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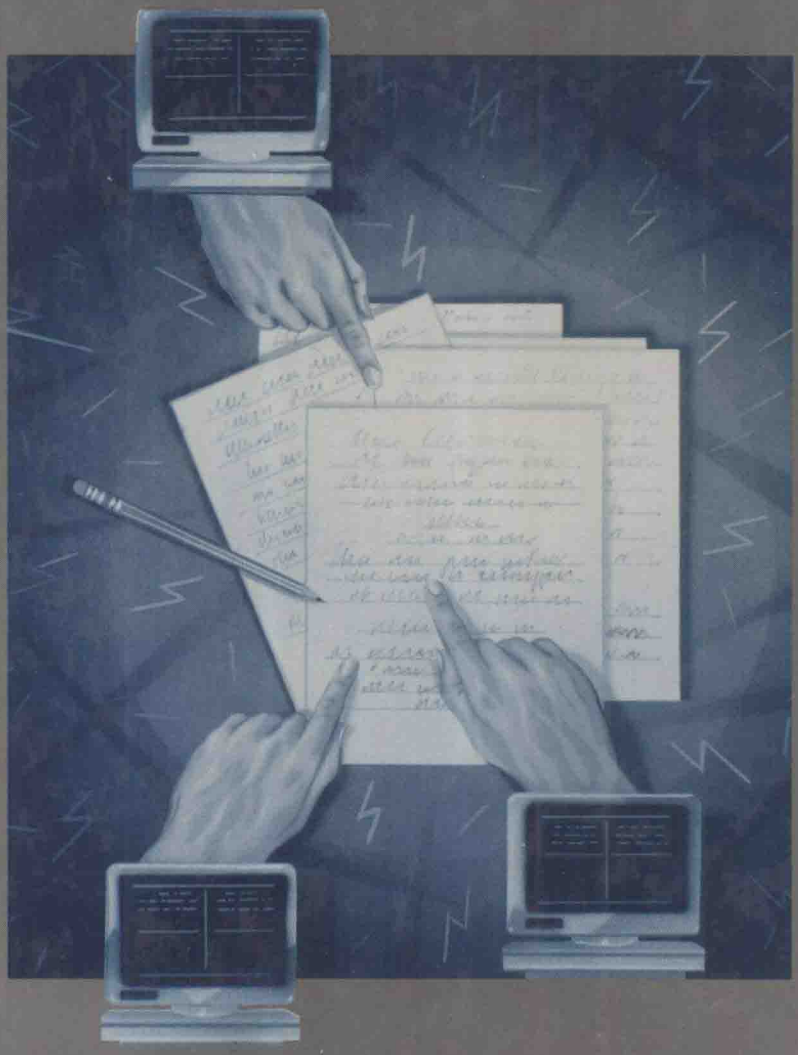
Computer-supported Cooperative Work and Groupware



Edited by

Saul Greenberg

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SAUL GREENBERG

Department of Computer Science,
University of Calgary, Calgary, Alberta,
Canada T2N 1N4

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Contributors

GARY BIRCH, Object Designers Ltd, Glebe House, Great Hallingbury, Bishop's Stortford, Herts CM22 7TY, UK.

SARA A. BLY, Xerox PARC, 3333 Coyote Hill Road, Palo Alto, California 94304, USA.

DANIEL G. BOBROW, System Sciences Laboratory, Xerox PARC, 3333 Coyote Hill Road, Palo Alto, California 94304, USA.

SUSANNE BØDKER, Computer Science Department, Aarhus University, Aarhus C, Denmark.

NATHANIEL S. BORENSTEIN, Bellcore, Room MRE 2A274, 445 South Street, Morristown, New Jersey 07960, USA.

ROBERT P. CARASIK, Pacific Bell, 2600 Camino Ramon 3N200W, San Ramon, California 94583, USA.

MICHAEL COHEN, Computer Music, Northwestern University, Evanston, Illinois 60208, USA.

STEVE COOK, Object Designers Ltd, Glebe House, Great Hallingbury, Bishop's Stortford, Herts CM22 7TY, UK.

GEORGE COULOURIS, Queen Mary and Westfield College, London E1 4NS, UK.

ALAN R. DENNIS, Management and Information Systems, Eller Graduate School of Management, University of Arizona, Tucson, Arizona 85721, USA.

ELIZABETH A. DYKSTRA, 109 Minna Suite 105, San Francisco, California 94105, USA.

CLARENCE A. ELLIS, Computer Science Department, University of Colorado, Boulder, Colorado 80309–0345, USA.

GREGG FOSTER, Apple Computer, Inc, 20525 Mariani Av. MS: 46A, Cupertino, CA 95014, USA.

SAUL GREENBERG, Department of Computer Science, University of Calgary, Calgary, Alberta T2N 1N4, Canada.

KAJ GRØNBÆK, Computer Science Department, Aarhus University, Aarhus C, Denmark.

JONATHAN GRUDIN, Computer Science Department, Aarhus University, Ny Munkegade 116 Building 540, DK-8000 Aarhus C, Denmark.

PETER JOHNSON-LENZ, Awakening Technology, 695 Fifth Street, Lake Oswego, Oregon 97034, USA.

TRUDY JOHNSON-LENZ, Awakening Technology, 695 Fifth Street, Lake Oswego, Oregon 97034, USA.

MARTIN LEA, Department of Psychology, University of Manchester, Manchester M13 9PL, UK.

LESTER F. LUDWIG, Bell Communications Research, New Jersey, USA.

JAMES R. MILLER, Human-Computer Interaction Department, Hewlett-Packard Laboratories, 1501 Page Mill Road, Palo Alto, California 94304, USA.

ALAN MURPHY, IBM UK Laboratories Ltd, Hursley Park, Winchester, UK.

BONNIE A. NARDI, Human-Computer Interaction Department, Hewlett-Packard Laboratories, 1501 Page Mill Road, Palo Alto, California 94304, USA.

J. F. NUNAMAKER, Jr, Management and Information Systems, Eller Graduate School of Management, University of Arizona, Tucson, Arizona 85721, USA.

MARGRETHE H. OLSON, Leonard N. Stern School of Business, New York University, New York, New York 10006, USA.

GAIL L. REIN, MCC, 3500 West Balcones Center Drive, Austin, Texas 78759–6509, USA.

RUSSELL SPEARS, Department of Social Psychology, University of Amsterdam, Roetersstraat 15, 1018 WB Amsterdam, The Netherlands.

JOHN C. TANG, Sun Microsystems, Inc, 2550 Garcia Avenue MS/MTV 23–41, Mountain View, CA 94043, USA.

DEBORAH TATAR, Department of Psychology, Building 420, Stanford University, Stanford, California 94305–2130, USA.

HAROLD W. THIMBLEBY, Computing Science, Stirling University, Stirling, Scotland FK9 4LA, UK.

CHRIS A. THYBERG, Hamburg Hall, Room 3017, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, USA.

JOSEPH S. VALACICH, Decision and Information Systems, Graduate School of Business, Indiana University, Tenth and Fee Lane, Bloomington, Indiana, 47405, USA.

JUDITH WEEDMAN, School of Library and Information Studies, University of California at Berkeley, 102 South Hall, Berkeley, California 94720, USA.

IAN H. WITTEN, Department of Computer Science, University of Calgary, Calgary, Alberta T2N 1N4, Canada.

JOHN WOOLSEY, IBM UK Laboratories Ltd, Hursley Park, Winchester, UK.

Contents

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Computer-supported cooperative work and groupware

SAUL GREENBERG

1. Introduction

Although computers are now familiar tools used by people to pursue their own individual tasks, they generally have not been exploited to assist people working together. Off-the-shelf applications in typical use are, for the most part, "single-user" systems. Word processors, spread sheets, idea outliners, drawing tools, and slide preparation packages (to name a few) are all built to support one person's work, with little regard to the fact that people often work together. Even the scientific study of human–computer interaction has emphasized exploring issues involved when a single user interacts with a computer. It is only recently that attention has turned to multi-user systems, through *computer-supported cooperative work* and *groupware*.

Groupware is software that supports and augments group work. It is a technically-oriented label meant to differentiate "group-oriented" products, explicitly designed to assist groups of people working together, from "single-user" products that help people pursue only their isolated tasks. The more familiar groupware examples include electronic mail, bulletin boards, asynchronous conferencing, group schedulers, group decision support systems, collaborative authoring, screen-sharing software, computer equivalents to whiteboards, video conferencing, and so on (e.g. Johansen, 1988).

In contrast, *computer-supported cooperative work* (CSCW) is the scientific discipline that motivates and validates groupware design. It is the study and theory of how people work together, and how the computer and related technologies affect group behaviour. CSCW is an umbrella collecting researchers from a variety of specializations—computer science, cognitive science, psychology, sociology, anthropology, ethnography, management, management information systems—each contributing a different perspective and methodology for acquiring knowledge of groups and for suggesting how the group's work could be supported.

However, CSCW is not particularly well defined, a consequence of its youth and its multi-disciplinary nature. A visible symptom of this uncertainty is the varying and at times controversial mix of papers accepted at CSCW conferences, with attendees often debating why certain topics were considered relevant by the programming committee. Nor is there consensus on what applications should be considered "groupware". Grudin (1991) lists examples of how people have drawn the line between groupware and its substrate, with some believing it starts at a very low technical level (e.g. a Network File Server), and others stating that it begins somewhere above electronic mail. Even the "computer-supported cooperative work" label has come under fire for a variety of reasons (Bannon & Schmidt, 1989; Grudin, 1991). For example:

- *computer*—technologies other than computers (such as video) are considered within the CSCW domain;
- *supported*—while support may be offered to the group as a whole, activities of particular individuals may be disrupted;
- *cooperative*—the social process can include not only cooperation, but aggression, competition, loose coordination and tight collaboration;
- *work*—casual and social interaction must be supported as well, for they are considered a vital precursor to the work process (e.g. Kraut, Egido & Galegher, 1988).

Essays exploring and arguing the foundations of CSCW have been forwarded by Bannon, Bjorn-Andersen & Due-Thomsen (1988), Bannon and Schmidt (1989), Greif (1988) and Grudin (1991). Rather than split semantic hairs of what CSCW is or should be, Bannon *et al.*'s original pragmatism is adopted here.

> We believe that for the moment the name CSCW simply serves as a useful forum for a variety of researchers with different backgrounds and techniques to discuss their work, and allows for the cross-fertilization of ideas, for the fostering of multidisciplinary perspectives on the field that is essential if we are to produce applications that really are useful (Bannon *et al.*, 1988).

2. Overview of the book

This book is based upon the *International Journal of Man Machine Studies* special editions on computer-supported cooperative work and groupware, published in February and March of 1991. The collection contains 16 original articles[1] selected from over 40 submissions to the journal, and an annotated bibliography to CSCW. As the papers were chosen on individual technical merit, the collection does not introduce all aspects of CSCW and groupware. Still, the new reader should gain some insight into what this field is about, while the active CSCW researcher and groupware implementor will be informed of several exciting new findings and perspectives.

This book loosely categorizes the collected papers into seven parts. In order to establish a sense of context for the reader, this section introduces each part and the papers within them.

2.1. STUDYING GROUPS WITHOUT GROUPWARE

Knowing how people work together without groupware is an essential first step for designing appropriate software. The articles in Part 1 take this approach. Tang analyses key aspects of shared activity around a paper sketchpad by studying video transcripts of small group design sessions. The result is a set of specific recommendations for the design of tools to support shared workspace activity, results which have now been taken up by several prototype video and electronic workspaces (for examples see Bly & Minneman, 1990; Greenberg & Bohnet, 1991; Ishii, 1990; Tang & Minneman, 1990).

Nardi and Miller's study is on spreadsheets, long considered a good example of a well designed "single user" application. Much to their surprise, they observed that spreadsheet co-development was the rule, not the exception. They saw a high degree of cooperation in sharing program expertise, transferring domain knowledge, debugging, training and face to face work in meetings. The general implication is

[1] A few articles have appeared in substantially different form elsewhere.

that cooperative work happens all the time, in spite of the inherent limitations of the software.

2.2. STUDYING GROUPS WITH GROUPWARE

When groupware is available, its effect on the group can be evaluated and further implications for design developed. Tatar, Foster and Bobrow, for example, review "Cognoter", a multi-user idea organizer that was part of Xerox PARC's original CoLab suite (Stefik, Foster, Bobrow, Kahn, Lanning & Suchman, 1987). They noticed that its users encountered unexpected communication breakdowns, which they attribute to the Cognoter's incorrect model of conversation implicit in its design. By using a more appropriate model of conversation, they were not only able to pin-point the previous design decisions that had contributed to the difficulties users had, but they were able to amend the design as well.

"Media Space" is a video, audio and computing network established to support distributed research across two quite distant laboratories. Olson and Bly observed the laboratories' usage evolution of Media Space over two years. The resulting article reports on the requirements for distributed research, and indicates where the technology both succeeded and failed to support various aspects of the collaborations.

Borenstein and Thyberg's article describes the "Messages" user interface to the "Andrew Message System" (AMS), a powerful multi-media mail and bulletin board program. The authors talk the reader through the original design assumptions of Messages and detail its features. What makes Messages interesting is that it is a real system, with several thousand users. The continuous user involvement meant that faults quickly became evident, motivating rapid redesign. As an example, they step us through three iterations of the "Adviser", a Messages subsystem designed to allow experts to provide advice to queries from AMS users.

2.3. COMPUTER-MEDIATED COMMUNICATIONS AND GROUP DECISION SUPPORT SYSTEMS

Computer support for meetings is becoming an increasingly common way to assist the group decision-making process. In face to face settings, we are not only seeing specially-built meeting rooms (e.g. Mantei, 1988), but also cheap LED projectors that can display a computer screen's contents on a large screen. In asynchronous environments, electronic mail and computer conferencing enable on-going discussions between time and distance-separated people.

But what makes good electronic meeting support? Valacich, Dennis and Nunamaker Jr have worked with the University of Arizona's "GroupSystems" face to face meeting room for several years. They highlight the theoretical assumptions behind the system's design and describe GroupSystems' workings. Of particular importance is that GroupSystems has been well-studied; 15 experimental and field studies are summarized and contrasted. The authors then provide recommendations for developers of electronic meeting rooms based upon the lessons learnt.

Technology changes the way in which people within a group behave. Lea and Spears discuss how computer-mediated communication affects de-individuation, the anonymity and loss of identity that occurs when people are submerged in a group. If de-individuation does exist, we would expect the social norms and constraints of people's behaviour to be weakened, which would have serious consequences on how

decisions made by the group should be interpreted. The authors question past findings on how electronic communication changes the group's psychological states, and then present their own study and alternative view of the role of de-individuation.

What is computer-mediated communication used for? Some systems are based upon the assumption that communication is related to a specific task or action which can be captured and formalized (e.g. the Coordinator, Winograd, 1988). Weedman noticed that typical, asynchronous computer communication also has a large non-task component used for such things as social exchange, expressing frustrations, and so on. She argues that since variety and vigour of communication is important to successful collaboration, the underlying technology should be flexible enough to support informal as well as formal talk.

2.4. NOVEL AND INNOVATIVE GROUPWARE TECHNOLOGIES

CSCW exhibits the same push and pull between theory and creative technologies that exists in traditional human–computer interaction. The four articles in Part 4 demonstrate innovations that may alter our perspectives of groupware fundamentals.

Recent developments in interactive *virtual environments* have sparked interest in spatially-located three-dimensional sound. Cohen and Ludwig describe an audio management system called *audio windows* that integrates spatial sound, audio emphasis, and gestural input recognition. While this exciting use of computer-controlled sound can be applied to *any* aspect of the human–computer interface, the article suggests new enhancements this technology can bring to tele-conferencing.

A large part of a group process is information sharing. While networked computers usually allow people within an institution to share information across common data files, networks are rarely available for loosely-coupled social groups. Witten, Thimbleby, Coulouris and Greenberg describe "Liveware", a socially productive benign virus used to spread information across intermittently connected people and groups. Unlike conventional wired networks, Liveware is cheap, does not require a technical infrastructure, and is intrinsically intertwined with social conventions of "casual" information sharing by mobile and flexible work groups.

Hypertext developers now recognize that hypertext documents will be used and updated by large groups of people. Rein and Ellis take the next logical step by combining both real-time with asynchronous hypertext manipulation in their "rIBIS" system. An rIBIS session is a distributed meeting where participants can be in a "tightly-coupled" or "loosely-coupled" mode. In the first, tightly-coupled members all see the same thing, and take turns controlling and manipulating the hypertext display. In the second, a person works semi-privately by editing a portion of the hypertext—only large-grained changes are broadcast to other members. The result is a system valuable not only for storing information, but also for allowing people to actively capture and structure critical aspects of a meeting process.

Cook, Birch, Murphy and Woolsey are "strict constructionists", i.e. implementors interested in the underlying architectures and technologies supporting groupware. They create a model of a groupware system, and use it to explore, implement and evaluate a system architecture. The paper reveals what constraints the developers chose to work under, how they actually built the system and how they judged what worked and what did not. The paper also highlights a serious problem currently

facing all groupware developers: the lack of an adequate toolkit for constructing applications.

2.5. REMOVING RIGIDITY FROM GROUPWARE

Peter and Trudy Johnson-Lenz suggest that today's approach to groupware is *mechanistic*, i.e. based upon some social theory of human interaction or upon a task-oriented approach that can be modelled by a machine. At the other extreme (also supported by Dykstra and Carasik) is *groupware as context*, based on the social theory that human systems are self-organizing and arise out of the unrestricted interaction of autonomous individuals. Dykstra and Carasik's article pursues this latter view. They argue that while systems should nourish conversation and stimulate interaction amongst group participants, they should not directly regulate the actual meeting process. Instead, the technology should be supple enough to allow the group itself to define its own (perhaps changing) conventions, structures and constraints. Several iterations of the "Amsterdam Conversation Environment", a system supporting groupware as context, are described.

The Johnson-Lenzs' delightful article takes the middle ground. Instead of eschewing system support for process, they describe how the computer can perhaps capture the emergence of the group's process, and then create appropriate forms for supporting it. They consider their approach "post-mechanistic" as the model of group behaviour is not rigidly codified into the system but evolves with the group. Their implementation is particularly intriguing not only for technical reasons, but because the subject domain is "self-help", a far cry from the usual business-oriented applications emphasized by developers.

2.6. PARTICIPATORY DESIGN

Unlike conventional interface design approaches that consider user involvement a sequence of intermittent consultations, *participatory design* has the design team comprised of developers and eventual system users. Both actively and continuously participate in planning and decision making in order to build a system that truly matches what the workers need. Participatory design is now touted as a critical requirement for successful groupware design, on the premise that the resulting product will be more usable by all team members.

While participatory design has generally succeeded for software development targetted to producing systems specific to an in-house organizational context, it has not really been applied to product development organizations that design mass-produced off-the-shelf products. Grudin suggests that in spite of the benefits participatory design may offer for improving a system interface (particularly for groupware systems), there are several serious obstacles to user involvement. Most stem from organizational structures and development practices that arose prior to the current market for interactive systems. Recognizing these obstacles is, of course, the first step to overcoming them.

Given an environment conducive to participatory design, how does one go about it? Bodker and Gronbaek describe one method called *cooperative prototyping*. This involves sessions where users experience the future-use situation, and then participate with designers in modifying the prototypes when usage breakdowns require it. Their article is especially valuable as it provides: a theoretical framework; a practical guide

for managing cooperative prototyping sessions, and an example of how cooperative prototyping develops in a real situation.

2.7. ANNOTATED BIBLIOGRAPHY

Computer-supported cooperative work is a new multi-disciplinary field with roots in many disciplines. Due to the youth and diversity of computer-supported cooperative work and groupware, few specialized books or journals are available, and articles are scattered amongst diverse journals, proceedings and technical reports. Building a CSCW reference library is particularly daunting, for it is difficult for the new researcher to discover the relevant documents. To aid this task, I have compiled, listed and annotated much of the current research in computer-supported cooperative work into the bibliography in Part 7. The article also includes an overview of the general sources that publish CSCW works and a list of groupware systems and concepts indexed to the bibliography.

2.8. METHODOLOGY

Traditional experimental methodologies employed to study human–computer interactions are often inadequate for studying group situations. When real group dynamics are awkward to replicate in a laboratory, researchers must resort to observing behaviour in the field. Studies are characterized by many variables and uncontrollable factors, and often require observations over lengthy time spans. New methodologies are essential.

Several of the articles interspersed in this collection serve a purpose beyond their specific research findings, for they also introduce methodologies that may be novel to the reader. Both Lea's and Weedman's articles, for example, illustrate how conventional experimental psychology can still be applied to study fine details of group behaviour. In contrast, Tang's use of "video as data" (Mackay & Tatar, 1989) is an example of a relatively new way of collecting data that helps establish insight into group behaviour under less controlled conditions. His article also provides an example of an ethnographic study, particularly in how complex group activity can be categorized, counted and interpreted. Nardi and Miller also offer an ethnographic study, in this case using extensive interviewing of subjects along with an analysis of the artifacts produced by the group. Tatar, Foster and Bobrow show how even brief usability studies—simple observations of "real" users (not developers) interacting through a system—can highlight serious problems that may be otherwise overlooked. They also demonstrate the value of using models and theories from non computer-based fields (in this case conversational analysis and psycho-linguistics) to explain the group's reaction to the particular groupware system. Olson and Bly reveal how an objective outside observer can be brought in to examine a long-term work process.

Although the methods employed by the above researchers are far from exhaustive, they do give an example of the diverse methodologies involved in CSCW research.

The articles in this book are derived from a cross-referee process, where each of the over 40 original submitters was asked to referee three other articles. In spite of the tight deadline, all referees returned their reports promptly. The selection of articles and the recommended improvements in the revised articles are due to their diligence.

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References

BANNON, L., BJORN-ANDERSON, N. & DUE-THOMSEN, B. (1988). Computer support for cooperative work: An appraisal and critique. In H. J. BULLINGER, Ed. *Eurinfo '88. Information Systems for Organizational Effectiveness*. Amsterdam: North-Holland.

BANNON, L. J. & SCHMIDT, K. (1989). CSCW: Four characters in search of a context. In *Proceedings of the European Community Conference on Computer Supported Work (EC-CSCW)*, pp. 358–372, London, September.

BLY, S. A. & MINNEMAN, S. L. (1990). Commune: A shared drawing surface. In *Proceedings of the Conference on Office Information Systems*, pp. 184–192, Boston, April 25–27.

GALEGHER, J., KRAUT, R. & EGIDO, C. (Ed.) (1990). *Intellectual Teamwork: Social and Technological Foundations of Group Work*. Hillsdale, NJ: Lawrence Erlbaum Associates.

GIBBS, S. & VERRIJN-STUART (Ed.) (1990). *Proceedings of IFIP WG8·4 Conference on Multi-User Interfaces and Applications (Crete)*. Amsterdam: North-Holland.

GREENBERG, S. (1991). *An Annotated Bibliography of Computer Supported Cooperative Work: Revision 2*. Research Report, Department of Computer Science, University of Calgary, Calgary, Alberta, Canada.

GREENBERG, S. & BOHNET, R. (1991). Group Sketch: A multi-user sketchpad for geographically-distributed small groups. In *Proceedings of Graphics Interface '91*, Calgary, Alberta, June 5–7. Also available as Research Report 90/414/38, Department of Computer Science, University of Calgary, Alberta, Canada.

GREIF, I. (Ed.) (1988). *Computer-supported Cooperative Work: A Book of Readings*. San Mateo, CA: Morgan Kaufmann.

GRUDIN, J. (1991). CSCW: The convergence of two disciplines. In *ACM SIGCHI Conference on Human Factors in Computing Systems*, April. New Orleans: ACM Press.

ISHII, H. (1990). Team WorkStation: Towards a seamless shared space. In *Proceedings of the Conference on Computer-Supported Cooperative Work*, pp. 13–26, October 7–10. Los Angeles, CA: ACM Press.

JOHANSEN, R. (1988). *Groupware: Computer Support for Business Teams*. New York: The Free Press, Macmillan Inc.

KRAUT, R., EGIDO, C. & GALEGHER, J. (1988). Patterns of contact and communication in scientific collaboration. In *Proceedings of the Conference on Computer-Supported Cooperative Work*, pp. 1–12, September 26–28. Portland, OR: ACM Press.

MACKAY, W. E. & TATAR, D. G. (1989). Special issue on video as a research and design tool. *SIGCHI Bulletin,* **21**(2), October.

MANTEI, M. (1988). Capturing the Capture concepts: A case study in the design of computer-supported meeting environments. In *Proceedings of the Conference on Computer-Supported Cooperative Work*, pp. 257–270, September 26–28. Portland, OR: ACM Press.

OLSON, M. H. (Ed.) (1989). *Technological Support for Work Group Collaboration*. Hillsdale, NJ: Lawrence Erlbaum Associates.

STEFIK, M., FOSTER, G., BOBROW, D., KAHN, K., LANNING, S. & SUCHMAN, L. (1987). Beyond the chalkboard: Computer support for collaboration and problem solving in meetings. *Communications of the ACM,* **30**, 32–47. Reprinted (1988) in I. GREIF, Ed. *Computer Supported Cooperative Work: A Book of Readings*. San Mateo, CA: Morgan Kaufmann.

TANG, J. C. & MINNEMAN, S. L. (1990). Videodraw: A video interface for collaborative drawing. In *ACM SIGCHI Conference on Human Factors in Computing Systems*, pp. 313–320, April 1–5, Seattle. Washington: ACM Press.

University of Guelph (1987). *The Second Guelph Symposium on Computer Conferencing*, University of Guelph, Guelph, Ontario, Canada, June 1–4.

University of Guelph (1990). *The Third Guelph Symposium on Computer Mediated Communication*, University of Guelph, Continuing Education Division, Guelph, Ontario, Canada, May 15–17.

WINOGRAD, T. (1988). A language/action perspective on the design of cooperative work. *Human–Computer Interaction*, **3**, 3–30.