

2. Use results from the pre- and post-study questionnaires to develop structured interview questions for participants and expert panel.

3. Conduct structured interviews with industry expert panel and participants.

4. Analyze content of interviews using QSR NUD.IST. Search for patterns within process and technology.

Research Question 3:

Is CSCW used as a communication-extension to CASE a viable and beneficial alternative to traditional modes of operation?

Research Protocol:

1. Collect data via questionnaires regarding methods of and satisfaction levels with communication before and after completion of CSCW supported revision.

2. Use results from the pre- and post-study questionnaires to develop structured interview questions for participants and expert panel.

3. Conduct structured interviews with industry expert panel and participants.

4. Analyze content of interviews using QSR NUD.IST. Search for patterns within process and technology.

Additional Findings Research Protocol:

1. Analyze content of interviews using QSR NUD.IST. Search for patterns that differ from anticipated responses.

APPENDIX I

SAMPLE QSR NUD.IST NODE INVESTIGATION REPORT

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Cengiz Capan.

PROJECT: CSCW, User Janet Bailey, 3:25 pm, Mar 6, 1997.

****

(1 1 1) /RQ #1/Quality/Positive
*** Definition:
Has Positive Effect On
++
+++ ON-LINE DOCUMENT: participant2
+++ Retrieval for this document: 6 units out of 136, = 4.4%
++ Text units 42-47:
Probably less. I think it was because when we had Notes, we had all the problems within one 42
program right there. It was like a title that said these are all the bugs in this particular program. 43
So when we actually went and fixed that program, we actually fixed all the bugs whereas I think 44
in the previous release, it was different people getting into the same program and you tend to step 45
on each other and that can cause a lot of problems. In Notes you have one person working in one 46
program. 47
++
+++ ON-LINE DOCUMENT: participant3
+++ Retrieval for this document: 10 units out of 210, = 4.8%
++ Text units 15-24:
Yea, probably. That wasn't as significant. It depends on your definition of quality. Quality in 15
my mind, helping us to communicate with our customers when they ask us questions, you could 16
say yes, this is the status of that issue, these are the issues you need to test. Just the quality of the 17
process I guess is what it improved but of the final product maybe not as much because even 18
using Word, by the end we got it all figured out. It was just a lot harder to figure out. So I think 19
it improved the quality of the process more than it improved the quality of the product. But it 20
helped in the communication with the customers which I think is part of the whole package. I 21
mean the quality of your release is your ability to communicate with your customers and their 22
frustration level is part of what they picture as quality. If you can't even tell them what they 23
need to test, they get really frustrated. 24
++
+++ ON-LINE DOCUMENT: participant4
+++ Retrieval for this document: 5 units out of 134, = 3.7%
++ Text units 18-20:
Yes, for those that did use it did improve the quality of the system. 18
19
Data was made available. There was an immediate availability. 20
++ Text units 59-60:
I think that there were less errors from what I heard. Simply because they were able to talk about 59
it. They knew what they were talking about because of the ready availability of the data. 60
****
+++ Total number of text units retrieved = 21

```
+++ Retrievals in 3 out of 9 documents, = 33%.
+++ The documents with retrievals have a total of 480 text units,
    so text units retrieved in these documents = 4.4%.
+++ All documents have a total of 1232 text units,
    so text units found in these documents = 1.7%.
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Cengiz Capan.

PROJECT: CSCW, User Janet Bailey, 3:38 pm, Mar 6, 1997.

****

(1 1 3) /RQ #1/Quality/No Effect
*** Definition:
Has no effect on
++
+++ ON-LINE DOCUMENT: expert1
+++ Retrieval for this document: 1 unit out of 89, = 1.1%
++ Text units 10-10:
I don't think so. 10
++
+++ ON-LINE DOCUMENT: expert3
+++ Retrieval for this document: 2 units out of 140, = 1.4%
++ Text units 10-11:
I will have to say this that I am probably going to have the most limited view of some of this 10
because I saw a lot of this on the periphery. No I didn't see a quality shift one way or the other. 11
++
+++ ON-LINE DOCUMENT: participant1
+++ Retrieval for this document: 7 units out of 181, = 3.9%
++ Text units 15-15:
I don't think so. 15
++ Text units 87-92:
Uh, I think it's the same. The reason is that every release we have such a huge enhancement. 87
When you add something new in there it always have new stuff. The problem is that the original 88
system has so many problems already so they keep adding stuff so the problem is getting bigger 89
and bigger. So Lotus is really not a tool to fix the problem it is a tool for recording the problem. 90
You see what I'm saying? So I think a lot of questions I think you can figure out what the 91
answer. 92
++
+++ ON-LINE DOCUMENT: participant2
+++ Retrieval for this document: 3 units out of 136, = 2.2%
++ Text units 15-15:
No I don't think so. 15
++ Text units 19-20:
No. Time consuming to actually document everything and actually use it. It did make you more 19
organized but that was about it. 20
++
+++ ON-LINE DOCUMENT: participant3
+++ Retrieval for this document: 8 units out of 210, = 3.8%
++ Text units 94-101:
No. I don't think so, but I think the number of times the users would report that error and we 94

would try to fix it was less because we were able to track the status of it more accurately. But as 95
far as the actual programming and the quality of the programming work, I don't think it 96
improved that, it was just improved the ability to coordinate which issues had already been 97
worked and when the users reported a problem, you would know right away if it was already in 98
work or it hadn't been worked - it just helped you track it better, but as far as the quality of the 99
programming, I don't think it made a difference. It really just keeps going back to the 100
coordination. It helped the project management and coordination. 101

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++ Total number of text units retrieved = 21
+++ Retrievals in 5 out of 9 documents, = 56%.
+++ The documents with retrievals have a total of 756 text units,
    so text units retrieved in these documents = 2.8%.
+++ All documents have a total of 1232 text units,
    so text units found in these documents = 1.7%.
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Cengiz Capan.

PROJECT: CSCW, User Janet Bailey, 3:38 pm, Mar 6, 1997.

****

(1 2 1) /RQ #1/Productivity/Positive
*** No Definition
++
+++ ON-LINE DOCUMENT: expert1
+++ Retrieval for this document: 3 units out of 89, = 3.4%
++ Text units 15-17:
There probably was. I know that after going to Notes they seemed to be more organized and 15
were able to find things quicker. If a question came up about an issue they were able to find the 16
answer quicker. 17
++
+++ ON-LINE DOCUMENT: expert3
+++ Retrieval for this document: 7 units out of 140, = 5.0%
++ Text units 16-22:
I think it did improve some especially in the areas of communication and documenting those 16
areas of communication because now they had one common repository for gathering all that 17
information. A lot of the times that we communicate we are here physically close. We 18
communicate well, but everybody's using something different. It may be as different as 19
electronic and paper and fax and everything else and its not collected so there is no one place to 20
go look for everything. Everything got communicated but when you need to back and find it 21
later a lot of time it doesn't happen. So I think from that respect it benefited from Notes. 22
++
+++ ON-LINE DOCUMENT: expert5
+++ Retrieval for this document: 9 units out of 142, = 6.3%
++ Text units 20-28:
A little bit because when you talk about development team members, they are pretty much 20
operating the same way, they know there specific issues but this improvement was focused on 21
project management, big picture, status type stuff. Besides when you are given an issue your 22
starting point may be a little bit bigger, I'm talking about an individual programmer, you are 23
given more to start with because all the documents are stored in Notes, all the relevant 24
information that you need but once you become familiar with the issue, it doesn't rely do a lot for 25
you because you know that issue. But for a project manager to come is and see what is the status 26
of all of my issues, how many are being worked that is where it helps. I think it helps more on 27
the higher level than it does at the individual programmer level. 28
++
+++ ON-LINE DOCUMENT: participant1
+++ Retrieval for this document: 3 units out of 181, = 1.7%
++ Text units 10-12:
Yes it is very useful. I think it is just to add more traceability what the problem caused before. 10
What we have changed. It's just recording. Lotus Notes, you know just to me is the 11

```
documentation, recording the problem we have and what we have changed.                    12
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++ ON-LINE DOCUMENT: participant3
+++ Retrieval for this document: 13 units out of 210, = 6.2%
++ Text units 8-12:
It helped us be able to keep track of what had already been fixed and what needed to be fixed.   8
So in my mind, yes, we were a lot more efficient.  We weren't reworking and answering the       9
same question.  So I think yes, it made us more productive.  We were getting by on Word, it was  10
just a lot more confusing as to what had already been worked, what issues were in this release,  11
what's the status of it.  It helped us track the status more efficiently.                        12
++ Text units 94-101:
No.  I don't think so, but I think the number of times the users would report that error and we   94
would try to fix it was less because we were able to track the status of it more accurately.  But as  95
far as the actual programming and the quality of the programming work, I don't think it          96
improved that, it was just improved the ability to coordinate which issues had already been     97
worked and when the users reported a problem, you would know right away if it was already in     98
work or it hadn't been worked - it just helped you track it better, but as far as the quality of the  99
programming, I don't think it made a difference.  It really just keeps going back to the        100
coordination.  It helped the project management and coordination.                               101
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++ Total number of text units retrieved = 35
+++ Retrievals in 5 out of 9 documents, = 56%.
+++ The documents with retrievals have a total of 762 text units,
    so text units retrieved in these documents = 4.6%.
+++ All documents have a total of 1232 text units,
    so text units found in these documents = 2.8%.
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

Q.S.R. NUD.IST Power version, revision 3.0.4d GUI.
Licensee: Cengiz Capan.

PROJECT: CSCW, User Janet Bailey, 3:38 pm, Mar 6, 1997.

****

(1 1 3) /RQ #1/Quality/No Effect
*** Definition:
Has no effect on
++
+++ ON-LINE DOCUMENT: expert1
+++ Retrieval for this document: 1 unit out of 89, = 1.1%
++ Text units 10-10:
I don't think so. 10
++
+++ ON-LINE DOCUMENT: expert3
+++ Retrieval for this document: 2 units out of 140, = 1.4%
++ Text units 10-11:
I will have to say this that I am probably going to have the most limited view of some of this 10
because I saw a lot of this on the periphery. No I didn't see a quality shift one way or the other. 11
++
+++ ON-LINE DOCUMENT: participant1
+++ Retrieval for this document: 7 units out of 181, = 3.9%
++ Text units 15-15:
I don't think so. 15
++ Text units 87-92:
Uh, I think it's the same. The reason is that every release we have such a huge enhancement. 87
When you add something new in there it always have new stuff. The problem is that the original 88
system has so many problems already so they keep adding stuff so the problem is getting bigger 89
and bigger. So Lotus is really not a tool to fix the problem it is a tool for recording the problem. 90
You see what I'm saying? So I think a lot of questions I think you can figure out what the 91
answer. 92
++
+++ ON-LINE DOCUMENT: participant2
+++ Retrieval for this document: 3 units out of 136, = 2.2%
++ Text units 15-15:
No I don't think so. 15
++ Text units 19-20:
No. Time consuming to actually document everything and actually use it. It did make you more 19
organized but that was about it. 20
++
+++ ON-LINE DOCUMENT: participant3
+++ Retrieval for this document: 8 units out of 210, = 3.8%
++ Text units 94-101:
No. I don't think so, but I think the number of times the users would report that error and we 94

```
would try to fix it was less because we were able to track the status of it more accurately.  But as                 95
far as the actual programming and the quality of the programming work, I don't think it                               96
improved that, it was just improved the ability to coordinate which issues had already been                          97
worked and when the users reported a problem, you would know right away if it was already in                         98
work or it hadn't been worked - it just helped you track it better, but as far as the quality of the                 99
programming, I don't think it made a difference.  It really just keeps going back to the                            100
coordination.  It helped the project management and coordination.                                                   101
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++ Total number of text units retrieved = 21
+++ Retrievals in 5 out of 9 documents, = 56%.
+++ The documents with retrievals have a total of 756 text units,
    so text units retrieved in these documents = 2.8%.
+++ All documents have a total of 1232 text units,
    so text units found in these documents = 1.7%.
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

REFERENCES

Aiken, M. and J. Carlisle. 1992. An automated idea consolidation tool for computer supported cooperative work. Information and Management 23 (December): 373-82.

Alavi, M. 1993a. An assessment of electronic meeting systems in a corporate setting. Information and Management 25: 175-82.

Alavi, M. 1993b. Making CASE an organizational reality: Strategies and new capabilities needed. Information Systems Management 10 (Spring): 15-20.

Albanese, R., and D.D. Van Fleet. 1991. Rational behavior in groups: The free riding tendency. Academy of Management Review 34.7 (July): 40-61.

Applegate, L.M., J.I. Cash, Jr., and D.Q. Mills. 1988. Information technology and tomorrow's manager. Harvard Business Review 66 (November/December): 128-36.

Bennis, W.G., and H.A. Shepard. 1956. A theory of group development. Human Relations, 9: 415-437.

Brown, T. 1996. The human side of downsizing. Management Review 85.8 (August): 15.

Buckley, J.W., M.H. Buckley, and H. Chiang. 1976. Research Methodology and business decisions. Montvale, NJ: National Association of Accountants.

Campbell, D.T., and J.C. Stanley. 1963. Experimental and quasi-experimental designs for research. Boston: Houghton Mifflin.

Chen, M. 1988. The integration of organization and information system modeling: a metasystem approach to the generation of group decision support systems. Ann Arbor: UMI.

Chen, M., and J.F. Nunamaker. 1991. The Architecture and Design of a Collaborative Environment for Systems Definition. Database 14 (winter/spring): 22-29.

Chen, M., J.F. Nunamaker, and B.R. Konsynski. 1987. PLEXACT: An Architecture and design of a knowledge-based system for information system development. Computer Personnel 7 (September): 2-10.

Chidambaram, L., R. Bostrom, and B. Wynne. 1990-91. A longitudinal study of the impact of group decision support systems on group development. Journal of Management Information Systems 7 (winter): 7-25.

Christakis, A.N. 1987. System profile: the club of rome revisited. System Research 4, no.1: 53-58.

Collaborative Technologies Corp. 1991. VisionQuest Fundamentals and Coordinator's Workshop, Austin, TX, July.

Connolly, T., L. Jessup, and J. Valacich. 1990. Effects of anonymity and evaluative tone on idea generation in computer-mediated groups. Management Science 36, (June): 689-703.

Conklin, P.F. 1992. Enrollment management, managing the Alpha AXP program. Digital Technology Journal 4, no. 4 (special issue).

Cook, T.D., and D.T. Campbell. 1979. Quasi-experimentation: design and analysis issues for field settings. Boston: Houghton Mifflin.

Crano, W.D. and M.B. Brewer. 1973. Principles of research in social psychology. New York: McGraw-Hill.

Cronbach, L.J. 1951. Coefficient alpha and the internal structure of tests. Psychometrika 16: 297-334.

Davis, G.B., A.S. Lee, K.R. Nickles, S. Chatterjee, R. Hartung, and Y. Wu. 1992. Diagnosis of an information system failure. Information and Management 23: 293-318.

Diehl, M. and W. Stroebe. 1987. Productivity loss in brainstorming in groups: Toward the solution of a riddle. Journal of Personality and Social Psychology 53, no. 3: 497-509.

Dennis, A.R., J.F. George, L.M. Jessup, J.F. Nunamaker, Jr., and D.R. Vogel. 1988. Information technology to support electronic meetings. MIS Quarterly 12 (December): 591-623.

Dennis, A.R. and J.S. Valacich. 1993. Computer brainstorms: more heads are better than one. Journal of Applied Psychology 78, no. 4: 531-37.

Dewan, P. and J. Riedl. 1993. Toward computer-supported concurrent software engineering. IEEE Computer 14 (January): 17-27.

Doyle, M. and D. Straus. 1976. How to make meetings work. New York: Jove.

Drucker, P. 1988. The coming of the new organization. Harvard Business Review 66 (January-February): 45-53.

Dunphy, D.C. 1974. The function of fantasy in groups. In Analysis of groups, ed. G.S. Gibbard, J.J. Hartman, and R.D. Mann. San Francisco: Jossey-Bass.

Eisenhardt, K. 1989. Building theories from case study research. Academy of Management Review 14, no. 4: 532-50.

Ellis, C.A., G.L. Rein, and S.L. Jarvenpaa. 1989-90. Nick experimentation: selected results concerning effectiveness of meeting support technology. Journal of Management Information Systems 6 (winter): 7-24.

Ewusi-Mensah, K., and Z.H. Przasnyski. 1991. On information systems project abandonment: an exploratory study of organizational practices. MIS Quarterly 15 (March): 67-86.

Fellers, J.W. 1989. The effect of group size and computer support on group idea generation for creativity tasks: an experimental evaluation using a repeated measures design. Ph.D. diss. Indiana University.

Fielding, R. and R. Lee. 1991. Using computers in qualitative analysis. Berkeley, CA: Sage.

Forte, G., and R. J. Norman. 1992. A self-assessment by the software engineering community. Communications of the ACM 35 (April): 28-32.

Galegher, J., and R.E. Kraut. 1992. Computer-mediated communication and collaborative writing: media influence and adaptation to communication constraints. CSCW 92 Proceedings: 155-62.

Galegher, J., and R.E. Kraut. 1994. Computer-mediated communication for intellectual teamwork: An Experiment in group writing. Information Systems Research 5 (June): 110-38.

Gallupe, R.B., L. Bastianutti, and W.H. Cooper. 1991. Unblocking brainstorms. Journal of Applied Psychology 76 (February): 137-42.

Gallupe, R.B., A.R. Dennis, W.H. Cooper, J.S. Valacich, J.F. Nunamaker Jr., and L. Bastianutti. 1992. Electronic brainstorming and group size. Academy of Management Journal 35 (June): 350-69.

Goodall, S.J. 1996. Teams and Team Room: Investigating the adoption of technology to support small work groups. Masters thesis, Massachusetts Institute of Technology.

Grudin, J. Groupware and cooperative work: Problems and prospects. 1993. Readings in groupware and computer supported cooperative work, ed. R.M. Baecker, San Mateo: Morgan Kaufman.

Hackman, J.R., and R.E. Kaplan. 1974. Interventions into group process: An approach to improving the effectiveness of groups. Decision Sciences 5: 459-80.

Henderson, J.C. and J.G. Cooprider. 1990. Dimensions of I/S Planning and design aids: A functional model of CASE technology. Information Systems Research 1, no. 3: 227-54.

Hirschheim, R., and M. Newman. 1988. Information systems and user resistance: Theory and practice. The Computer Journal 31, no. 5: 398-408.

Hill, G.W. 1982. Group versus individual performance: Are N + 1 heads better than one? Psychological Bulletin 91, no. 3: 517-39.

Hiltz, S.R., and M. Turoff. 1985. Structuring computer-mediated communication systems to avoid information overload. Communications of the ACM 28, no. 7: 680-89.

Hirokawa, R.Y., and R. Pace. 1983. A descriptive investigation of the possible communication based reasons for effective and ineffective group decision making. Communication Monographs 50: 363-79.

Hofman, J.D., and J.F. Rockart. 1994. Application templates: Faster, better, and cheaper systems. Sloan Management Review 36 (fall): 49-60.

Jablin, F.M., and D.R. Seibold. 1978. Implications for problem solving groups of empirical research on 'brainstorming: A critical review of the literature. The Southern States Speech Communication Journal 43 (summer): 327-56.

Janson, M.A., C.C. Woo, and L.D. Smith. 1993. Information systems development and communicative action theory. Information and Management 25: 59-72.

Jarvenpaa, S.L., V.S. Rao, and G.P. Huber. 1988. Computer support for meetings of groups working on unstructured problems: A field experiment. MIS Quarterly 12 (December): 645-66.

Johnson, D., and F. Johnson. Joining together. Boston: Allyn and Bacon.

Keyes, J. 1992. Team tools targeting development process. Software Magazine 12 (November): 45-56.

Lamm, H., and G. Trommsdorff. 1973. Group versus individual performance on tasks requiring ideational proficiency (brainstorming): A review. European Journal of Social Psychology 3: 361-87.

Lin, E., and C. Hsieh. 1990. Dysfunctional user behavior in systems development. Journal of Information Systems Management 7 (Winter): 87-89.

Liou, Y.I., and M. Chen. 1993-94. Using group support systems and joint application development for requirements specification. Journal of Management Information Systems 10 (Winter): 25-41.

Lou, H. 1994. Groupware at work: User's experience with Lotus Notes. Journal of End User Computing 6 (Summer): 12-19.

Lucas, H.C. 1975. Why information systems Fail. New York: Columbia University Press.

Mabry, E. A., and Barnes, R. E. 1980. The dynamics of small group communication. Englewood Cliffs, NJ: Prentice-Hall.

Markus, M.L. 1983. Power, politics, and MIS implementation. Communications of the ACM 26, no. 6: 430-44.

Marshall, C., and G.B. Rossman. 1995. Designing qualitative research. 2nd ed. Thousand Oaks, CA: Sage.

Miles, M.B., and A.M. Huberman. 1994. An expanded sourcebook: Qualitative data analysis. Thousand Oaks, CA: Sage.

Mintzberg, H., D. Raisinghani, and A. Theoret. 1976. The structure of 'unstructured' decision processes. Administrative Sciences Quarterly 21: 246-75.

Mohrman, S. and T. Cummings. 1989. Self-designing organizations: Learning how to create high performance. Reading, PA: Addison-Wesley.

NEC IC Micron. 1987. NEC IC Micron deming prize application. Kawasaki City, Japan: NEC IC Microcomputer Systems.

Nunamaker, Jr., J.F., A.R. Dennis, J.S. Valacich, D.R. Vogel, and J.F. George. 1991. Electronic meeting systems to support group work. Communications of the ACM 34, no. 7: 40-61.

Olson, J.S., G.M. Olson, M. Storrosten, and M. Carter. 1992. How a group-editor changes the character of a design meeting as well as its outcome. CSCW 92 Proceedings: 91-98.

Orlikowski, W.J. 1996. Improvising organizational transformation over time: A Situated change perspective. Information Systems Review 7 no. 1: 63-92.

Osborn, A.F. 1957. Applied imagination: principles and procedures of creative thinking. 2nd ed. New York: Scribners.

Patton, M.Q. 1987. Creative evaluation. 2nd ed. Newbury Park, CA: Sage.

Patton, M.Q. 1990. Qualitative evaluation and research methods. 2nd ed. Newbury Park, CA: Sage.

Petrovic, O., and O. Krickl. 1994. Traditionally-moderated versus computer supported brainstorming: a comparative study. Information and Management 27: 233-43.

Pinsonneault, A., and K.I. Kraemer. 1989. The impact of technological support on groups: An assessment of the empirical research. Decision Support Systems 5: 197-216.

Richards, T., and L. Richards. 1991. The NUD.IST Qualitative Data Analysis System. Qualitative Sociology 14 (Winter): 307-24.

Richards, T., and L. Richards. 1994. Using computers in qualitative analysis. In Handbook of qualitative research., ed. N. Denzin and Y. Lincoln, Berkeley, CA: Sage. 445-62.

Shaw, M. 1981. Group dynamics: The psychology of small group behavior. New York: McGraw-Hill.

Smith, J.Y., and M.T. Vanecek. 1980. Dispersed group decision making using nonsimultaneous computer conferencing. Journal of Management Information Systems 7 (Fall): 71-92.

Stake, R.E. 1995. The art of case study research. Thousand Oaks, CA: Sage.

Troboy, L.K. 1994. A study of differences perceived by information systems professionals in the systems development job environment due to the use of ICASE technology. Diss. proposal, University of North Texas, Denton.

Tuckman, B. 1965. Developmental sequence in small groups. Psychological Bulletin 63: 384-99.

Tuckman, B., and M. Jensen. 1977. Stages of small group development revisited. Group and Organizational Studies 2: 419-27.

Turner, J.A. 1982. Observations on the use of behavioral models in information systems research and practice. Information and Management 5, no. 4: 207-13.

Valacich, J.S., A. Dennis, and T. Connolly. 1994. Idea generation in computer-based groups: A new ending to an old story. Organizational Behavior and Human Decision Processes. 57, no. 3: 448-67.

Vessey, I., and A.P. Sravanapudi. 1995. CASE tools as collaborative support technologies. Communications of the ACM 38, no. 1: 83-95.

Yellen, R.E. 1992. What do users really think about CASE. Journal of Systems Management 43, no. 2 (February): 16, 89.

Yin, R.K., P.G. Bateman, and G.B. Moore. 1983. Case studies and organizational innovation: Strengthening the connection. Washington, DC: COSMOS Corporation.

Yin, R.K. 1993. Applications of case study research: Applied social research methods series vol. 34. Newbury Park,CA: Sage.

Yin, R.K. 1994. Case study research: Applied social research methods series vol. 5. 2nd ed. Newbury Park, CA: Sage.

Zahniser, R. 1993. Design by walking around. Communications of the ACM 36 (October): 115-23.